

Keehi Interchange

Honolulu, Hawaii

HIGH-MAIN STREET BRIDGE
Hamilton, Ohio

MONROE STREET BRIDGE
Spokane, Washington

LEE ROY SELMON CROSSTOWN EXPRESSWAY
Hillsborough County, Florida

ELK AVENUE-DOE RIVER BRIDGE
Elizabethton, Tennessee

WEST ROAD BRIDGE
Hamilton County, Ohio

SEATTLE SOUND TRANSIT LIGHT RAIL
Seattle, Washington

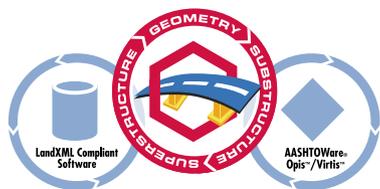


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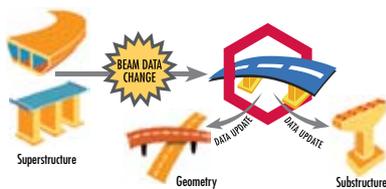
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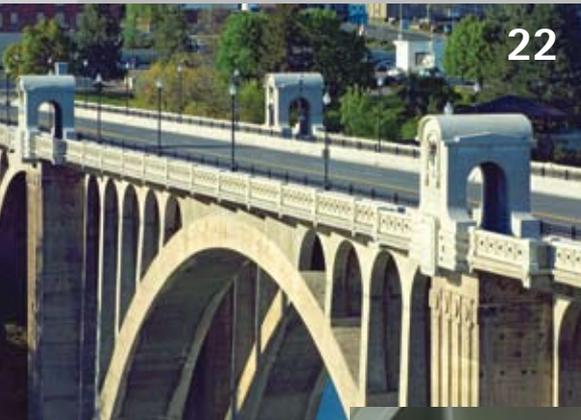
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1-15 U.S. Route 95 Interchange
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Do you have an opinion about *ASPIRE*™ Magazine?

Please, share your ideas with us!

John S. Dick, *Executive Editor*

We invite you to share your impressions about *ASPIRE*™ magazine with the editors and staff. A simple survey is available at www.aspirebridge.org. It involves multiple choice and fill-in-the-blank type questions. It'll take you less than 5 minutes to complete.

Why? This is a magazine by and about bridge practitioners. It must be relevant to you! Whether you are employed at any level by an owner agency, a design consultant, a contractor, a university, or an industry supplier, your opinion is crucial to keeping this magazine on target for you and your peers.

As illustrated by the articles in this issue, our intent is to cover all types of concrete design solutions: cast-in-place, precast, reinforced, pretensioned and post-tensioned. Our goal is to showcase concrete bridges from all areas of the country. We've featured large projects and small; exotic and straight forward. All are, we believe, at the leading edge of practice.

ASPIRE will grow in 2008. There'll be more editorial pages and more advertising (relevant to readers). We're planning a new special feature in every issue. This will be on the topic of accelerated bridge construction. In addition,

in 2008, we'll theme the entire year around "sustainable design" of transportation bridges. The subscription list, already reaching more than 21,000, will continue to expand. Your input will guide us in our growth.

Please take time to read the "Buyers Guide" on pages 50 and 51. Our advertisers have provided the means to bring you *ASPIRE*. We greatly appreciate their support and we strongly encourage you to consider their products and services. Also in this issue, on page 6, is an informative and useful "Concrete Calendar."

What else would you like to see in the pages of *ASPIRE*? What do you like about the magazine? What do you dislike? What would you change? Do you have suggestions for projects we ought to feature? How about one of yours? Go to www.aspirebridge.org and let us know.

We look forward to seeing many of you as we close out the year at the Western Bridge Engineers' Seminar in September, the PCI-FHWA National Bridge Conference in October and the ASBI Conference in November. Perhaps we can also chat there on making *ASPIRE* the best magazine that it can be!

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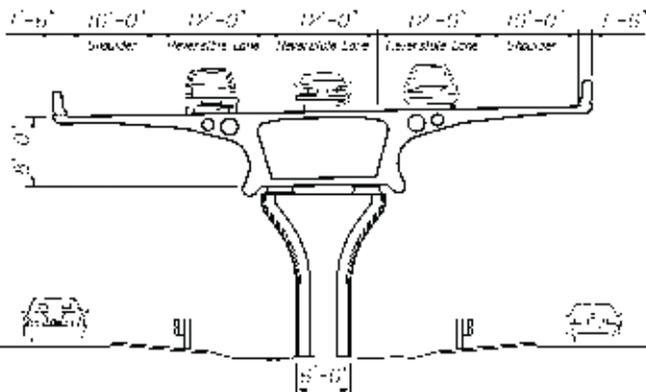
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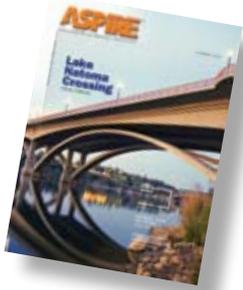


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READER RESPONSE



"I enjoy reading the ASPIRE™ magazine and find it to be a fine addition to the periodicals available within the industry. ASPIRE definitely fills a niche which no other magazine does. As an advertiser, DSI sees opportunity in this publication. In browsing the latest (summer) edition, I was surprised while reading the Veterans Glass City Skyway project article. This is a project we at DSI are very involved with and proud of. As a major supplier for stay cables, post-tensioning, and reinforcement we were not mentioned in the profile."

David Martin, DYWIDAG-SYSTEMS INTERNATIONAL USA, Inc., Bolingbrook, Ill.

[Editor's Note: Mr. Martin was gentle with us when he discovered our omission. We do make every effort to recognize the important participants in each article. And DSI did indeed play a major role in this amazing project. FIGG got it right in their reporting to us... but we dropped the ball. A quality improvement change should eliminate the glitch. Our apologies to DSI. In researching this information, we discovered that RJ Rebar, Muncie, Ind. should have also been mentioned as a supplier of other reinforcement.]

"The department currently subscribes to your publication and would certainly like to continue as your publication is a valuable source of information for our employees. Would it be possible to place a link to the on-line version... on our Policy and Research Center Intranet site...?"

Diana Sternitzke, Chief, Quality and Document Management Services, Illinois Department of Transportation

"The 'Summer 2007' issue of the ASPIRE magazine is 'SUPERB.' The quality of the articles, illustrations and the magazine itself is way above any similar publications I receive.

"I was especially impressed with the article by Rob Turton of HDR... 'The Right Bridge for the Right Reasons.' Likewise: 'When Light is

Better' by Ganapathy Murugesb of California DOT and Karen Cormier of T.Y. Lin International. 'Both of these articles were describing the use of 'Lightweight Concrete' on bridges which are not simple ones but extremely complicated and above all they are gorgeous..."

"The Lightweight Concrete Technology has come a long way since the early 1960s when some of us young pioneering engineers used this material for bridges.

"The contributions from the government agencies like M. Myint Lwin of FHWA, many other excellent articles and the 'Selected' audience guarantees nothing but SUCCESS for this long awaited periodical on bridges, the 'ASPIRE.™' Congratulations."

George Laszlo, Consultant, Chief Engineer (Retired)

[Editor's Note: Mr. Laszlo is in fact a "pioneer." He spent several decades as chief engineer for companies in the Pacific Northwest including Morse Bros. Mr. Laszlo ploughed much new ground for the prestressed concrete industry. He was also a contributor to the *PCI JOURNAL*.]

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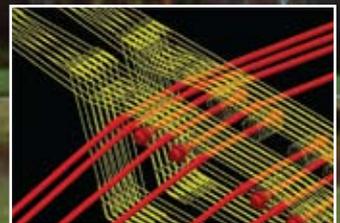
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Frederick Gottemoeller is an engineer and architect, who specializes in the aesthetic aspects of bridges and highways. He is the author of *Bridgescape*, a

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MANAGING TECHNICAL EDITOR



Photo: Ted Lucey Photography

Dr. Henry G. Russell is an engineering consultant, who has been involved with the applications of concrete in bridges for over 35 years and has published many papers on the applications of high performance concrete.

September 23-26

Western Bridge Engineers' Seminar & Exhibition
Boise Centre on the Grove, Boise, Idaho

October 14-18

ACI Fall Convention
El Conquistador, Fajardo, P.R.

October 22-24

National Concrete Bridge Conference and PCI Annual Convention & Exhibition
Includes meeting of AASHTO Technical Committee on Concrete Design (T-10)
Hyatt Regency Phoenix/Phoenix Civic Plaza Convention Center, Phoenix, Ariz.

November 4-6

ASBI Annual Convention and Exhibition
Includes ASBI Board of Directors meeting, November 7
Includes meeting, AASHTO Technical Committee on Concrete Design (T-10)
The Orleans Hotel, Las Vegas, Nev.

November 5-7

PCI Quality Control & Assurance Personnel Training & Certification Schools
Level I and Level II
Embassy Suites, Nashville, Tenn.

December 1

ASBI Certified Grouting Technicians and Training Certificate Holders Class of 2002
Deadline for On-line Recertification.

January 13-17, 2008

Transportation Research Board Annual Meeting
Marriott Wardman Park, Omni Shoreham, and Hilton Washington, Washington, D.C.

March 20-21, 2008

Accelerated Bridge Construction Conference – Highway for Life
Hyatt Regency Baltimore on the Inner Harbor
Baltimore, Md.

April 24-27, 2008

PCI Annual Committee Days
Includes meeting of AASHTO Technical Committee on Concrete Design (T-10)
Westin Hotel. Chicago, Ill.

May 6-8, 2008

Concrete Bridge Conference and PTI Annual Conference
Hyatt Regency, St. Louis, Mo.

June 2-4, 2008

International Bridge Conference & Exhibition
Pittsburgh Convention Center, Pittsburgh, Penn.

July 27-30, 2008

Sixth National Seismic Conference on Bridges & Highways
Abstracts due October 1, 2007
Organized by the Federal Highway Administration (FHWA), the Transportation Research Board (TRB), the South Carolina Department of Transportation (SCDOT) and MCEER, University at Buffalo, N.Y.
Charleston, S.C.

November 2-6, 2008

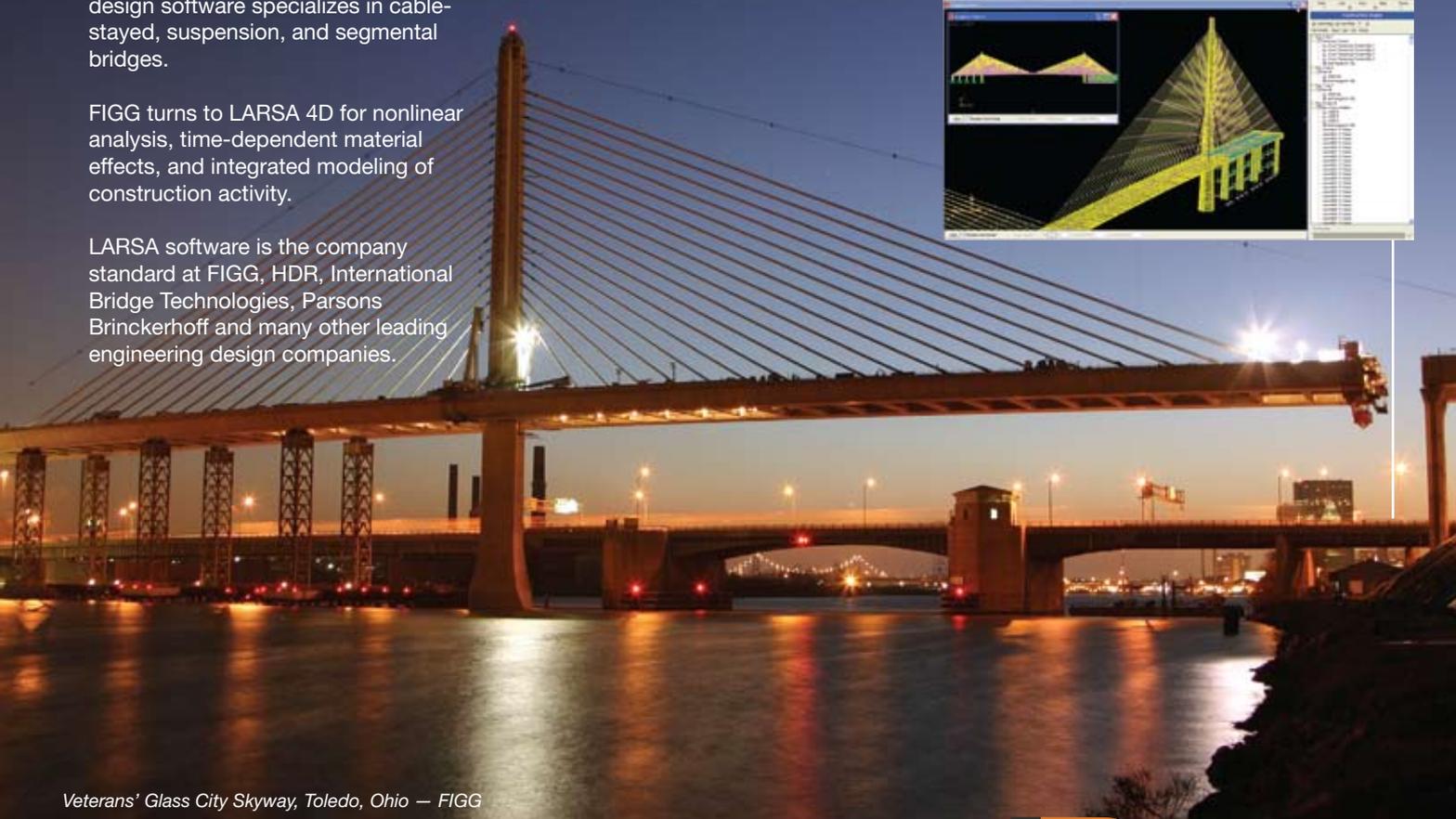
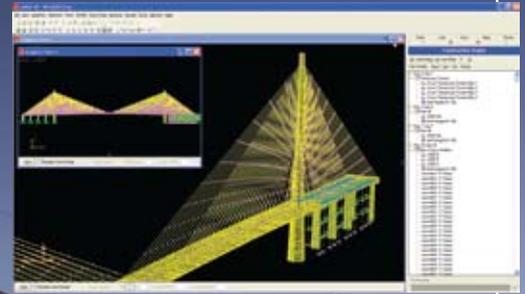
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- Composite
- Cable-Stayed & Suspension
- Post-Tensioned
- Steel Plate Girders

ANALYSIS

- Geometric Nonlinearity
- Material Nonlinearity
- Finite Element Library
- Progressive Collapse
- Nonlinear Dynamics
- Plastic Pushover

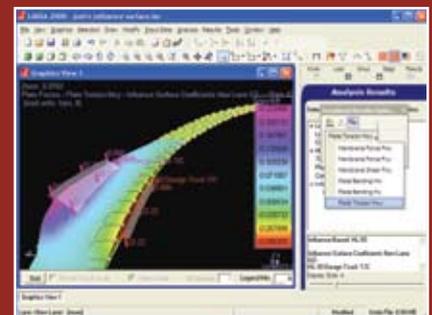
DESIGN

- 3D Tendons
- Influence Surfaces
- Creep & Shrinkage
- Relaxation
- AASHTO LRFD 2006 Code Check

CONSTRUCTION

- Time-Dependent Materials
- Staged Construction
- Incremental Launching
- Balanced Cantilever
- Span-by-Span

Susquehanna River Bridge, I-76, Pennsylvania — FIGG



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Lightweight high performance concrete was used in the spliced girders and concrete decks of the Route 33 Bridge over the Mattaponi River in Virginia. Photo: ©PB.



STAYING ON THE CUTTING EDGE

by Craig A. Shutt

Throughout its 120-year history, Parsons Brinckerhoff has pushed the boundaries of design for concrete bridges



*Vijay Chandra,
Senior Vice President*

Since its founding in 1885, the company now known as PB has remained at the forefront of design by continually examining new technologies and incorporating new ideas into its concepts. That work has paid dividends in its bridge designs throughout its history, and it continues to pay off today and for tomorrow.

"PB's accomplishments in bridge designs represent a microcosm of innovative efforts and events that have occurred throughout the larger industry," says Vijay Chandra, Senior Vice President for the New York-based engineering firm. "PB has designed hundreds of concrete bridges, viaducts, and ramps during our history."

The company defines success for a project by delivering a sustainable value to its clients, communities, employees, and profession, he notes. "Since our founding, we've seen the world transition from discrete industrial societies to a technological culture on a global scale," he says. "As an integral part of this transition, the design of large-scale engineering works has proven to be an intensely human activity fueled by innovation and vision."



Concrete Designs

The company designs bridges using both concrete and steel based on a variety of factors including owner preference, location, design parameters, unique challenges, and aesthetics. PB has been using prestressed concrete from its earliest days in the 1950s, Chandra notes. Those projects include the first Sunshine Skyway Bridge, a 15-mile structure near St. Petersburg, Florida, on which it worked from 1947 to 1955. The design featured 16,000 ft of precast, prestressed concrete girders, one of the first uses of the technology.

PB has continued to embrace the development of concrete designs ever since. "In the 1960s and early 1970s, whenever designers thought of creating spans greater than 75 to 80 ft, they thought of steel," he says. "In some measure, that was because of limitations in the plants and in transportation for concrete, so the spans were shorter. But even by the early 1970s, the market had changed so that concrete was being used to create longer spans.

One of the earliest such uses, in the late 1960s, was the Halawa Interchange in Honolulu, Hawaii, which comprised 16 major bridges, nearly all of which used precast, prestressed concrete girders. Two of those featured one of the first uses of what is now called "spliced-girder technology" to extend the span lengths of the girders.

