

SW Line Flyover Bridge, Nalley Valley Interchange

Tacoma, Washington

MON-FAYETTE EXPRESSWAY BRIDGE

Brownsville, Pennsylvania

NORTHEAST 36TH STREET BRIDGE

OVER SR 520

Redmond, Washington

BIG BEAR BRIDGE

*San Bernardino Mountains at Big Bear Lake,
California*

DULLES CORRIDOR METRORAIL

PROJECT AERIAL GUIDEWAYS

Tysons Corner, Virginia

I-80 BRIDGES OVER ECHO DAM ROAD

Echo, Utah

THE COVERED BRIDGE OVER THE

KENNEBEC RIVER

Norridgewock, Maine

SANTA URSULA CONNECTOR

Laredo, Texas

Efficient, Innovative, and Sustainable Concrete Bridges

As part of a design-build team, FIGG works closely with contractors to deliver cost effective, efficient, innovative and sustainable concrete bridges. Focusing on creative solutions and design details early in the process results in quality bridges that can be built quickly and economically.

(top to bottom)