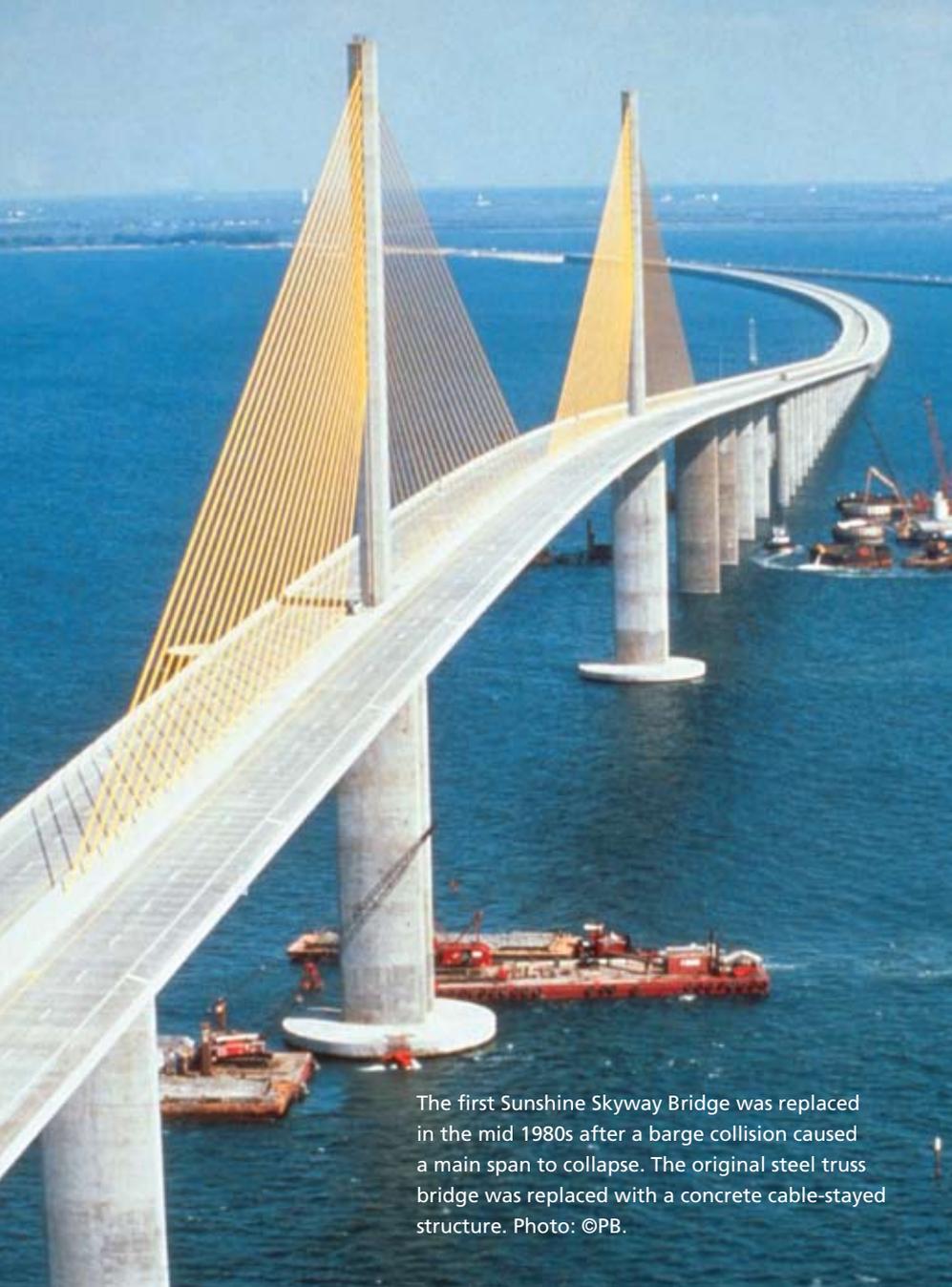
"We have since designed many spliced-girder concrete bridges, and we have helped to increase the span lengths that can be achieved," he notes. To succeed with spliced girders, he adds, designers have to be certain they know what they're doing and are using experienced personnel. They also have to do detailed analyses to ensure they account for thermal effects and long-term creep and shrinkage. "That analysis has to be

Two of the bridges at the Halawa Interchange in Honolulu, Hawaii, featured one of the first uses of spliced-girder technology. Photo: ©PB.



The I-10 Bridge over Escambia Bay makes extensive use of precast components for the pier footings, bent caps, pier caps, prestressed concrete piling, and bulb-tee beams.

Photo: ©David Sailors.



The first Sunshine Skyway Bridge was replaced in the mid 1980s after a barge collision caused a main span to collapse. The original steel truss bridge was replaced with a concrete cable-stayed structure. Photo: ©PB.

'Repair and investigative analysis is becoming a larger part of the market.'

done precisely to be sure it is absolutely accurate," he says. "Constructability also is a key concern with spliced-girder bridges and has to be reviewed closely."

The firm designed the James River Bridge in Newport News, Virginia, during the mid 1970s. This bridge featured a monolithic design in which the deck girders and top slab were cast as a single unit 75 ft long and 36 ft wide. "The design was changed to the monolithic approach to create a smooth ride for the traveling public, greatly minimize future creep camber, and provide a durable structure," Chandra says. It was the second use of monolithic design in the country and provided a new approach that produced smoother riding surfaces.

PB returned to one of its earlier successes in the mid-1980s with the redesigned new Sunshine Skyway Bridge. It built on the innovations of the first structure by designing piles, piers, and superstructure of the low-level approaches to resist ship impact forces. This was unprecedented at the time as ship impact design was only performed for the piers adjacent to the navigation channel.

The company was part of the design-build team for the Arthur Ravenol, Jr. Bridge across the Cooper River at Charleston, South Carolina. This bridge was the most complex project ever completed by the South Carolina Department of Transportation. The 3-mile-long crossing includes two interchanges, two high-level approaches, and a cable-stayed main span. A 100-year service life was an important design criteria for the cast-in-place and precast concrete.

New Markets and Technologies

"Repair and investigative analysis is becoming a larger part of the market, as more designers understand the need to strengthen what is already in place," Chandra says. The firm took such measures when it undertook one of its most recent high-profile projects—the Central Artery/Tunnel (CA/T) Project in Boston from 1996 to 2004. The massive project included a wide range of bridges, with innovations incorporated in small-, medium-, and long-span bridges.

The PB/Bechtel team design was the first to use the newly developed New England bulb-tee girder for some of the structures. Specialized techniques for integrating precast segmental box elements into the piers, as well as saw-



James River Bridge
Photo: ©PB.

'Durability is a key reason that we look at concrete designs.'

cutting precast segmental box elements to join them to straddle bents, were developed.

"We took on the challenge of doing extensive analysis and inspections for these bridges to avoid any problems with post-tensioning and took corrective and protective measures, when necessary. We have since used these evaluation techniques with other projects," he says. The evaluation approach is being used on the recent Jamestown Bridge in Rhode Island.

Concrete bridges offer a lot of benefits in a variety of situations, he says. "Durability is a key reason that we look at concrete designs for specific bridges. In addition, concrete can be used for longer span bridges that we can design and erect very quickly."

Aesthetics also are growing in importance, he notes, a goal that concrete designs can help meet. "There is more regard for aesthetics today in many communities, and we are paying more attention to it," he says. Greater input is being seen by local citizens particularly for longer, high-profile bridges, he notes. "We are starting to see many more context-sensitive designs being used, and we have focused a lot of attention on creating harmony by balancing the design with its surroundings through a unique design or by fitting it to the surrounding environment."

PB continues to expand its capabilities with concrete bridges and is keeping a close eye on new technologies. It was one of the first engineering firms in the mid-1970s to replace ½-in.-diameter prestressing strands in bridges with the 0.6-in. size. "We were looking to create spans as long as 110 to 115 ft," he explains. "So we developed new beam types and used the larger strands to reduce the total number of strands while keeping the same spacing required for a ½-in. strand." The approach saved about 15 percent in costs, he notes.

Today, research is proving that the design was a cost-effective method. "The research is showing that we were

right in our analysis, and that's great," he says. "The use of 0.6-in.-diameter strands will add more opportunities for concrete designs."

PB has extensive design experience with cast-in-place and precast concrete segmental box girder bridges and has supported the development of new post-tensioning techniques, especially related to grouting applications. "Prepacked grout, in particular, has great application potential and will speed up the construction process," he says.

Many of the bridges on the Boston Central Artery/Tunnel project used segmental construction.
Photo: ©PB.





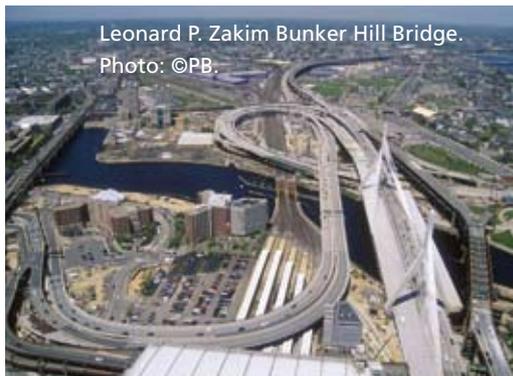
The Ocean City-Longport Bridge, N.J., included three-span continuous units made from modified AASHTO Type VI 90-in.-deep spliced post-tensioned girders with a maximum span length of 222 ft. Photo: ©PB.

Throughout its history, PB has won many awards for its innovative bridge designs. Most recently, it won three awards in the 2007 PCI Bridge Design Awards competition. One award for Best Bridge with Spans less than 75 ft (Route 10 Bridge over Mink Creek, New Hampshire) and two awards for the Best Bridge with Spans over 150 ft (Arthur Ravenel, Jr. Bridge, Charleston, South Carolina and the I-10 Bridge over Escambia Bay, Florida). These bridges uniquely demonstrate the versatility of PB.

“We expect to see self-consolidating concrete used more often in the next four to five years,” Chandra says. His interest in the material was piqued during the CA/T project, when a precaster elected to use a rejected rebar cage for a segmental box girder to evaluate the use of self-consolidating concrete. “It was a complex cage that had mistakes, so the precaster used it to see how self-consolidating concrete would work in a highly congested reinforcement system,” he explains.

The result was an excellent concrete component. “He didn’t touch it up at all, and it looked great,” he reports. “The best part is that, in using it, you don’t have to sequence the placement or vibrate the forms to ensure they are completely filled. The concrete flows even into congested corners quickly with hardly any blemishes and no trapped air voids.” That will save considerable time and cost as honeycombing and voids are eliminated—and the assurance that they are not present, saves even more time in inspection and improves reliability.

“The level of confidence I have is very high that it doesn’t need to be re-worked and will save cost while adding durability. Currently, general specifications for the material that we can rely on are lacking. When that is settled and people have gained confidence in its use, I expect we’ll see it being use more often. We’ll certainly go for it.”



Leonard P. Zakim Bunker Hill Bridge. Photo: ©PB.

Self-Consolidating Concrete

Self-consolidating concrete also is becoming a key material that PB expects to see grow in usage. The concrete mix incorporates higher proportions of fine aggregate and a high-range water-reducing admixture, which significantly increase the material’s workability and fluidity. As a result, it flows quickly into place, fills every corner of a form, and surrounds even densely packed reinforcement—all with little or no vibrating of the concrete.

‘We expect to see self-consolidating concrete used more often.’

PB led the joint venture responsible for preliminary and final design of the Keehi Interchange near Honolulu International Airport. Photo: ©David Sailors.



The bridge industry is on the cusp of accepting the material for specific applications. Had it been available in the mid-1990s, I certainly would have been interested in its capabilities for helping with construction on the CA/T project. I know the FHWA is very enthusiastic about it, and I share their enthusiasm. I think it will be a good product."

Lightweight Concrete to Grow

Chandra also has his eye on the advances being made in lightweight concrete. It was used on the Leonard P. Zakim Bunker Hill Bridge, a cable-stayed structure over the Charles River in Boston. It also was used on the recently constructed Mattaponi River spliced-girder bridge in West Point for the Virginia Department of Transportation. Lightweight concrete was used in both the precast, prestressed concrete girders and the cast-in-place concrete deck.

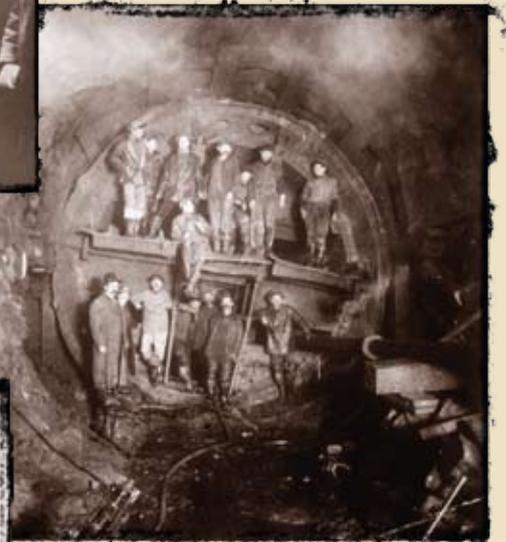
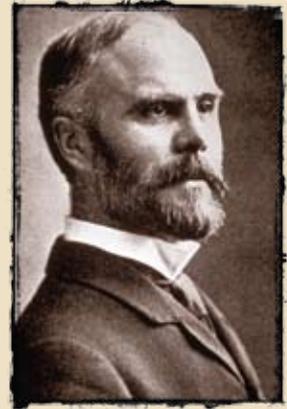
"Lightweight concrete has potential, but you have to look carefully at the conditions and the situation to ensure that the reduced weight will provide a strong benefit, as otherwise it can be an expensive approach," he says. "Spliced-girder bridges and cantilevered designs, such as at the Zakim Bridge, offer good opportunities, because we could offset the weight of the cantilever by using lightweight concrete."

As these concepts become more familiar and new ideas enter the market, PB undoubtedly will be evaluating their capabilities. "We have been at the forefront of technology, and we expect to continue to be there," he says. "We hope that the advancements that we've been a part of have helped to shape the concrete bridge industry and will be a catalyst for future innovations."

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

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His second major project was to chart the 1,000-mile railroad from Hankow to Canton, China, establishing the firm's global reach early in Parsons' career.

Pioneering highway engineer Henry M. Brinckerhoff became a partner in 1906, bringing his expertise in electric railways—and his invention of the third rail—to the firm. He designed the network of roads at the 1939 World's Fair in New York

After many iterations of its name due to partners being added and subtracted over the years, the firm became known as Parsons Brinckerhoff Quade & Douglas, Inc., in 1960. In 2006, the company and its worldwide subsidiaries became officially known as PB.

Today, PB provides comprehensive services for all types of infrastructure projects, including power, buildings, environment, and telecommunications. It works in 80 countries around the world through a staff of nearly 10,500 people in 150 offices from Boston to Beijing.

Photos: ©PB.



HAMILTON FORM CREATES FUNCTION

2

CASE STUDY

ESCAMBIA BAY BRIDGE



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*Don Theobald
Vice President of Engineering
Gulf Coast Pre-Stress*



The Challenge:

Gulf Coast Pre-Stress — which itself was reeling from Katrina's impact — was awarded four major bridge projects damaged by hurricanes, including Escambia Bay Bridge near Pensacola, Florida.

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PTI's bridge activities include:

- *6th Edition of the Post-Tensioning Manual*—this major update includes two new chapters on bridges and stay cables.
- *Grouting Specification*—developed by PTI's Grouting Committee, this new specification represents a major advance in post-tensioned construction.
- *Recommendations for Stay Cable Design, Testing and Installation*—these recommendations serve as the standard for cable-stayed bridge construction around the world.
- *Certification – Bonded Tendon Installation*—this comprehensive training and certification program is intended for all field personnel involved in the installation of bonded post-tensioning, including installers, inspectors, and construction managers.

The *PT Journal* is published semiannually and often includes papers on durability and bridge design. PTI also sponsors an annual technical conference to showcase the latest in post-tensioning technology.

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 Long Beach, CA 90805
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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.

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.

Completion of four lines of girders for Stage 1.



'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.

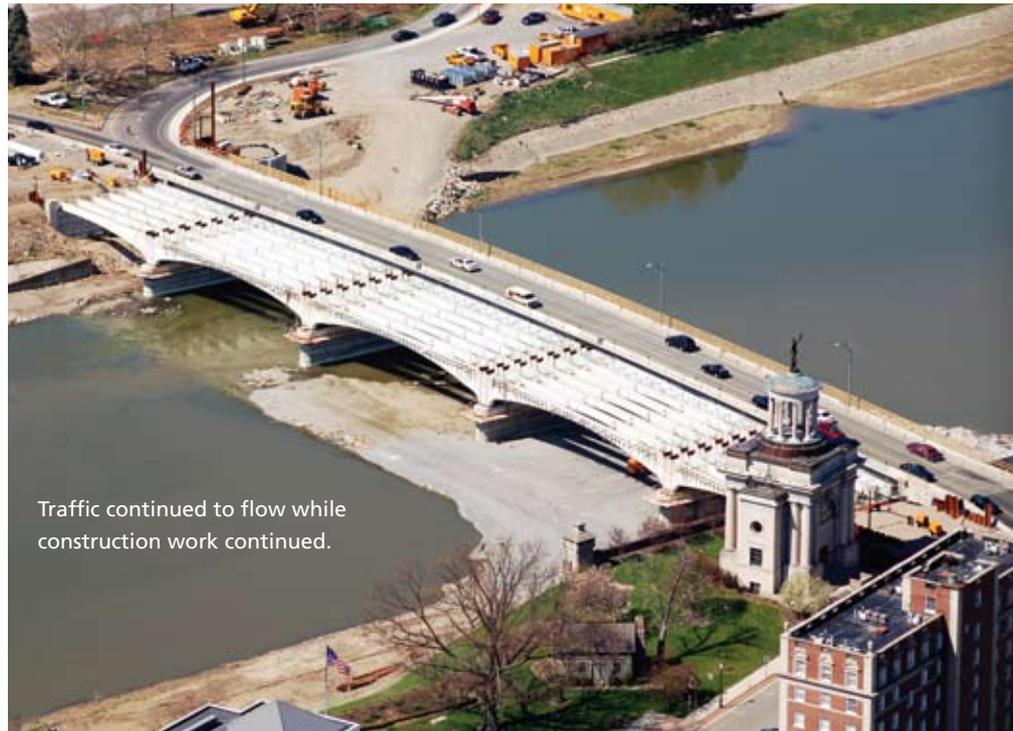
The massive wall-type piers and counterfort abutments with substantial pile foundations were considered as rigid supports in the modeling of the superstructure. Elastomeric bearings were modeled using appropriate spring constants.

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

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



Traffic continued to flow while construction work continued.

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 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.

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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.

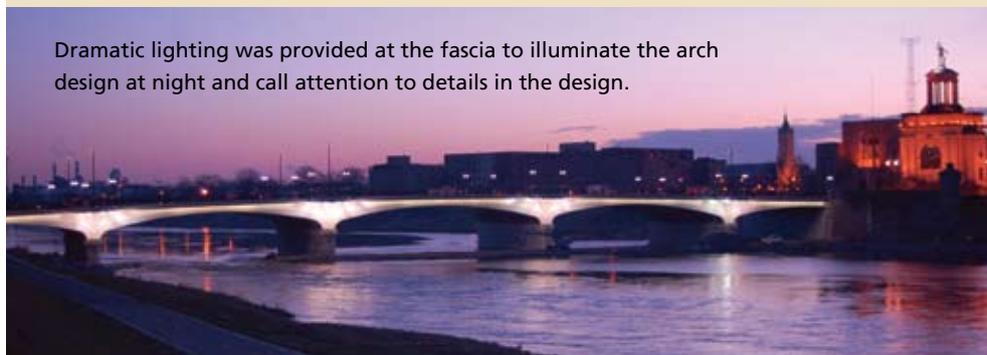
Normally in a situation like this, it is preferable to develop a contemporary bridge design fitting the historical and monumental context of the site. However, it is not uncommon for communities to insist, as in this case, on a more traditional structure. So, the design team resolved to use the best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



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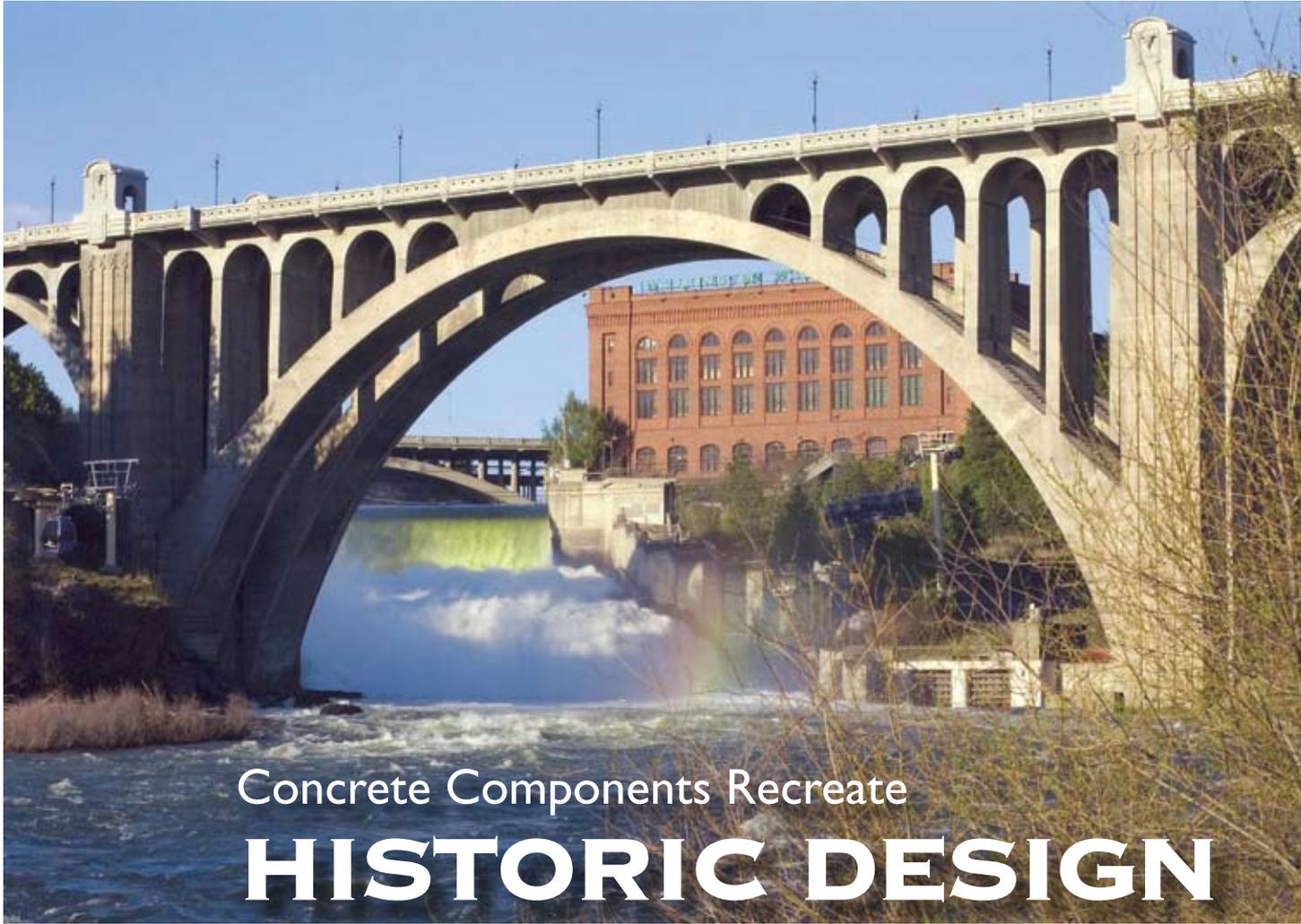


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Concrete Components Recreate **HISTORIC DESIGN**

by Leora Casey, David Evans and Associates, Inc.



The replicated railings were created with precast concrete and connected with cast-in-place concrete posts.

The Monroe Street Bridge in downtown Spokane, Wash., has provided a critical north-south traffic link within the city since 1911. At almost a century old, the bridge was near the end of its useful life when a rehabilitation project was launched in 2001. The project posed a number of significant challenges due to historic preservation requirements, environmental concerns, and the functional aspects of replacing a bridge that spans a 136-ft-deep river gorge. The project designers used a

combination of precast and cast-in-place concrete components to meet these requirements.

The existing design featured a three-span concrete arch structure with reinforced concrete approaches. The total length is 896 ft with a main river span of 281 ft and two side spans of 120 ft. Four original pavilions over the sidewalks at the main piers projected into the travel lanes and had been damaged repeatedly by vehicle impacts.

profile

MONROE STREET BRIDGE / SPOKANE, WASHINGTON

ENGINEER: David Evans and Associates, Inc., Salem, Ore., and Spokane, Wash.

PRIME CONTRACTOR: Wildish Standard Paving, Eugene, Ore.

CAST-IN-PLACE CONCRETE SUPPLIER: Central Pre-Mix Concrete Co., Spokane, Wash.

AWARDS: 2003 Honor Award, Historic Preservation, American Planning Association, Washington Chapter; 2006 Gold Award for Engineering Excellence, American Council of Engineering Companies, Washington; and 2006 PCI Design Award, Best Rehabilitated Bridge

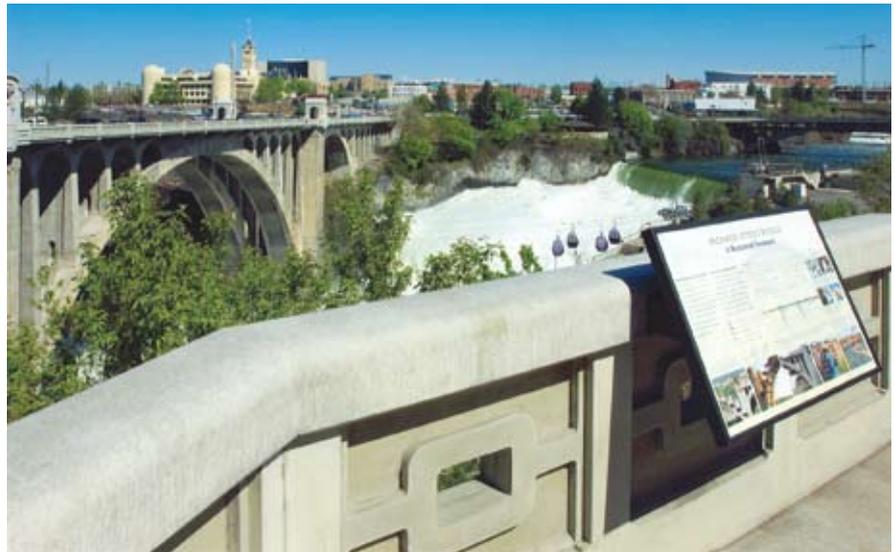
Precast, prestressed concrete panels and railings combine with cast-in-place superstructure on historic Spokane bridge

Historic plaques were attached to alcoves provided at key overlooks to highlight the historic nature of the bridge.

A study of the bridge's condition found that the superstructure was in very poor condition. As a result, city officials began a major 5-year, \$18-million project to preserve this historic city landmark, which is used by an estimated 25,000 vehicles daily, plus bicycles and pedestrians. The essence of the program involved replacing the entire deck system, the spandrel arches, and columns down to the main arches, and the viaduct on the north end of the bridge. It also included moving the pavilions away from the roadway and repairing other damage throughout the bridge.

A key element of the project was to ensure this work maintained the historic features and extended the useful life of the bridge by at least 75 years. A 20-year option, which would have required minimal work, was also considered but the city leaders decided that a longer-term perspective was required.

The project presented several challenges for the design team, including multiple agency coordination, historic preservation, strict environmental requirements, unusual construction details, deteriorating conditions, traffic management, and safety. The designers held a number of meetings and received feedback from citizen groups of various kinds. This helped produce a realistic design and construction plan for successful rehabilitation, while maintaining the important historical integrity of the bridge.



'The design needed to meet federal and state requirements to secure funding.'

Because of the historic nature of the bridge, the design needed to meet federal and state requirements to secure funding from these agencies. The design team worked closely with the State Historical Preservation Office and the local Landmarks Commission to determine the best ways to meet traffic-safety requirements and provide economical construction. This process showed that the use of precast, prestressed concrete for the sub-deck structural system and precast concrete for the historically significant pedestrian railing were the best option.

Six Systems Considered

Six deck-system alternatives with varying span lengths and topping combinations were evaluated. The selected option features a cast-in-place deck made integral with 408 precast, prestressed concrete sub-deck panels and 1776 ft of historic railing reproductions. The deck panels were 19.6 ft long, 4 ft wide, and 12 in. deep, with a 5-in.-thick, cast-in-place concrete topping. This choice was based on cost, ease of erection, and serviceability. The spandrel arches, columns, and crossbeams were made from cast-in-place concrete to maintain

THREE-SPAN CONCRETE ARCH / CITY OF SPOKANE, OWNER

BRIDGE DESCRIPTION: Rehabilitation of a three-span concrete arch with a total length of 896 ft and a main span of 281 ft using a combination of precast and cast-in-place concrete components

PRECASTER: Central Pre-Mix Prestress Co., Spokane, Wash., a PCI-Certified Producer

STRUCTURAL COMPONENTS: Cast-in-place concrete spandrel arches, columns, and crossbeams; precast, prestressed concrete sub-deck panels; precast concrete railings; and cast-in-place concrete deck

BRIDGE CONSTRUCTION COST: \$13.3 million

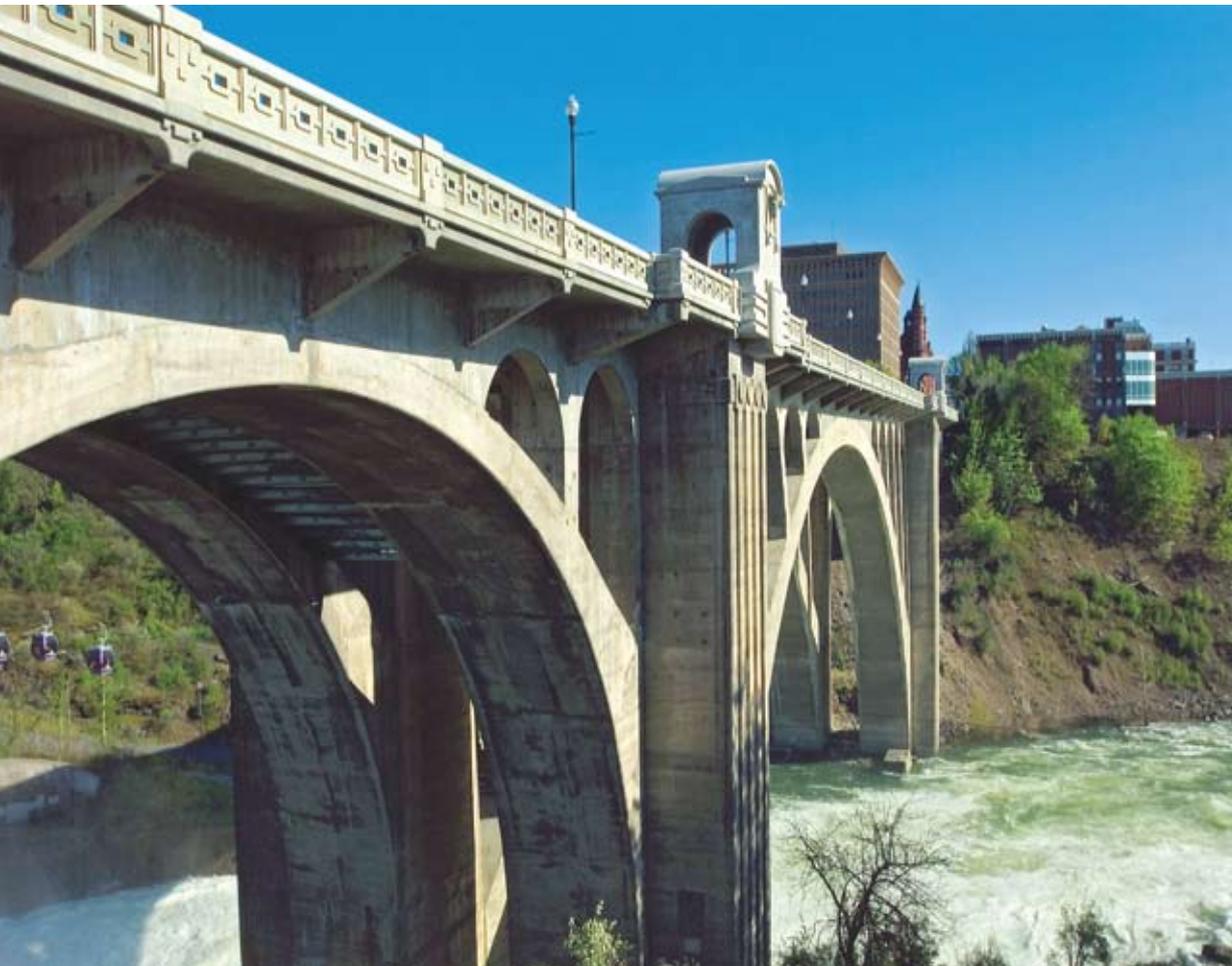
the historical integrity. The new superstructure was designed to allow future widening from four lanes to six.

The precast, prestressed concrete sub-deck system was a great benefit to the contractor due to the relatively inaccessible location. Its use allowed heavy equipment to travel out on the deck earlier than other options, thereby, accelerating the construction.

The ornamental railings on the bridge incorporate an intricate, historically significant "chain" motif. Precasting these elements was readily recognized as the best choice to attain a consistently accurate and high-quality replication of the original railing as well as helping to meet the schedule. The railing sections were cast upside down in metal forms to achieve an extremely smooth handhold top surface.



The precast, prestressed concrete sub-deck system allowed heavy equipment to travel out onto the deck early and accelerated construction.



The Monroe Street Bridge in Spokane, Wash., was rehabilitated with cast-in-place concrete spandrel arches, columns, and crossbeams; precast, prestressed concrete sub-deck panels; precast concrete railings; and a cast-in-place concrete deck.



Decorative pavilions were placed above the piers out of the line of the roadway to add visual interest to the design and replicate the original pavilions.

Self-consolidating concrete created smooth surfaces and substantially reduced voids.

The project included a spectacular overlook of the bridge and Spokane Falls, because of federal funding requirements for historical project-impact mitigation. Alcoves were provided along the walk. Historical information displays attached to the alcoves emphasize the historical nature of the area. Precast concrete railings, using essentially the same design and construction process as those on the bridge, formed the most visible part of this project element. The overlook railing visually tied this observation area to the bridge and helped convey the massive, solid nature of the concrete bridge construction.

The innovative design for the cast-in-place high performance concrete deck, which included a state-of-the-art silica fume mix, led to funding and testing/monitoring participation by federal agencies. Funding for the deck system

was secured under the Innovative Bridge Research and Construction program, administered by the Federal Highway Administration. Ongoing monitoring and testing will be performed until January 2008.

Four precast concrete pavilions were created above the piers, replicating the design of the original pieces but located entirely on the pedestrian walkway and out of the roadway. The pavilions have interior lighting to provide additional safety for pedestrians and visual interest from afar.

Rehabilitating the bridge was made more challenging because there were no detailed plans available, and component dimensions had to be verified in the field. In several areas, poor quality concrete and little reinforcement required more demolition and reconstruction than originally anticipated. Even so, the combination of good engineering planning and close cooperation with well-qualified contractors and subcontractors resulted in a project that cost only \$13.3 million, which was \$2 million below the original estimate. The construction period was only slightly longer than the anticipated 2½-year schedule. The new bridge opened to traffic in September 2005 to great fanfare, with a 3-day city celebration that ended with a spectacular fireworks display.



Precast concrete panels were used to replace the existing sub-deck.

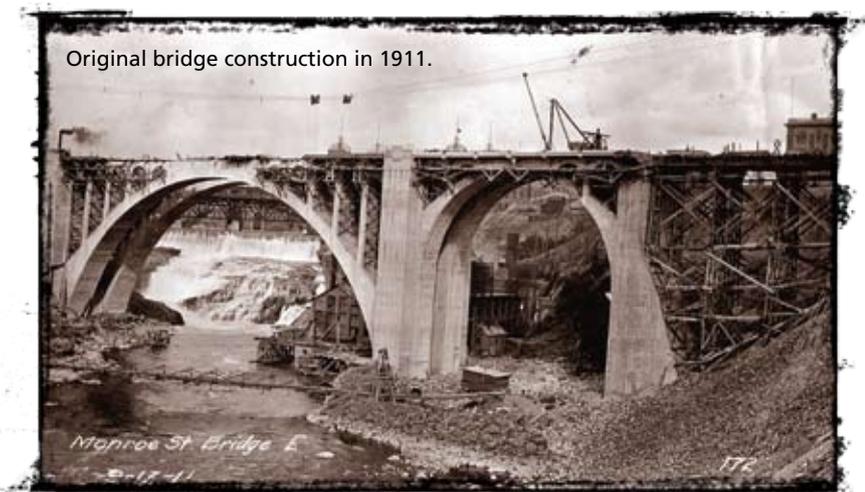
Self-Consolidating Concrete

Self-consolidating concrete was used in the intricate formwork to assist in creating smooth surfaces and substantially reducing voids. The rail components, which varied in length from 16 to 18 ft, were plant cast and stored for delivery to the construction site as each particular piece was required. Cast-in-place posts joined the railing segments to provide the final historical match.

The Monroe Street rehabilitation project is now viewed by the agencies and the citizens alike as a resounding success, and an example that others can follow for rehabilitating older, historical structures. The project approach assured that this National Historic Landmark will remain a key part of the city's transportation system as well as a historical and scenic focal point for citizens and visitors alike.

Leora Casey is Business Development Manager with David Evans and Associates, Inc., Salem, Ore.

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



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*Bridge-Brick is a term coined by Scott System to define the use of thin brick in bridge work.



The elevated roadway near Brandon uses colors reflective of the more natural environment, landscaping, and water features found in the area. Photos: ©FIGG

Construction of the elevated roadways was within the existing at-grade median, allowing toll paying customers on the expressway to travel freely during rush hours.

AN ELEGANT, ELEVATED, ELECTRONIC SOLUTION **TO URBAN CONGESTION**

by Martin Stone, Tampa-Hillsborough Expressway Authority and Jose Rodriguez, FIGG

Precast concrete elevated tollway drastically reduces travel times

In 2006, events across the United States celebrated the 50th anniversary of the Interstate system—Eisenhower’s bold vision to solve logistic and economic issues of the 1950s. That transportation challenge was met with a powerful mobility plan that created a new system of highways to connect people, deliver goods and services, and improve the quality of life across the United States. Fast forward to today. Our cities have grown and the demands on our roadway system, including many of our interstate highways, require expansion to meet capacity needs.

Many roadways are faced with failing levels of service and gridlock rules the day for far more hours than ever envisioned. Development has closed in on the boundaries of the existing roadway rights-of-way, prohibiting

at-grade expansion from being available at any cost. One solution to provide the next generation of capacity in existing corridors, within existing right-of-way, is to create elevated roadways along the median. This offers the opportunity to double traffic capacity without the expense of right-of-way acquisition.

This common sense transportation solution addresses urban congestion by combining the innovations of precast concrete segmental bridges, reversible express lanes, cashless open road tolling, and full electronic controls. The revolutionary “six lanes in six feet” freeway was designed by FIGG and constructed within the 46-ft-wide median of the at-grade existing Lee Roy Selmon Crosstown Expressway, saving the costly acquisition of expensive, urban right-of-way, while reserving the

profile

LEE ROY SELMON CROSSTOWN EXPRESSWAY / HILLSBOROUGH COUNTY, FLORIDA

ENGINEER AND CONSTRUCTION ENGINEERING INSPECTION: FIGG, Tallahassee, Fla.

PRIME CONTRACTOR: PCL Civil Constructors, Inc., Tampa, Fla.

CONCRETE SUPPLIER FOR CAST-IN-PLACE AND PRECAST CONCRETE: CEMEX, Tampa, Fla.

POST-TENSIONING SUPPLIER: VSL, Hanover, Md.

AWARDS: *The project has received awards or recognition from six organizations.*



remaining median for future at-grade expansion. The expansion provides three lanes toward Tampa in the morning peak rush hour and three lanes out of Tampa, into the rapidly growing suburb of Brandon, in the afternoon peak commuter hours. During midday, a central segment is closed and the

Tampa and Brandon segments operate independently in a direction that optimizes local traffic circulation. The elevated lanes are limited to use by cars and buses, leaving truck traffic to the at-grade lanes. The current toll rate is \$1.50 for a passenger vehicle and entry is free flowing as tolls are collected

electronically via in-vehicle transponders or with license plate recognition.

The opening of the elevated lanes has provided a spectacular reduction in congestion and increased the ease of commuters' daily travel. Previous speeds of less than 15 mph in the peak hours

PRECAST CONCRETE SEGMENTAL BRIDGE / TAMPA-HILLSBOROUGH EXPRESSWAY AUTHORITY, FLA., OWNER

BRIDGE DESCRIPTION: Precast concrete segmental single cell box girder erected using the span-by-span method

SUPERSTRUCTURE FORMWORK: Southern Forms, Guild, Tenn.

SUBSTRUCTURE FORMWORK: EFCO, Orlando, Fla.

STRUCTURAL COMPONENTS: 3023 concrete segments in 196 spans with a typical span length of 142 ft

BRIDGE CONSTRUCTION COST: \$120 million

rose to free-flow speeds of about 60 mph, translating into one full hour of round-trip travel timesavings for some commuters. The elevated lanes were efficient to construct, had the least environmental impacts, allowed at-grade traffic to remain in operation, were built in the existing right-of-way, and improved economic development in both Tampa and Brandon.

Now, less than a year since opening to traffic, the reversible elevated lanes of this new expressway are carrying traffic volumes that exceed forecasts by 25 percent, bringing the Tampa-Hillsborough Expressway Authority, which owns the Crosstown, a good return on their investment, while the newly expanded highway has also served as a major impetus for the renaissance of the Channelside area of Tampa. Forecasts for the first year of operation pegged ridership at 12,500 vehicles per day. By March of 2007, traffic on the elevated lanes was already exceeding 16,000 vehicles per day.



Precast concrete segments, 59-ft-wide and weighing 70 tons, were cast in a nearby facility, then delivered to the site for erection. Erection activities were timed to allow rush hour traffic on the at-grade lanes to move freely.

Looking Backward and Moving Upward

Through the Tampa region's rapid growth, the Crosstown Expressway volume more than doubled from 13.1 million tolling transactions in 1982 to 30.2 million transactions in 2002, resulting in severe congestion for thousands of commuters coming into Tampa from the eastern suburbs. Commuter traffic frequently

'Minimal environmental impacts also sped approvals.'

translates into highly directional percentage splits and this holds true in Tampa, with more than a 75:25 split during the peak hours. Additionally, almost 80 percent of all of the daily traffic occurs during the morning and afternoon commuting peak periods.

It was clear early in the planning stages that a reversible lane project would address commuters' needs, allowing the Authority to build just one facility that would serve double duty. The next challenge was to determine how to expand within a congested corridor that had developed around the Expressway. Acquiring right-of-way was prohibitively expensive and in many areas, not available at any price; thereby, restricting the Authority to the existing footprint. Elevating the roadway within the existing median and right-of-way provided the answer to expanding in a financially feasible manner.

The majority of the project is a three-lane precast concrete segmental bridge, founded on 6-ft-wide piers, to provide six lanes of capacity; thus, "six lanes in six feet." The public in Tampa reacted favorably during the planning stages of the project, readily endorsing a solution for easing gridlock and supporting the pleasing aesthetics of the project, along with the extensive gateways planned for each terminus. Minimal environmental impacts also sped approvals and the

project was bid to begin construction in June 2002. The low bid, offered by PCL Civil Constructors, Inc., was approximately \$65 per sq ft, far below the average cost for all bridges built in Florida during the past 20 years. A total of 17.5 lane-miles was constructed at approximately \$120 million, translating into \$7 million per lane-mile. Costs for the entire project, including extensive development at both gateways; the Traffic Management Center, which includes new offices for the Authority; major at-grade improvements; and the elevated lane construction were approximately \$420 million.

Gigantic Legos

Because of the unique characteristics related to building precast concrete segmental bridges, the media often used the term "legos" to describe the construction technology and the quick, systematic assembly of this highly visible project. Segments for the elevated expansion were precast in a facility established in the Port of Tampa, just a few miles from the site. A total of 3023 concrete segments were cast in 24 months, utilizing 11 casting cells. On average, 46 segments were match cast each week (40 typical segments and six pier or expansion joint segments). Concurrent with the off-site casting operations, drilled shafts for the foundations and cast-in-place piers were being constructed in the median.



In several areas, where access was limited, segments were delivered over the already completed sections of the elevated roadway—building the new roadway from the top.

Match casting of the segments ensured that they would fit together precisely once on-site for erection. The reinforcing cage is being lowered into one of the 11 casting cells used for the project.

Span-by-span construction was used to erect the 59-ft-wide, 70-ton segments, which were delivered during non-peak traffic hours in order to maintain traffic on the existing expressway. In areas where access was limited, precast segments were delivered over completed sections of the elevated lanes. A steel truss was used to temporarily support the segments, allowing for post-tensioning of the typical 142-ft-long spans while traffic below moved freely. Once an entire span was stressed with post-tensioning strands, the structure became self-supporting and the truss was launched forward to repeat the operation for the next span. This led to fast, efficient erection that proved to be seamless for the traveling public as the contractor achieved an average erection rate of two spans per week. During the month of March 2004, 2400 linear ft of bridge was completed. And, this was all accomplished with no interruption to rush hour traffic.

Of key importance during design was that drivers utilizing the original at grade expressway lanes feel comfortable with the elevated lanes in close proximity. The use of precast concrete provided the opportunity to create a sculpted rounded, smooth bridge structure that is visually appealing to the traffic below, as well as for the areas outside the right-of-way. This was also accomplished through the use of light surface sealants with tint and an alternating color used as an inset to the pier to create additional perceived height of the structure.

A special feature of the box shape is that the at-grade driver views only half of the smooth structure underside,

In one month, 2400 linear ft of bridge were erected.



'On average, 46 segments were match cast each week.'

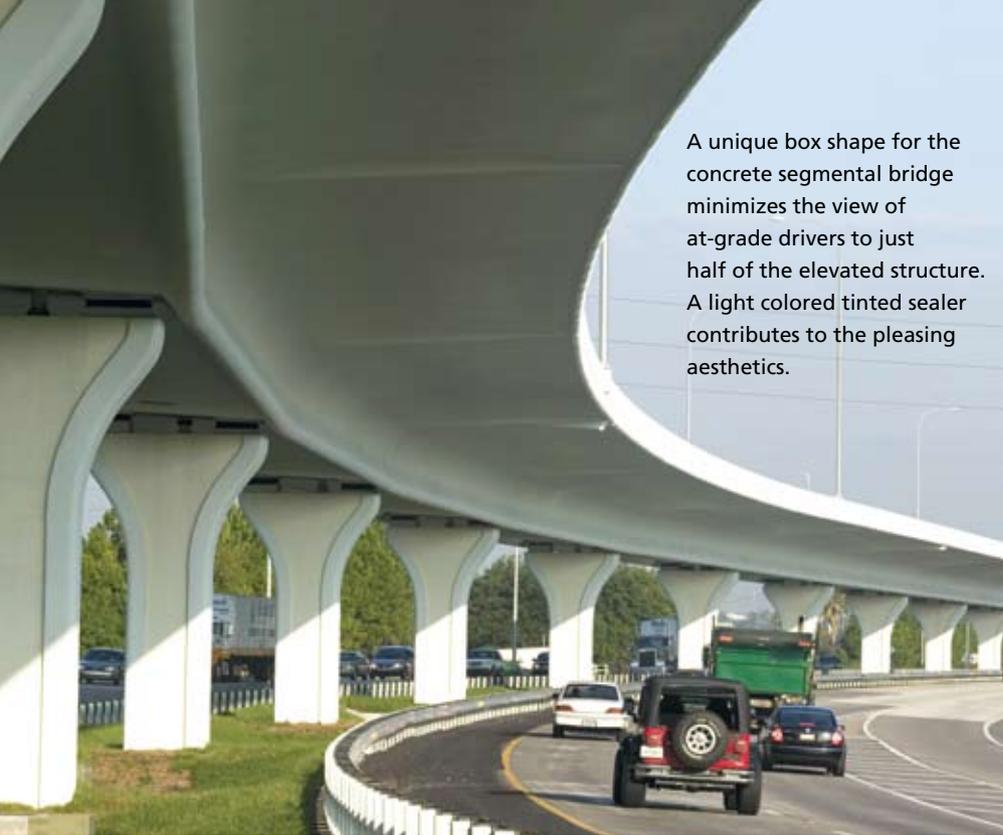
limiting the structure's visual size. The resulting perception of those traveling at grade is a streamlined, aesthetically pleasing structure. With two sections of elevated lanes, totaling more than 5 miles in length, different color schemes were developed, appropriate to each setting. The more urban bridge, nearing downtown Tampa, has a very light blue-white overall tinted sealer, with a tan inset to the piers; while the Gateway Bridge, closer to Brandon, uses a very light colored tint on the overall bridge, with a metallic blue inset on the piers—reflective of the more natural environment, landscaping, and water features found in the area. All drainage from the elevated lanes is internal to the piers, keeping the structure lines very clean.

Gateways

In addition to efficiently increasing the volume of traffic that could be moved through the corridor, it was important to

address the disbursement of that traffic at the terminal gateways. The gateways are new entrances to both downtown Tampa and Brandon. Urban aesthetics with extensive landscaping, signage, and other features were planned to enhance the respective neighborhoods. In Brandon, scenic landscaping, a winding off-road recreational trail for walking and cycling, along with numerous sites for resting, relaxing, and enjoying the environment have enhanced property values and added to the community.

At the downtown terminus, Meridian Avenue has been transformed from a two-lane street through an aging industrial district to a modern six-lane urban thoroughfare. A \$50 million investment in the city included urban aesthetics that created a visually stimulating and exciting pedestrian-friendly walkway, which spurred approximately \$1 billion in new residential and commercial development. The Authority also consolidated traffic management operations for the city and expressway under one roof, with state-of-the-art software to safely control traffic operations and provide efficient emergency response, when necessary.



A unique box shape for the concrete segmental bridge minimizes the view of at-grade drivers to just half of the elevated structure. A light colored tinted sealer contributes to the pleasing aesthetics.

The Results

The end results are a beautiful new parkway, community asset gateways at both downtown Tampa and Brandon, positive economic growth driven by the infrastructure development, decreased commuter timeframes—all positive, direct benefits to residents and visitors in the greater Tampa area. The bottom line is impressive. Prior to opening the elevated lanes, morning drive times from the Brandon area to downtown averaged between 30 and 40 minutes. With the opening of the new elevated lanes, average drive time is now just 10 minutes or less. Safety has increased with the diversion of trucks to the at-grade lanes and the elimination of merging traffic with limited access ramps. More than 110,000 trips per month were added to the system after full operations were achieved in January 2007. These additional expressway trips represent

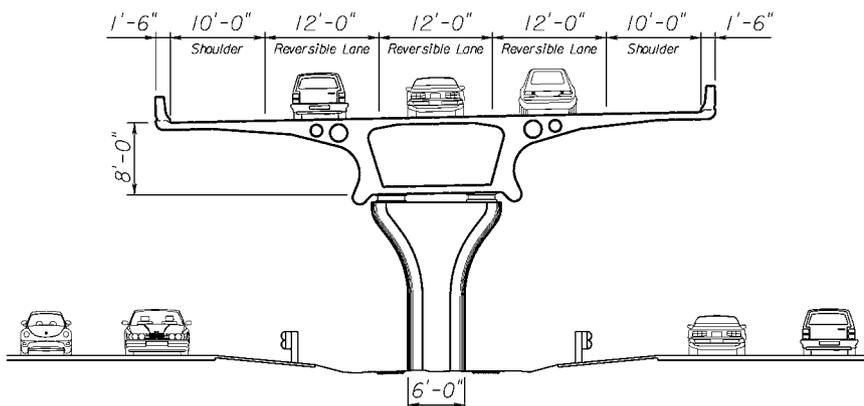
Free-Flow Tolling

During planning, it was recognized that traffic needed to be as free flowing as possible, while minimizing the labor to collect tolls. The elevated lanes are the first Florida transportation project to utilize totally cashless Open Road Tolling. It is also the first application of free-flow tolling in the statewide SunPass™ system that is wider than two lanes. Video toll collection was added to allow open access to all users, with or without a transponder. The Toll-by-Plate program creates a unique Video Toll Account (VTA) for occasional users, who may call a special toll-free number prior to

entering the elevated lanes, or up to 72 hours afterwards, to register for a VTA. Users with a credit card provide their license number to receive either a limited time use of the facility or an on-going VTA, which requires only a minimum \$5 balance in a prepaid account. By providing a variety of payment options, both prior to and following use of the system, the Authority focuses their enforcement resources on those who intentionally and repeatedly refuse to pay tolls, reducing mistaken violations and increasing net revenues.



The Lee Roy Selmon Crosstown Expressway is the first transportation project in Florida to use Open Road Tolling—a totally cashless system. Tolls are collected electronically with the statewide SunPass™ system or the Toll-by-Plate program.



“Six lanes in six feet” With the pier base just 6 ft wide in the existing median, the reversible elevated lanes provide six lanes of capacity.

diversions from local parallel nontolled highways, which improve the mobility of the entire local transportation network. Public transit service from Brandon to downtown Tampa has experienced a ridership increase of over 40 percent on two express routes, now that the buses truly do travel at express rates of speed, resulting in two additional successful express routes on the elevated lanes.

Martin Stone is Planning Director with the Tampa-Hillsborough Expressway Authority and Jose Rodriguez is Senior Project Director with FIGG.

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

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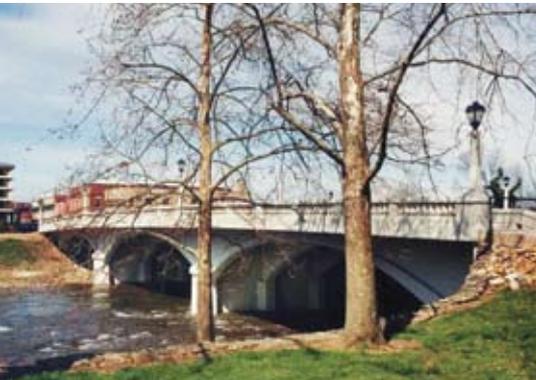
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Saving A Piece Of History

by Edward P. Wasserman,
Tennessee Department of
Transportation



As a result of its restoration,
the bridge can now carry all
legal loads. All photos: TDOT

In 1926, the town of Elizabethton, in Carter County, Tennessee, proudly cut the ribbon to open a newly completed concrete bridge, the Elk Avenue Bridge over the Doe River, just downstream from its only other river crossing, a covered timber bridge, built in 1882. The beautifully ornate bridge has stood just off the town square for over 80 years, surrounded by buildings dating from the 1700s to the 1930s.

By the late 1990s, the bridge had begun to suffer the affects of its age and lack of maintenance. It was required to be weight restricted and subsequently became a candidate for replacement under the Federal Highway Rehabilitation and Replacement

Program. However, during discussions with the local government and citizens, it became apparent that there was a strong desire to save this treasure. The Tennessee Department of Transportation (TDOT) agreed.

The Elk Avenue Bridge is a classic example of a reinforced concrete fixed arch design developed by Daniel B. Luten, a 1894 graduate in Civil Engineering from the University of Michigan. Later, moving to Purdue University as an instructor, Luten was one of the leading United States proponents of using steel bar reinforcement in concrete arch construction in order to maximize structural efficiency and minimize cost.

profile

ELK AVENUE-DOE RIVER BRIDGE / ELIZABETHTON, TENNESSEE

ENGINEER: Division of Structures, Tennessee Department of Transportation

PRIME CONTRACTOR: General Constructors, Elizabethton, Tenn.

CONCRETE SUPPLIER: Summer-Taylor Construction Company, Elizabethton, Tenn.

AWARDS: Award of Excellence, PCA 2006 Tenth Biennial Bridge Awards Competition

Reconstruction of a 1926 reinforced concrete arch bridge



Whereas many structural engineers of the day preferred to design arches using either steel bar mesh or structural shapes embedded in a cement and sand mortar mix to carry the stresses, Luten recognized the greater potential of structural concrete using sand, stone, and cement. He transformed arch construction by introducing the concept whereby steel bars provided a maximum of tension reinforcement and a minimum of compression reinforcement, allowing the concrete to serve as the main structural member resisting compressive stresses.

The Elk Avenue Bridge is one of only 1000 left, out of approximately 12,000 Luten bridges constructed. This particular one was designed and constructed by the Luten Bridge Company of Knoxville, Tennessee, one of several regional bridge companies established by Luten. The structure is a three-span arch with closed spandrel walls. Seven arch ribs support a 54-ft-wide roadway and two 12-ft-wide sidewalks on the 1-ft-thick concrete deck. Each span has a nominal length of 78 ft and a rise of 10 ft from the spring line.

A field inspection was undertaken to supplement the numerous biennial inspections that had previously been carried out under the National Bridge Inspection Standards. Limited cores were taken from the deck and indicated an average concrete compressive strength of about 3500 psi. Hands-on inspection in areas of evident deterioration as well as hammer soundings were used in order to quantify and characterize the type of repairs that would be required. Inspection was followed by a study of the details of construction, as well as limited analysis, to confirm to the

REINFORCED CONCRETE FIXED ARCH / CITY OF ELIZABETHTON, TENN., OWNER

BRIDGE DESCRIPTION: Three span arch with closed spandrel walls

STRUCTURAL COMPONENTS: Seven arch ribs with a span lengths of 78 ft supporting a 1-ft-thick concrete deck

BRIDGE REPAIR COST: Superstructure \$506,000; Substructure \$125,000

TDOT's satisfaction, that the bridge was indeed designed and constructed as a deck arch and not as a T-beam system. The existing reinforcement was square deformed bar and was assumed to be ASTM A 15-14 with allowable service load stress of 16,000 psi.

The general plan for rehabilitation called for complete closure of the bridge and then staged partial- and full-depth slab removal as well as removal and replacement of sections of the arch ribs in selected areas of each span. The work was organized such that only one line of arch ribs and contiguous concrete deck would be under repair on any given span, at one time. However, work in all spans could be carried out concurrently. In this manner, stable thrust block action could always be maintained in the bridge as a whole and it could be assured that the top of the arch ring and slab would remain in compression, as a system, after repairs. Upon completion of all repairs, the surfaces of the existing and repaired portions of the deck were milled 1-in. deep, swept, vacuumed, and washed and a 4½-in.-thick continuously reinforced concrete overlay placed.



The bridge is a three-span arch with closed spandrel walls that the residents wanted to save.

The 4½-in.-thick concrete overlay was selected for three reasons:

- To bridge over existing temperature control joints with structural concrete;
- To provide an enhanced barrier against further ingress of chlorides; and
- To increase the compression area at the crown of the arch, thereby enhancing live load capacity.

The seven arch ribs support a 54-ft-wide roadway and two 12-ft-wide sidewalks on a 1-ft-thick concrete deck.

The first two reasons are TDOT standards for most rehabilitation work. All reinforcement in the overlay was epoxy coated.

The quantity of estimated full-depth deck replacement increased about 25 percent during construction. More surprisingly to TDOT engineers, the amount of arch rib replacement tripled. The primary reason for this large overrun is rooted in the method of construction. For reasons unknown to TDOT, five of the seven 1-ft 4-in.-thick ribs were cast monolithically, while the first interior rib on each side of the bridge was 2 ft thick and cast with a longitudinal construction joint. During repair operations, it was determined that there were extensive internal pockets in these two ribs that contained uncombined sand, stone, and cement. Therefore, it was necessary to remove more rib material than planned.

Two classes of concrete were specified for the project. The repairs used a Class A concrete with a specified minimum compressive strength of 3500 psi and a maximum water-cementitious materials ratio of 0.45. The overlay concrete was a Class D bridge deck concrete with a specified minimum compressive strength of 4000 psi and a maximum water-cementitious materials ratio of 0.40. The contractor elected to use five different mixes for the Class A concrete depending on the application and the need to achieve the compressive strength at early ages. All concrete for the repairs was gravity fed and vibrated



The original spindles were made using a mortar and were replaced with precast concrete spindles.

inside the forms. The overlay concrete was pumped.

The spindles of the original barrier were made using a cement-sand mortar and were badly deteriorated. The replacements, made of Class A concrete, were individually cast in a mold fashioned from one of the original spindles. The top rail was cast in place.

The restoration was completed within 12 months, and the bridge is ready for its second 80 years of service. The bridge can now carry all legal loads.

Because of the success of the Elk Avenue project, the TDOT proceeded to restore a sister, state-owned Lutens arch located downstream, thus saving two outstanding examples of Daniel Lutens' pioneering work.

Edward P. Wasserman is Civil Engineering Director, Structures with the Tennessee Department of Transportation.

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



'The bridge is ready for its second 80 years of service.'



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The roadway curve, hill, and adjacent intersection created a challenge for the design.



PRESERVING A Community Gateway

by Mark P. Henderson, LJB, Inc.



The 1939 bridge was in need of replacement.

Dry Fork Creek in Hamilton County, Ohio, is recognized as one of the state's cleanest streams, holding many species of fish that the county and local park district are interested in preserving. Crossing Dry Fork Creek was the original West Road Bridge, which was badly in need of replacement. So, in addition to the standard challenge of designing a new bridge structure that is affordable, functional, and aesthetically pleasing for the community, LJB Inc.—a Dayton, Ohio-based full-service consulting firm—also had larger responsibilities.

Design Considerations

In its original condition, the West Road Bridge, which was built as a Works Progress Administration structure in 1939, featured a curved three-span, reinforced concrete T-beam superstructure

supported on reinforced concrete cap and column piers with wall-type abutments. In evaluating the appropriate design for the new bridge, two structure types were considered—a single-span structure and a three-span structure. The evaluation also took into account the impact to nearby roads, the existing hydraulic conditions, and improved functionality.

A single-span structure was considered in an attempt to avoid the creek and its wildlife as much as possible. To execute this option, though, the horizontal alignment would have to be adjusted, and the road's profile would have to be raised. This significant change was not possible due to an adjacent intersection.

The option of a three-span bridge allowed for a reduced superstructure

profile

WEST ROAD BRIDGE / HAMILTON COUNTY, OHIO

ENGINEER: LJB, Inc., Dayton, Ohio

PRIME CONTRACTOR: Sunesis Construction, West Chester, Ohio



A three-span cast-in-place reinforced concrete bridge provided an affordable, functional, and aesthetically pleasing solution



The replacement three-span structure was selected to preserve the surrounding environment.

depth, which meant that the vertical alignment of the road did not have to change and the length of affected roadway could be minimized. LJB then considered eliminating the curve of the bridge, which would improve the alignment, while simultaneously simplifying the design and construction. The design team determined that a cast-in-place concrete slab bridge could easily be constructed on the curve, so the roadway would not have to be realigned. As a result, the three-span reinforced concrete slab option provided a viable solution that met the basic needs of the project. This structure type also allowed for aesthetic enhancements to maintain much of the same look and feel that community members and park visitors enjoyed with the existing bridge.

Because the creek level rises significantly during high water, the proposed bridge could not create an additional restriction to the water flow. To maintain the environmental integrity of the surroundings, this project required various hydraulic analyses and extensive

coordination with the Federal Emergency Management Agency (FEMA).

Design began in June 2003 and was complete by the following April. Construction began in November 2004, and the bridge was completed and opened to traffic in July 2005. All aspects of the project went smoothly, despite the project's design and construction challenges.

The Solution

Today, the new West Road Bridge is 132 ft long and includes three spans with lengths of 40, 50, and 40 ft. The bridge is supported on cast-in-place reinforced concrete wall-type piers and semi-integral abutments behind mechanically stabilized earth (MSE) retaining walls. The abutments are jointless rigid stub abutments on two rows of piles. At each abutment, the approach slab and superstructure slab sit on and are tied



A nearby park makes this an important community thoroughfare.

CAST-IN-PLACE BRIDGE / HAMILTON COUNTY, OHIO, OWNER

BRIDGE DESCRIPTION: 132-ft long, three-span cast-in-place concrete slab bridge

TOTAL PROJECT CONSTRUCTION COST: \$1,196,000

to an end diaphragm that slides across the top of the abutment on laminated elastomeric bearing pads. The detail still allows the bridge to expand and contract, but eliminates the expansion joint. This support is a unique detail developed by LJB specifically for this project.

The MSE walls supporting the abutments are large and deep. The wall at the rear abutment is approximately 100 ft long, and the wall at the forward abutment is approximately 75 ft long. Both walls are embedded deep into the creek bed due to scour concerns, with each wall being more than 26 ft tall. One of the MSE wingwalls also functions as a retaining wall to support a private drive at the northwest quadrant of the bridge.

The bridge carries two 10-ft-wide traffic lanes with a 6-ft-wide shoulder on each side to accommodate bicycle and pedestrian traffic. The deck was cast with Hamilton County's high performance concrete mix design, which includes fiber reinforcement, silica fume, and a corrosion inhibitor. This mix was developed to provide a minimum service life of 75 years, maximizing the longevity of the bridge.

Pretty and Practical

The bridge's owner, Hamilton County, also wanted to provide an aesthetically pleasing structure for the community since it is the gateway to the nearby



The new bridge provides ample space for vehicles, pedestrians, and bicycles.

The bridge's owner wanted an aesthetically pleasing structure.

Miami Whitewater Forest Park. LJB worked with the park district and the county engineer to match the aesthetics of the existing bridge's Texas-style railing. In addition, variable depth haunches along each slab fascia, cast integrally with the slab superstructure, add visually to the bridge elevation as seen from the park. A stone pattern form liner used on both the cast-in-place concrete piers and the precast concrete MSE wall panels also gives the effect of a stone finish. Finally, using two colors for the sealing of concrete surfaces—including the rails, fascias, piers, abutments, and MSE walls—adds additional aesthetic appeal and ties the bridge into its natural surroundings.

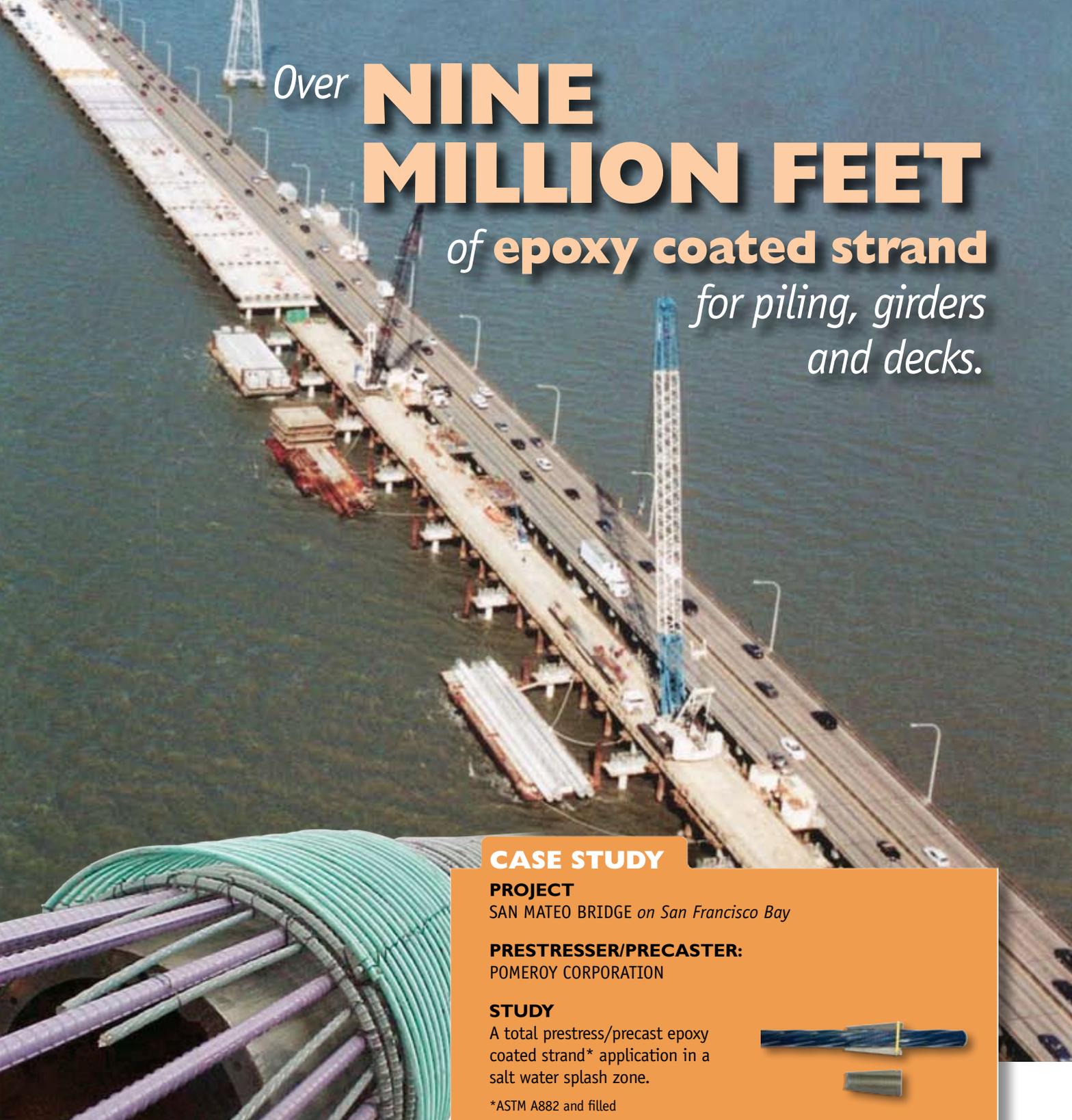
The new West Road Bridge over Dry Fork Creek protected the wildlife interests and the aesthetics of the community, while still achieving the functional and budgetary goals set forth by the project. With a short 9-month construction schedule, the new bridge not only created a safer environment for travelers, but also maintained the appearance the community had come to appreciate.

Mark P. Henderson is a Managing Principal with LJB, Inc. in Dayton, Ohio.

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



LJB worked with FEMA and the local park district to maintain the creek environment.



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PROJECT

SAN MATEO BRIDGE on San Francisco Bay

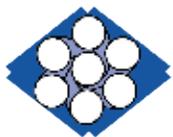
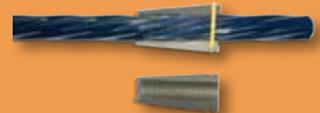
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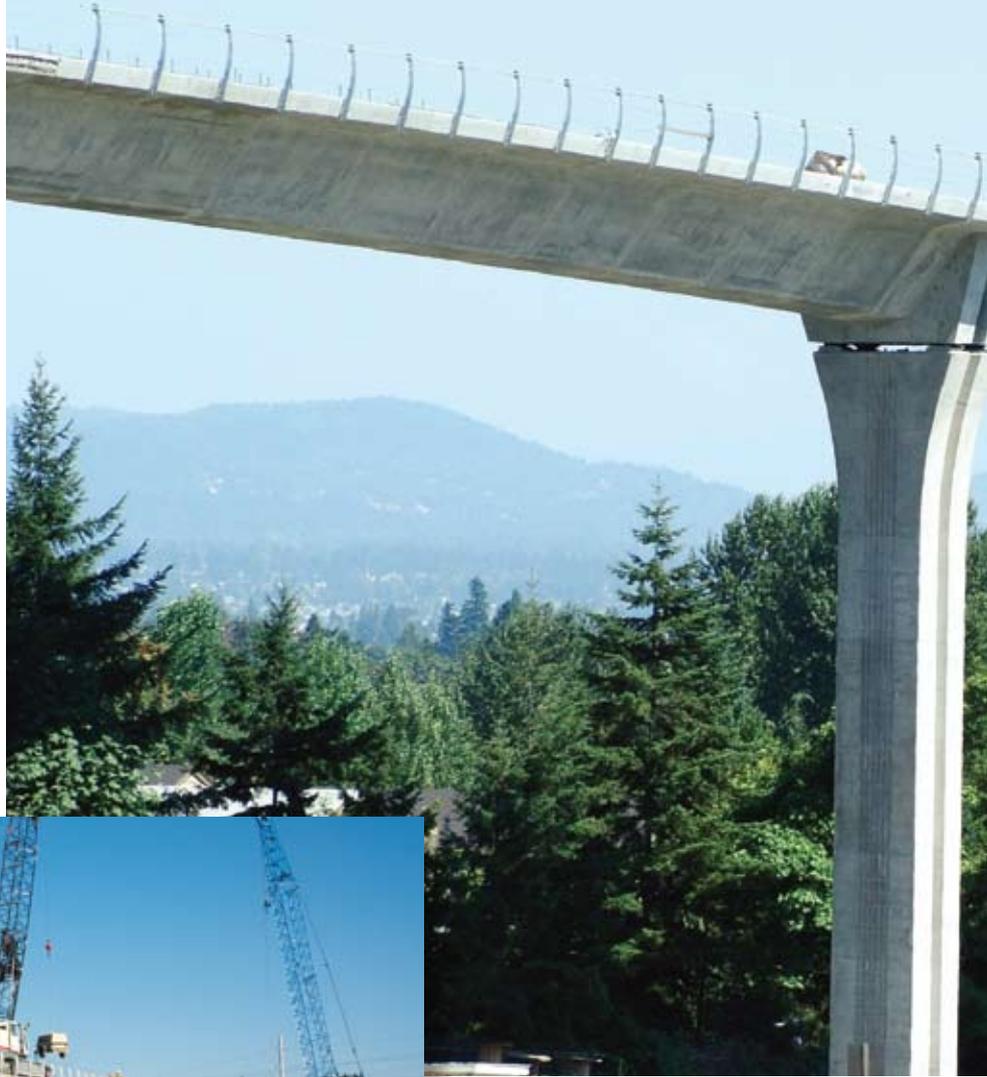
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Precast Segmental Guideway Forges Important Transit Link

by Wayne A. Endicott



Construction of the 350-ft span over the Duwamish River. Photo: IBT.

When engineers were tasked with the assignment of designing the last link in the new Seattle Sound Transit light rail system, they already had a model to work from. The same group had recently completed a similar project in Vancouver, British Columbia, Canada. "Conceptually, we looked at a lot of different possibilities for the project, but our experience from the Vancouver project pointed us toward building an elevated system employing segmental precast concrete bridges," says Christopher Hall, Senior Project Manager for International Bridge Technologies (IBT) in San Diego, designers of the bridges.

'Big, long viaduct' completes Seattle's new light-rail system with airport link

profile

SEATTLE SOUND TRANSIT LIGHT RAIL / SEATTLE, WASHINGTON

PRIME DESIGN CONSULTANT: Hatch Mott MacDonald, Bellevue, Wash.

PRECAST SEGMENTAL GUIDEWAY DESIGN CONSULTANT: International Bridge Technologies, Inc. (IBT), San Diego, Calif.

CONSTRUCTION MANAGEMENT CONSULTANT: Parsons Brinckerhoff CS, Seattle, Wash.

PRIME CONTRACTOR: PCL Construction Services, Inc., Bellevue, Wash.

CONSTRUCTION ENGINEER: T.Y. Lin International, Olympia, Wash.

PRECASTER: Bethlehem Construction, Inc., Cashmere, Wash., a PCI-Certified Producer



The winding, twisting bridge includes super elevations as well as horizontal and vertical curves, all compensated for in the casting of the segments.
 Photo: Hatch Mott MacDonald.

Alternative Dramatically Speeds Construction

This alternative solution appealed to the team and to the system’s owner, Seattle Sound Transit. The first consideration was the promise of completing the project more rapidly. “The whole rapid transit system had schedule challenges for a variety of reasons,” Hall says. “As the last section of the light rail project to be constructed, there was already a potential deficit in the scheduled completion time. We proposed precast concrete segmental construction as a way of cutting that deficit. We felt that we could complete this portion of the system—the last link to the airport—a full nine months faster than the project could be built in the original plan. This would allow us to cut into that time deficit and give the owner flexibility in the schedule.”

Hall points out that the contractor could perform multiple operations, including

Constructing the project within a tight right-of-way was challenging enough, Hall says. But several other factors entered into the planning, not the least of which was the sensitive environmental area the system was to traverse. “Access and mobility problems for other traditional bridge structures would have caused a loss of efficiency in the construction of the link. The need to work within the limitations of the area would have required much longer to complete,” explains Hall.

Armed with the knowledge gained during the construction of the Vancouver

project, the team, which included Hatch Mott MacDonald in Bellevue, Washington, as the prime consultant, proposed the precast segmental solution over twin, full-length precast box girders.

The construction system allowed the guideway to be built over I-5 with little disruption to traffic.
 Photo: PCL.



PRECAST SEGMENTAL BOX GIRDER / SEATTLE SOUND TRANSIT, OWNER

BRIDGE DESCRIPTION: 4.2 miles of 26-ft 6-in. wide precast concrete segmental box girder (plus 0.9 miles of on-grade railway) carrying two light rail tracks with an emergency exit walkway

POST-TENSIONING SUPPLIER: Schwager Davis, Inc., San Diego, Calif.

STRUCTURAL COMPONENTS: 2207 V-shaped precast concrete segments and 160 cast-in-place piers. Typical spans are 120 ft with longer spans (220 to 350 ft) carrying the line over I-5, the BNSF tracks, and the Duwamish River.

CONSTRUCTION COST: \$270 million

We felt that we could complete this portion of the system a full nine months faster.

site work, foundations, piers, and similar activities, while the precast concrete segments were being cast.

“Our staff has done precast concrete segmental bridges on several light rail projects,” Hall explains. “We have found that the process especially lends itself to this type of project. By building it over everyone’s head, we were able to avoid a great deal of the traffic. It was especially critical in this job, since the new rail line is adjacent to surface streets and also spans I-5, the main West Coast artery between San Diego and Seattle.” By “going over the top,” the new rail line avoids the necessity of disrupting traffic on that major thoroughfare.

The benefits of building an elevated rail line were not limited to traffic impacts, Hall explains. The line, which crosses a river and spans some sensitive wetlands, creates a much smaller footprint than a surface rail line would require. “By building it overhead, we were able to stay out of the water where the line crosses the Duwamish River and minimize its impact on the wetlands, which pleases the multiple groups and state agencies charged with oversight. The cost of mitigation that otherwise would have been required was also reduced. Other challenges included crossing a large Burlington Northern Santa Fe (BNSF) rail yard, a large intersection at a Boeing company access road as well as the freeway. It’s difficult to imagine one project facing

The overhead gantry places the segments from above, keeping contact with environmentally sensitive areas to a minimum during construction. Photo: IBT.

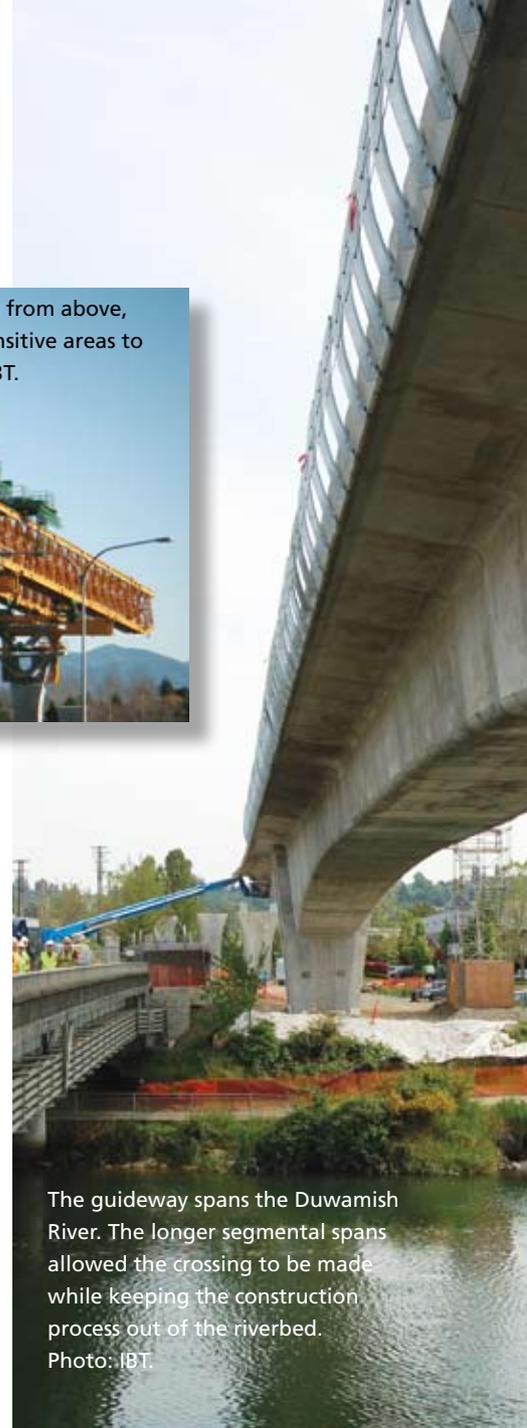


so many challenges, and being able to solve them all with a single construction technology.”

Costs Lower than Estimated

Surprisingly to all parties concerned, the project, which was bid at a time of sharply rising material costs, actually proved less expensive than originally estimated, Hall says. Four contractors submitted bids, and two were at least 10 percent under the engineer’s estimates. With the reduced construction time, further savings will be realized and Seattle Sound Transit will have its last link to the airport completed sooner

The gantry holds several segments, ready to be epoxied to adjoining segments and post-tensioned. Photo: PCL.



The guideway spans the Duwamish River. The longer segmental spans allowed the crossing to be made while keeping the construction process out of the riverbed. Photo: IBT.

and open to traffic. In fact, Hall says, the original plan called for the link to end short of the airport, but the lower bids allowed the owner to extend and complete the line to just outside the Seattle-Tacoma International airport.

The final design of the 5.1-mile-long project, which is approximately 80 percent above ground, includes 4.2 miles of elevated guideway carrying twin tracks with continuously welded rails fastened to the top of the superstructure. The grade level portion of the project sits atop retained cut and fill. The track elevation ranges from 20 ft above ground to as high as 70 ft.



The superstructure is 26 ft 6 in. wide and carries two light rail tracks. It also contains a maintenance and emergency exit walkway between the tracks.

Girders Feature Triangular-Shaped Cross-Section

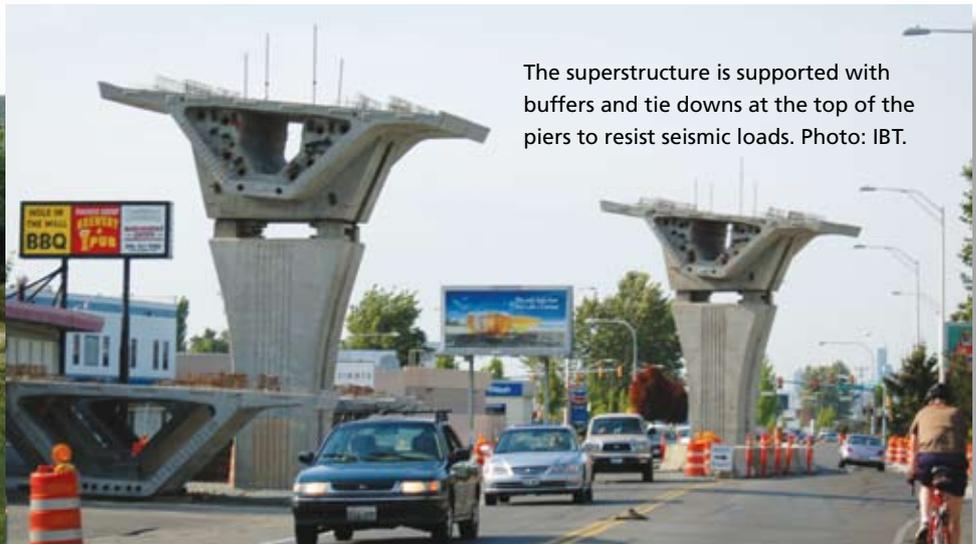
An important decision early in the design process led to the development of a unique triangular-shaped cross-section for the box girder. This design was developed for several reasons. First, the appearance of the 4-mile-long ribbon of concrete entered into the design equation. For this reason, the width of the bottom slab was sized to satisfy the box girder bending stresses.



A precast pier segment is lowered into place by the overhead gantry. Photo: IBT.

sections. Small blisters at the point of entry on the bottom slab simplify the core forms.

The twisting, rising, and falling path of the alignment was cast into the guideway, which allowed the rail's



The superstructure is supported with buffers and tie downs at the top of the piers to resist seismic loads. Photo: IBT.

A unique triangular-shaped cross-section was created for the precast concrete box girders.

Foundations typically consist of single 10-ft-diameter drilled shafts to minimize the impact of construction on the right-of-way. A few piers rest atop spread footings. Steel pipe piles are used at special locations where the drilled shaft would be uneconomical to build because of the required depth.

The superstructure features a 7-ft-deep precast concrete segmental box girder, with the segments put into place by an overhead traveling gantry. Typical spans for the project are 120 ft. However, where the structure crosses I-5, the Duwamish River, and the BNSF tracks, spans vary from 220 to 350 ft.

Lateral stability at the piers was provided by external diaphragms. These outside diaphragms were integrated with the pier shapes designed as twin walls with a center diaphragm. The resultant profile produces a sleek, narrow section. This significantly reduces material quantities when compared with traditional box girder designs. The inclined webs of the V-shaped box girder also provide a less intrusive appearance to the guideway.

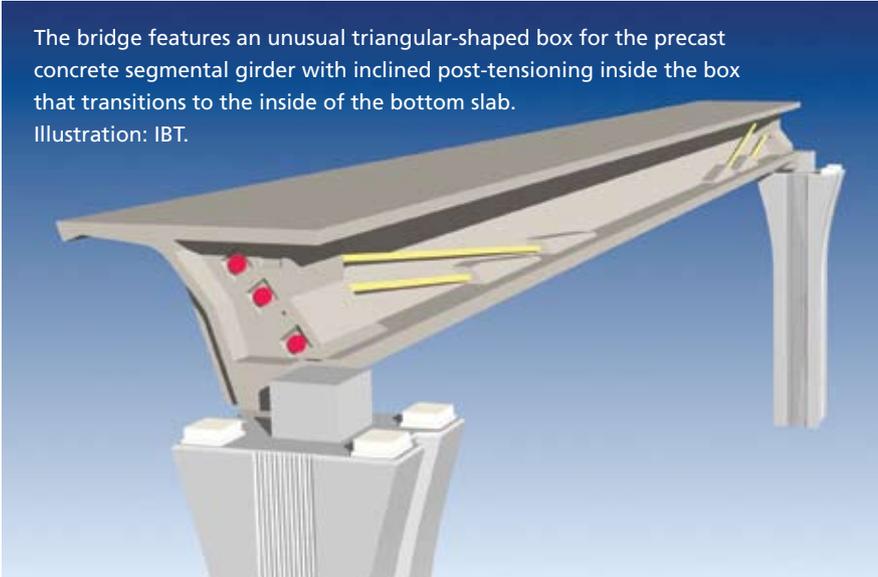
Within the core of the box girder, post-tensioning tendons start outside the concrete section and then transition to the inside of the bottom slab, allowing them to be bonded in the mid-span

concrete plinth dimensions to be reduced. The box girders are designed to follow all aspects of track alignment geometry, including super-elevation and horizontal and vertical curvature. The resulting rail plinth maintains a constant shape and greatly simplifies casting in the field, replacing the common detail of casting the rail plinth alone to accommodate the trackwork alignment.

Another feature is a continuous transverse diaphragm cast with the pier segment at the end of each span. This could easily be adjusted in the casting yard so the bottom face of the diaphragm was always parallel to the

The bridge features an unusual triangular-shaped box for the precast concrete segmental girder with inclined post-tensioning inside the box that transitions to the inside of the bottom slab.

Illustration: IBT.



horizontal surface at the top of the piers when it is necessary to rotate the box girder. This accomplishes several things, he explains, including creating a constant gap between the bottom of the plinth and the top of the pier, thereby simplifying detailing for bearings and seismic buffers. It also improves the visual melding of the superstructure and substructure.

Designed for High Seismic Needs

The structure was designed to resist large seismic loads. Large vertical accelerations as large as two-thirds of the horizontal accelerations played a part in the design. The typical spans are simply supported with buffers and tie downs resisting seismic loads at the top of the piers. These are contained in the space between the two half-pier segments at the top of each pier.

As the practice of seismic design advances, greater demands are placed on designers to accommodate higher loads for elevated structures, Hall says. For this project, pioneering work was performed to develop project specific criteria to ensure a design approach that was consistent with the precast segmental structural scheme.

The piers themselves are designed as rectangular double walls with a center diaphragm. The flaring shape of the pier cap matches the shape of the outside pier segment diaphragms. The heavily-reinforced piers utilize ductile detailing to satisfy the area's high seismic

demands. The contractor fabricated the pier cages in one piece and was able to place the pier concrete in one continuous placement.

Throughout the design process, aesthetics remained a key concern. For example, instead of traditional straddle bents typical in high-seismic regions, resulting in bulky rectangular boxes atop circular columns, the straddle bents received the same reveal treatments provided on

typical piers. The sloping sides of the bent beams and lower arch-shaped reveal treatments give the effect of reducing the depth of the bent beams.

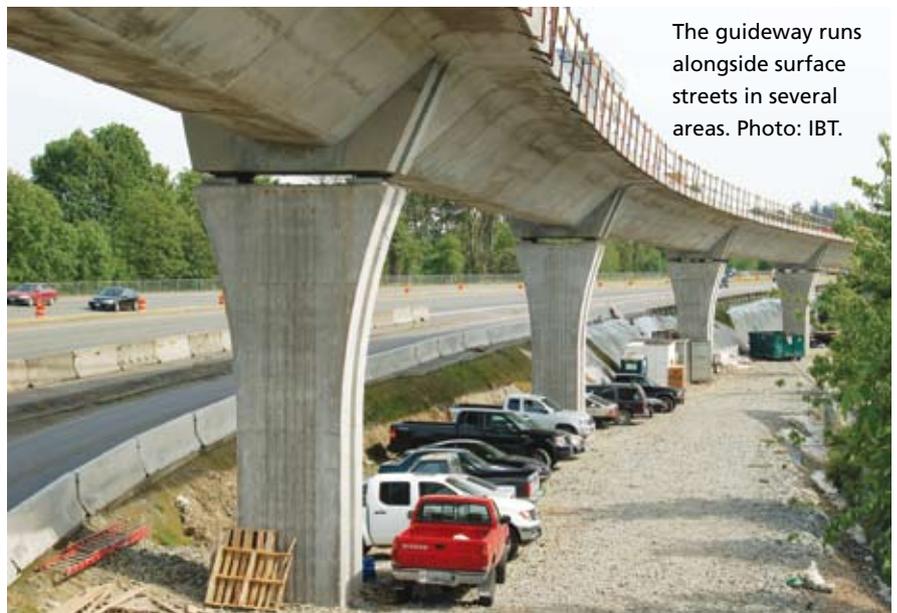
Precast segments were cast in the precaster's casting yard about 145 miles from the site. The firm employed nine casting cells, including five for typical segments, two for pier segments, and two for variable depth segments. After transporting to the site, the segments were erected with an overhead erection truss.

The total cost of the rail line, including the airport extension, is set at \$270 million, a full \$20 million less than the engineer's estimate and \$30 million less than the original concept. Hall says that the project began in February 2005 and is scheduled to be finished in March 2008.

"This was the first project to utilize the 'V-box' shape that was developed by IBT president Daniel Tassin," he says. "Because of the multiple challenges, much of the work needed to occur up in the air, making it ideal for precast concrete segmental construction and an overhead truss."

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

'Much of the work needed to occur up in the air, making it ideal for precast concrete segmental construction and an overhead truss.'



The guideway runs alongside surface streets in several areas. Photo: IBT.



AESTHETICS COMMENTARY

by Frederick Gottemoeller

This issue of *ASPIRE*TM brings an embarrassment of riches to someone who likes to see improved appearance in bridges—they are all noteworthy. Spokane's Monroe Street Bridge is a particularly fine example of the sensitive reconstruction of an existing historic bridge. However, I decided to focus on the Seattle Sound Transit light rail link because it helps answer a question that I am often asked: what is the increased cost of aesthetics?

The preliminary design for the rail link was quite a different structure. Based on the region's experience in the construction of highway bridges, it had been assumed that precast concrete U-shaped girders would once again offer the most economical solution. After all, it is a long viaduct with many similar spans. However, that led to a design that required hammerhead pier caps at each pier and one girder for each rail track. The weight of the precast girders created construction difficulties, as did the many curves that had to

be accommodated. With all of that in mind, the designer asked for and received permission to evaluate the original assumption.

The result is the design now under construction. It turned out to be 15 percent less expensive than the preliminary design. It is also a more attractive design. With a single segmental box section and without the miles of hammerheads, it is much sleeker, less massive, and more transparent. The designers did an excellent job of marrying the piers and the girders in an attractive and structurally honest way. Finally, the piers have vertical insets that create shadow lines that minimize their apparent width. At piers near stations mirrored tiles are set in these insets to create a flash of color for users approaching the structure, something that will surely be appreciated during Seattle's rainy weather.

So now, when I am asked the question about the added cost of aesthetics I say, based on the Seattle Sound Transit light rail link, the cost could be less. Of course, the real answer is, it depends. If you start with a standard structure and just add decoration to it, you automatically add cost. But if you look at the problem from the ground up, consider all of the options and try to improve the structure's efficiency, economy, and elegance all at the same time, you will certainly come up with a better-looking structure. You might even reap some savings.



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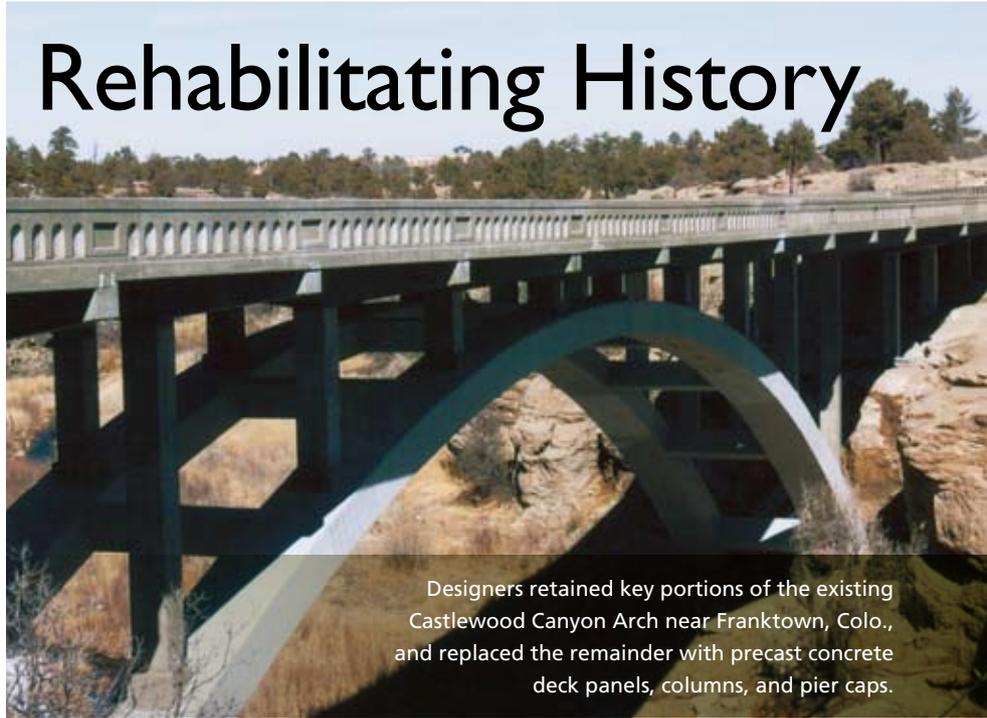
Precast concrete upgrade retains original arch on historic Colorado design

Designers on the Castlewood Canyon Arch Bridge near Franktown, Colorado, faced a number of challenges when they decided to replace the 446-ft-long 1940s-era bridge. By upgrading the structure with precast concrete deck panels, columns, and pier caps, while retaining key elements of the original design, a multitude of goals were accomplished.

In designing the new structure, officials at the Colorado Department of Transportation wanted to preserve as much of the existing structure as possible while improving safety, increasing the structural capacity, and widening its lanes. The structure also had to be environmentally friendly, aesthetically pleasing, and historically considerate to the previous design.



Precast concrete components of various sizes were installed due to their ease of use and rapid construction.



Designers retained key portions of the existing Castlewood Canyon Arch near Franktown, Colo., and replaced the remainder with precast concrete deck panels, columns, and pier caps.

Their design retained the bridge's arch ribs and part of the south abutment as well as the spread footings on the north side due to their historical value. The rest of the bridge was replaced with precast, prestressed components to create a 15-span, 404.5-ft-long structure.

Construction was accomplished by working from above to avoid harming the environment, with components removed and replaced from the center outward, balancing loads as two crews worked toward the abutments.

The design allowed for longitudinal and lateral connection of the deck-girder members, which function as the new deck. Connections between other precast and between precast and cast-in-place

were made with NMB splice-sleeves. The arched ribs were encased in wraps made of carbon-fiber reinforced polymer. Carbon-fiber plastic reinforcement strengthened the connections between the arch ribs and the foundation.

The aesthetics of the original bridge were retained in replacement components, such as the Colorado Type-7 rails with indentation on the exterior side, resembling the original rail. To ensure smooth progress on the arch's reconstruction, the design engineer remained on site throughout construction.

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

profile

CASTLEWOOD CANYON ARCH BRIDGE / FRANKTOWN, COLORADO

ENGINEER: Colorado Department of Transportation, Denver.

OWNER: Colorado Department of Transportation, Denver.

GENERAL CONTRACTOR: Kiewit Western, Littleton, Colo.

PRECASTER: Plum Creek Structures, Littleton, Colo., a PCI-Certified Producer

SPLICE SLEEVE SUPPLIER: Splice Sleeve North America, Inc., Ontario, Calif.

BRIDGE DESCRIPTION: Precast concrete replacement bridge, retaining key original components

STRUCTURAL COMPONENTS: 15 spans of precast concrete deck panels, precast columns and pier caps, carbon fiber plastic reinforcement, and carbon fiber polymer wrap

BRIDGE CONSTRUCTION COST: \$3.2 million

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*Sound Transit
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NRMCA works in conjunction with state associations on issues such as quality, business excellence, promotion, and regulatory concerns. We strive for constant communication on the latest information, products, services, and programs to help our members expand their markets, improve their operations, and be their voice in Washington.

NRMCA offers certifications for both ready mixed concrete production facilities and personnel. Certified producers strive to provide the highest quality ready mixed concrete in the safest and most efficient ways possible.

NRMCA is a principal sponsor of CONEXPO-CON/AGG. This show features over two million square feet of exhibits including an information technology pavilion and an emphasis on live demonstrations throughout the exhibit areas. The show brings together contractors, producers, and equipment manufacturers at the largest construction industry exposition in the Western Hemisphere.

NRMCA is also the principal sponsor the Concrete Technology Forum, an annual symposium on state-of-the-art concrete technologies. The Forum brings researchers and practitioners together to discuss the latest advances, technical knowledge, continuing research, tools, and solutions for ready mixed concrete.

For more information, contact the National Ready Mixed Concrete Association, 900 Spring Street, Silver Spring, MD 20910, 888-84NRMCA (846-7622), www.nrmca.org.



Silica Fume Association

The Silica Fume Association (SFA), a not-for-profit corporation based in Delaware, with offices in Virginia and Ohio, was formed in 1998 to assist the producers of silica fume in promoting its usage in concrete. Silica fume, a by-product of silicon and ferro-silicon metal production, is a highly-reactive pozzolan and a key ingredient in high performance concrete, dramatically increasing the service-life of structures.

The SFA advances the use of silica fume in the nation's concrete infrastructure and works to increase the awareness and understanding of silica fume concrete in the private civil engineering sector, among state transportation officials and in the academic community. The SFA's goals are two-fold: to provide a legacy of durable concrete structures and to decrease silica fume volume in the national waste stream.

Some of the recent projects completed by the SFA, under a cooperative agreement with the Federal Highway Administration (FHWA), include:

- The publication of a *Silica Fume User's Manual*—the manual is a comprehensive guide for specifiers, ready mixed and precast concrete producers, and contractors that describes the best practice for the successful use of silica fume in the production of high performance concrete (HPC).
- The introduction of a Standard Reference Material (SRM)[®] 2696 Silica Fume for checking the accuracy of existing laboratory practices and to provide a tool for instrument calibration. This SRM is available from the National Institute of Standards and Technology (NIST).

A much anticipated research program nearing completion by the SFA is the testing of in-place silica fume concrete under service conditions. At the conclusion of this research the results will demonstrate the benefit of silica fume concrete's unparalleled long-term performance. For more information about SFA, visit www.silicafume.org.

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Rehabilitation to Improve Safety, Reduce Congestion, and Extend Service Life of Highway Bridges

by M. Myint Lwin

There are about 600,000 highway bridges in the United States with state and local governments owning most of them. More specifically, 47 percent are owned by the states and 51 percent owned by local governments, such as counties and municipalities. The remaining 2 percent are federally and privately owned. Concrete, steel, prestressed concrete, and timber are the predominant materials used in bridge construction. Other materials, such as masonry, cast or wrought iron, aluminum, and composites are used in less than 1 percent of the bridges.

The average age of the highway bridges in the United States is about 45 years. Many are approaching 100! As the aging bridges are used by an increasing number of vehicles and subjected to higher vehicular loads, forces of nature, and corrosive environment, their physical conditions are deteriorating, their load-carrying capacities are reduced, and their roadway widths are becoming inadequate. Over 28 percent of the nation's highway bridges are considered structurally deficient or functionally obsolete.

The U.S. Congress finds and declares that it is in the vital interest of the United States that a highway bridge program be carried out to enable states to improve the condition of their highway bridges over waterways, other topographical barriers, other highways, and railroads. This is to be accomplished by replacement and rehabilitation of bridges that are determined to be structurally deficient or functionally obsolete, and through systematic preventive maintenance of bridges.

Highway Bridge Replacement and Rehabilitation Program

The Surface Transportation Assistance Act of 1978 replaced the Special Bridge Replacement Program (SBRP) with the Highway Bridge Replacement and Rehabilitation Program (HBRRP) extending funding to include rehabilitation to restore the structural integrity of

a bridge on any public road, and rehabilitation work necessary to correct major safety defects.

The Surface Transportation Assistance Act of 1982, the Surface Transportation and Uniform Relocation Assistance Act of 1987, and the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) continued the HBRRP. Additionally, ISTEA allowed federal participation in bridge painting, seismic retrofitting, and calcium magnesium acetate applications.

The Transportation Equity Act for the 21st Century (TEA-21) continued HBRRP. It authorized the set-aside of \$100 million for each FY1999-2003 for discretionary allocation by the secretary for major bridges with the provision that a maximum of \$25 million would be made available for seismic retrofit of bridges, including projects in the New Madrid fault region. It also authorized a set-aside of \$25 million for FY1998 for seismic retrofit of the Golden Gate Bridge. TEA-21 changed the HBRRP eligible work activities to include sodium acetate/formate or other environmentally acceptable, minimally corrosive anti-icing and deicing compositions, and installing scour countermeasures.

The Safe, Accountable, Flexible, and Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) of 2005 continued the HBRRP for replacement or rehabilitation of structurally deficient and functionally obsolete highway bridges in the states. Under this legislation, painting, seismic retrofit, systematic preventive maintenance, installation of scour countermeasures, and the application of calcium magnesium acetate, sodium acetate/formate, or other environmentally acceptable, minimally corrosive anti-icing and deicing compositions are eligible for HBRRP funding.

Eligibility for Federal Funds for Rehabilitation

In general, rehabilitation project requirements necessary to perform the major work required to restore the structural integrity of a bridge as well

as work necessary to correct major safety defects are eligible for federal-aid funds. Bridges to be rehabilitated shall, as a minimum, conform to the provisions of 23 CFR Part 625, Design Standards for Federal-Aid Highways, for the class of highway on which the bridge is a part.

An AASHTO-approved sufficiency rating formula is used as a basis for establishing eligibility and priority for rehabilitation of bridges. The sufficiency rating formula is a numerical rating system, 0 to 100, based on the bridge's structural adequacy and safety, essentiality for public use, and its serviceability and functional obsolescence. In general, the lower the rating, the higher the priority. A rating of 100 represents an entirely sufficient bridge, which does not require any work. A rating of 80 or less will be eligible for rehabilitation. A rating of less than 50 will be eligible for replacement. A rating of 0 represents an entirely insufficient or deficient bridge. A more detailed description of the sufficiency rating formula may be found in the FHWA Report No. FHWA-PD-96-001 Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges.

Systematic Preventive Maintenance

SAFETEA-LU has a special rule for preventive maintenance, allowing a state to perform seismic retrofit, systematic preventive maintenance, or installation of scour countermeasures for a highway bridge without regard to whether the bridge is eligible for replacement or rehabilitation.

This legislation makes systematic preventive maintenance activities, such as crack sealing, expansion joint repair, controlling deterioration, seismic retrofit, scour countermeasures, and painting, eligible for federal-aid funds. A state may carry out preventive maintenance for a highway bridge without regard to sufficiency rating or deficiency status. Systematic preventive maintenance implies the use of an effective

maintenance strategy or a prioritization and optimization system to gain the most benefit from the investment on preventive maintenance activities.

Systematic preventive maintenance and preservation activities are necessary for assuring proper performance of highway bridges. Experience has shown that preventive maintenance is a cost-effective way for extending the service life of highway bridges and preserving the highway systems.

Integrating Management Systems

As the population of bridges grows in number and age, the management tasks associated with preserving the serviceability and condition of bridges become very complex, time-consuming, and costly. Management and analytical tools are needed to collect and analyze the bridge data for predicting the present and future bridge preservation strategies and related costs. As the transportation agencies are facing limited resources—generally much less than the needs—for maintaining and preserving an

efficient network of highways, it becomes ever more important to invest the resources in areas where the benefit-to-cost ratios are the highest. Since the 1980s, transportation agencies are using modern analytical methods, deterioration models, and high-speed computers to develop bridge management, maintenance management, and asset management systems to meet varying needs.

The challenge is the ability to effectively integrate a maintenance management system, bridge management system, and asset management system through a strategic framework to assure timely decisions in committing adequate resources to maintenance and rehabilitation to improve safety, reduce congestion, and extend service life.

The FHWA is committed to perform research, deploy tools, and provide training to assist the states and local governments in implementing and integrating effective management systems for making sound technical and financial decisions on maintaining the structural health and serviceability of a bridge or a network of

bridges. For more information, please visit www.tfhr.gov/structur, www.fhwa.dot.gov/infrastructure, www.fhwa.dot.gov/resourcecenter, and www.nhi.fhwa.dot.gov/training.

Closing Remarks

Congress has given us the technical and financial responsibility and flexibility to carry out the Highway Bridge Program to improve the condition and performance of the highway bridges through systematic preventive maintenance, cost-effective rehabilitation, and timely replacement. The works of a project should be coordinated and integrated to identify and meet the needs of the designers, constructors, inspectors, maintenance personnel, and others—working together to achieve safety, quality, and efficiency.



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Concrete Bridges in

Florida

A History of Innovation

by Lex Collins, Florida Department of Transportation



Florida has long been famous for its sunshine and beautiful beaches. So it is only natural that most of the state's population is located along the coastline. Florida is the fourth most populous state in the United States, yet it ranks only 22nd in land area. The Sunshine State is also the top travel destination in the world. Because of all it offers, the state's population is growing at a significant rate. All this means that large numbers of bridges continue to be required for so many people living in a relatively small

Small arch bridge in Mexico Beach is fitting for the site. Photo: PB.



area. However, the same warm weather and salt water that bring people to Florida also combine to create a severely corrosive environment for its infrastructure. Thus, concrete has been and remains a natural choice for the state's bridge designers. Florida has been using concrete for bridge construction for over 90 years. We have a reinforced concrete bridge built in 1915 and a series of precast, prestressed concrete I-beam bridges built in the mid-1950s, all of which are still in service.

Because all bridges tend to be a focal point for the landscapes in which they are placed, the state's citizens demand and deserve attractive structures that enhance their surroundings, instead of dividing and detracting from them. At the same time, public budgets are always tight and owners require bridges that are both affordable and durable. This is one of the major challenges of our day; to help create livable communities as urban areas become more densely populated. Concrete continues to be a versatile, economical, and weather-resistant material for the construction of bridges that are attractive and cost effective throughout the state. One example of an aesthetic, affordable, small structure is the recent replacement of a bridge carrying U.S. 98 in Mexico Beach. The use of a

Bow-tie struts in the pylons at Dame Point Bridge are an example of form following function. Photo: HNTB.

precast concrete arch opens the channel without raising the roadway profile so that local business access is unaffected. Pleasure boats once had to line up to pass beneath the structure, but now the passage is significantly wider because of the thoughtful arch design. On the other end of the spectrum, Florida is home to the longest span concrete bridge in the United States over the St Johns River at Dame Point, near Jacksonville. With a 1300-ft cable-stayed main span, this bridge is another example of an elegant design that meets the needs of the public.

Florida Embraces New Ideas

Because much of Florida's 1100 miles of coastline are protected by barrier islands on which people live, work, and vacation, many of the major water crossings in the state are between these islands and the mainland. The navigable Intracoastal Waterway is often spanned by these bridges, so the channel spans need to be longer than the typical shallow water approach



The versatility of precast segmental concrete was proven with the Skyway Bridge replacement. Photo: FIGG.

span construction in the world, and it introduced the economy of precasting continuous bridges to long viaducts in Florida. Then, the replacement of the Sunshine Skyway Bridge used span-by-span box girders spanning 135 ft in the high-level approaches, balanced cantilever spans of 240 ft in the main unit, and a cable-stayed main span of 1200 ft; thereby, proving that segmental



Spliced beams continue to be economical for main-span construction. Photo: PB.

spans. As Florida's population growth began to accelerate at a rapid pace in the late 1950s, engineers were faced with finding affordable, durable bridge types for its salt-water crossings. With the advent of prestressed concrete and the standardized AASHTO I-beam sections in the 1950s, they had a tool with which to construct the approach spans quickly and efficiently. At that time, the main spans were typically constructed using steel beams or trusses when they had to span more than about 120 ft. Moveable bridges

were also often used, but as vessel and vehicular traffic increased, the inconvenience and expense associated with movable spans also increased.

In the late 1970s and early 1980s, U.S. 1 was being reconstructed out to Key West using a new technology for the United States: segmental concrete construction. Most of the longer bridges between the islands in the Keys were constructed using precast segmental box girders erected with the span-by-span method. This series of bridges was the first large-scale use of precast span-by-



Entire spans were moved during the I-10 repair.

Self-Propelled Modular Transporters moved spans on land for the Graves Avenue replacement.

concrete construction can be an economical method for virtually any span length. Soon, precast segmental boxes were also being used for long viaduct structures on land, as well as curved ramps at interchanges. The economical use of these various types of precast, segmental box girder bridges during the 1980s showed that Florida's large Intracoastal Waterway crossings could be constructed using concrete box girders in place of steel girders or trusses.

In the early 1980s, the Florida Department of Transportation introduced its bulb-tee girders, which were more efficient than AASHTO beams. These allowed for longer span lengths or fewer beam lines for Florida's simple-span, prestressed beam construction. Later in the 1980s, Florida's bulb-tee girders were married with segmental concrete design and construction techniques to form spliced bulb-tee spans. Early forms of this bridge type consisted of simply splicing girders at the piers with cast-in-place joints and continuous post-tensioning. Later, haunched pier segments were connected to standard bulb-tee drop-in segments with post-tensioning to form continuous three- to five-span units. These



haunched, spliced girder units continue to be routinely constructed over the Intracoastal Waterways and navigable rivers. This type of segmental construction has proven to be extremely versatile and cost effective when the aesthetics of a box girder are not warranted. Main span lengths of 200 to 250 ft are typical, though the longest spliced girder span in the state is 320 ft. More recently, Florida's standard depth bulb-tee beams have been spliced in the same manner to provide 180 ft spans for standard

highway overpasses. These longer spans have become increasingly necessary in urban areas, which require provisions for future widening of the interstate combined with increased clear zones to abutments.

In the late 1990s, Florida developed its concrete U-beam series, modeled after the U-beams that were being used in Texas. With no external diaphragms, wide girder spacing, and capable of simple spans up to about 150 ft, these bridges have an uncluttered appearance when viewed from underneath. They have proven to be quite competitive with steel box girders when enhanced aesthetics are called for in urban areas.

More recently, Florida has led the nation in the development of its structural requirements for post-tensioning materials and methods in order to combat our extremely aggressive climate for corrosion. No longer can grout be mixed on site using cement and water. Instead, prequalified, premixed grout that minimizes shrinkage and bleed water must be used. All post-tensioning ducts must be rigid plastic instead of galvanized metal. Post-tensioning anchorages must be inspected after grouting. Details such as enhanced corrosion protection at anchorages, requirements for anchorage placement, time to grouting, and grout injection/vent locations have been developed to fight corrosion and enhance the durability of the state's post-tensioned bridges. Also, post-tensioning systems must now be tested and approved for leak resistance and all grouting must be done by ASBI-certified grouting technicians. Further, requirements specifying the number of tendons in certain elements have been put in place to ensure that structures have more redundant load paths. All these items combine to contribute to what will be significantly more durable structures for Florida's future.



The graceful 630-ft-long span of the Acosta Bridge, in Jacksonville. Photo: T.Y. Lin International.



The Broadway Bridge pleases both an engineer's and an artist's eye. Photo: FIGG.

Accelerated Delivery

In use since the late 1990s, design-build is now a staple of Florida's construction environment. This system dramatically decreases delivery time, which is a requirement for some construction projects as Florida's population continues to grow at the rate of about 300,000 people per year. Precast concrete, with its relatively short lead times, has been the principal material used in most of Florida's design-build bridges.

In the wake of Hurricane Ivan's strike of the low-lying I-10 bridge over Escambia Bay near Pensacola in 2004, one of the twin bridges was cannibalized by moving entire spans to the bridge that fared better. Though significant portions of the miles of approach spans were damaged, the contractor used huge barge-mounted cranes and self-propelled modular transporters (SPMTs) to replace entire spans and open the one bridge in just a few days. Borrowing on that experience, the Graves Avenue Bridge replacement over I-4 just north of Orlando was built using SPMTs, as well. Old spans were removed in one piece using the SPMTs. Then, the two new bulb-tee spans were constructed off to the side of I-4 and moved in at night in just hours apiece. This type of erection may prove beneficial for congested urban areas where working room is limited and maintenance of traffic is at a premium.

Also, the final replacement bridges for I-30 over Escambia Bay have been constructed in a very short time using many precast concrete components. For the approach trestle spans,

concrete cylinder piles support precast bent caps, which in turn, carry simple-span bulb-tee girders. At the taller sections near the main channel, the piles are capped with precast waterline footings. The main span unit is a spliced bulb-tee bridge. Construction of the approximately 3-mile-long twin bridges is on schedule to be completed soon.

Summary

A beautiful bridge can become a true source of pride for a community. Because concrete can be formed into virtually any shape imaginable, it can be used to accurately describe the form follows function requirements of an aesthetically pleasing structure. It is versatile enough to serve in major metropolitan areas as a canvas for artwork, and it can be cast-in-place or precast. Through the years, Florida has readily embraced new technologies and construction methods. Because we construct so many bridges each year, Florida intends to continue leading the way in the development of materials, details, and specifications that ensure durability without undue burden on project budgets. Concrete structures have been and will continue to be a mainstay of the transportation system in the state.

Lex Collins is Assistant State Structures Design Engineer, Florida Department of Transportation.

For more information on Florida's bridges, visit www.dot.state.fl.us.

Florida's

Measure of Prestressed Concrete Products Quality

by Thomas O. Malerk,
Florida Department of Transportation

The Florida Department of Transportation (FDOT) and the Florida Prestressed Concrete Association (FPCA) are working together to develop and initiate a flagship Quality Assurance Program for the production of prestressed concrete products. Through the combined efforts of the state and the prestressed concrete industry, Florida is now striving to further improve upon its existing high standards for prestressed concrete.

FDOT's Quality Assurance Program

The FDOT specifications are now a 100 percent Contractor Quality Control (CQC) system. All materials and construction operations for the state's highways and bridges are produced with the contractor and producer assuming direct responsibility for the quality of the product. The Florida prestressed concrete industry was the first in the state to implement producer CQC.

Prestressed concrete plants that produce products for FDOT construction projects are required to be on the current certified plant list of the Precast/Prestressed Concrete Institute (PCI) for the groups and categories of products that they produce. In addition, the plants are required to submit their Quality Control Plan (QCP) for department review. The QCP includes a copy of the plant's PCI approved Quality Systems Manual (QSM) and any additional specifications or contract document requirements that are not contained within the QSM. Upon the department's acceptance of a plant's QCP and satisfactory initial and annual inspections, the plant is qualified to begin or continue the production of the certified categories of prestressed concrete products for department projects.

Measuring Quality in Prestressed Concrete Products

Major defects are a possible occurrence in prestressed concrete products during the production process. These defects are usually correctable and the proper correction often results in the department's final acceptance of the product. The department, however, does not consider the quality of a corrected product to be as good as the quality of a product that needs no correction. Since the department seeks to place products with the very best quality into service whenever possible, the number of corrected or defective products must be kept to a minimum. In order to encourage prestressed concrete producers to establish and maintain efforts that minimize defects, the department compiles defect rates on a semiannual basis for each prestressed concrete product group. At each plant location, these rates are used as the basis for establishing a "Defect Rate Limit." A defect rate limit is the defect rate that a producer must stay below in order to achieve the required level of product quality that is acceptable to the department.

FDOT compiles the results of the defect rate data for each plant. The defect rate is then calculated and summarized every 6 months, referred to as the monitoring period, beginning July 1 each year. To ensure confidentiality, plants are assigned a blind plant number that is scrambled with each reporting period. An individual plant's defect rates and defect rate limit are reported to the plant only. A summary table, which is made available to all plants, shows prestressed concrete products organized by product type that have similar casting, stressing, and handling characteristics and, therefore, have defect rates and a defect limit that are also characteristic of the group.

Quality Results from a Quality Product

Conceivably repeated measures that exceed the defect rate limit would lead to the conclusion that a plant's QCP was inadequate for the continued production of acceptable products, and certainly inadequate for the production of high-quality products. However, the department has found the measures of quality to be far more valuable as a tool for continuous improvement.

The FDOT and the prestressed concrete industry are using these measures of quality to identify problem areas and to search for the root cause. Consistently measuring quality has shown that assumptions are often wrong. Problems are now known to arise from many parameters that can include the design, materials, production

process, or any related combination. These measures also show that the overall quality of prestressed concrete products have been rated as very good to excellent with many of those products produced with no defects at all.

What's Next?

FDOT and FPCA's experience in the measurement of prestressed concrete product quality is proving to be a valuable tool in the process

of continuous quality improvement. What began as possibly a negative program focused on defects is now viewed as a positive program that provides valuable insight into prestressed concrete products. The FDOT and FPCA's joint partnership has set the stage for a new era of teamwork in identifying and addressing problems where measures show they exist.

Thomas O. Malerk is Director, Office of Materials, Florida Department of Transportation.



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Although precast concrete bulb-tee girders are used most often, unique designs have been created for special situations.

Spokane County Adapts to Project Needs

by Neil Carroll, Spokane County, Washington



The Harvard Road Bridge near Spokane, Washington, features three precast concrete spans to minimize the number of piers. The bridge also spans the adjacent Centennial Trail.



To open up the waterway, the Argonne Road Bridge features cast-in-place concrete box girders, which are used in the end spans and extend over the piers to support the precast concrete drop-in girders in the center span.



The Deep Creek Bridge uses thin-flange precast concrete deck bulb-tee girders with a cast-in-place concrete deck. It is the county's first with integral abutments.

The bridges that we build in Spokane County, Washington, use a variety of precast concrete elements to allow us to be creative in our designs. The majority of the 162 county bridges involve water crossings, with the largest bridges spanning the Spokane River. This presents a variety of challenges. Our definition of a successful project is one that balances the structural, environmental, and functional elements.

Our larger bridges are 450-ft long and incorporate main spans of about 160 ft. These structures are typically continuous for live loads and have been framed with both spliced girders and a combination of cast-in-place concrete box girders and drop-in precast concrete elements. The bridges often are supported on drilled shafts to ensure adequate support for critical scour conditions.

The system that we favor for bridges in the 80- to 120-ft range uses precast, prestressed concrete thin-flange deck bulb-tee girders with a 7-in.-thick cast-in-place deck in a simple-span arrangement. The girders have a top flange width equal to the girder spacing and require a cast-in-place deck. Flange widths are usually in the 6- to 7-ft range. In this system, girder erection is streamlined because welded ties between adjacent girder flanges are not required and difficulties associated with leveling the traditional deck bulb-tee girder are eliminated. In addition, the girder flanges act as the deck formwork. This speeds up construction of the deck, as no wooden forms need to be built or

removed. Our contractors appreciate both time-saving aspects. As the owners, we appreciate that the cast-in-place concrete deck eliminates the maintenance associated with joints in the riding surface. We promote this as a plus to our permitting agencies, as a good-faith effort to get projects constructed within tight time windows and to minimize concrete spills into the waterways. The foundations consist of either driven piles or spread footings, depending on geotechnical and scour conditions.

The use of precast concrete represents a significant upgrade during bridge replacement projects. Often, we are replacing older timber bridges that have span lengths of 40 ft or less. After removing the deteriorated bridge, we cut back the banks on both sides to create a larger hydraulic opening. This also allows better blending with the site. We then replace the shorter span bridge with a much longer precast concrete bridge, which keeps the piers out of the water and creates less environmental impact.

Unique Design Examples

Every project is unique, so we use the design approach that is most appropriate. One of our most dramatic projects spans the Spokane River at Harvard Road near the Centennial Trail, a recreational pathway that follows the riverbank. The design, which incorporated the trail's path into its structure, features eight lines of precast, prestressed concrete spliced girders of five segments each.

The Argonne Road Project, constructed in 2004, was built in two stages. The 339-ft-long, three-span bridge used 89.5-ft-long cast-in-place box girders for the end spans. The box girders extended continuously over the piers, and 100-ft-long precast concrete girders were dropped into the center and then post-tensioned to form a continuous structure. This design allowed us to open up the waterway for better viewing and access.

We are currently constructing the Deep Creek Bridge replacement. This 88-ft-long bridge is framed with thin-flange bulb-tee girders composite with a 7-in.-thick cast-in-place concrete deck. The 38-in.-deep girders have flange widths of 6 ft 1¾ in. They were cast in a traditional deck bulb-tee girder form but instead of casting a 6-in.-thick top flange, a 2-in.-thick flange was used. This bridge is our first with integral abutments, and we will be monitoring its performance with an eye toward eliminating bridge bearings in future designs.

At present, we are conducting framing studies for yet another replacement bridge over the Spokane River, using the relatively new Washington State Department of Transportation "supergirders." With contemplated main spans in the 180-ft range, we anticipate reduced substructure costs and a shortened construction schedule.

The options provided by the numerous precast girder shapes available in Washington State allow us a great deal of flexibility as we strive to meet the challenges that we face in creating new bridge designs.

Neil Carroll is the Bridge Engineer for Spokane County Public Works, Spokane, Washington.



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Using lightweight concrete for bridge rehabilitation can provide the following benefits:

- Wider decks with little or no modification of the existing structure;
- Reduced deck weight to improve the load rating on an existing structure;
- Reduced weight of precast elements for hauling and installation; and
- Enhanced durability.

For more information on lightweight concrete, including a listing of ESCSI members and available publications, please visit www.escsi.org. The members of ESCSI look forward to assisting owners, designers, and concrete producers in using lightweight concrete for bridges.



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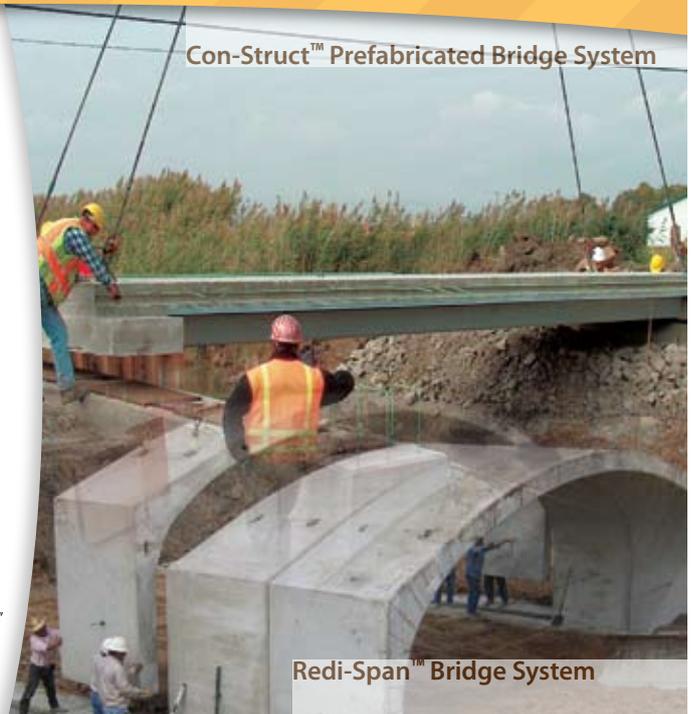
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More 2007 Interim Changes



by Dr. Dennis R. Mertz

A discussion of the revisions and additions to Section 5: Concrete Structures, new to the Fourth Edition of the *AASHTO LRFD Bridge Design Specifications* began in the previous issue of *ASPIRE*.™ This discussion included Agenda Items 8 through 13 as considered by the AASHTO Subcommittee on Bridges and Structures (SCOBs) at their annual meeting in Utah in 2006. The final agenda items from the 2006 meeting relating to concrete bridges—Agenda Items 14 through 15A—are reviewed in this column.

The approximate equations of Article 5.7.3, intended to provide a simplified method of calculating the flexural resistance of reinforced and prestressed concrete members, are modified in Agenda Item 14. The previous equations inherently assume that both the tension and compression reinforcement are yielding at nominal resistance, which is not always the case. For compression reinforcement, a simple check that $c \geq 3d_s$ can assure that the compression reinforcement is at or near yield at nominal flexural resistance. If not, the compression reinforcement can either be conservatively ignored, or a strain compatibility analysis can be performed. For mild steel tension reinforcement, a new limit of $c/d_s \leq 0.60$ assures yielding of the mild steel tension reinforcement in conjunction with the approximate equations.

Agenda Item 15 deals with interface shear transfer or shear friction, concentrating on Article 5.8.4 but including some other articles relating to interface shear transfer. The Third Edition of the *LRFD Specifications* requires substantially more interface shear reinforcement for slab-on-girder bridges than had been required by the *AASHTO Standard Specifications for Highway Bridges*. So much so that interface shear

reinforcement requirements generally govern over vertical (transverse) shear reinforcement requirements.

An extensive review of available literature indicated that the interface shear resistance equation of the Third Edition was extremely conservative relative to experimental data. An effort was made, primarily by Chris Hill of Prestress Services Industries of Lexington, Kentucky, to reevaluate the content and format of the entire article with this agenda item and the subsequent interim changes. The overall objective is to eliminate over-design, introduce proper LRFD notation, eliminate a significant dependence on commentary equations for specification application, and eliminate

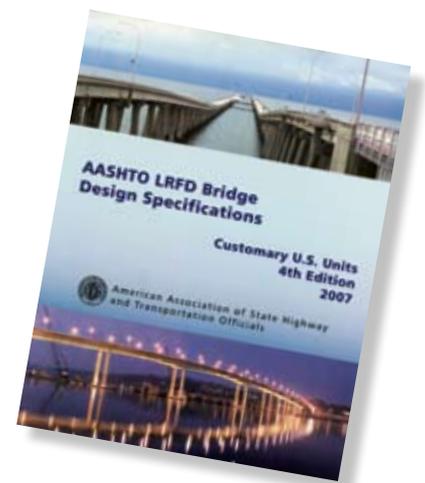
A more economical design for interface shear transfer will result.

numerous changes in units from one portion of the article to another. More economical design of bridges designed on the basis of interface shear transfer will result. A reduction in mild reinforcing steel within the girder, increased jobsite safety by virtue of fewer bars projecting from the top of the girder that construction workers might trip over, and cost savings associated with future slab removal will also be a benefit of this interim change. The end result is a more comprehensive list of cohesion and friction factors that represent a lower bound of the substantial body of experimental data available in the literature. One change from

previous editions is the elimination of different factors for all-lightweight and sand-lightweight concrete.

The final interim change related specifically to concrete bridges adopted in 2006 is Agenda Item 15A which consists of a list of editorial changes to Section 5: Concrete Structures. Despite SCOBs's best efforts to write concise and complete specifications and commentary, editorial changes are needed occasionally to correct mistakes or to provide further clarification. Agenda Item 15A includes 12 editorial changes related to loss of prestress calculations.

With the recent 2007 AASHTO SCOBs meeting in Wilmington, Delaware, in July, a new set of interim changes to the specifications was adopted. These interim changes will be published in 2008 as the first stand-alone changes to the Fourth Edition, and will be reviewed in a future column.



How to do it in Precast...

... a moment-resisting bridge pier or abutment.

Q How is the moment connection made?

A All you need is an emulative detail, reconnect the concrete and rebar.



Edison Bridge, Fort Myers, Florida

Q How do you connect the rebar?

A Use the...
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DF Moment, Interior Girder
For Beam-Stub Bridge (Type A), Two or More Design Lanes:

$$M_{max} = 0.675 \left(\frac{S}{8.5} \right)^{0.75} \left(\frac{S}{L} \right)^{0.25} \left(\frac{K_y}{12.5L^2} \right)^{0.25}$$

where:
S = Beam spacing (ft)
L = Beam length (ft)
t = Slab thickness (in)
K_y = Longitudinal stiffness parameter



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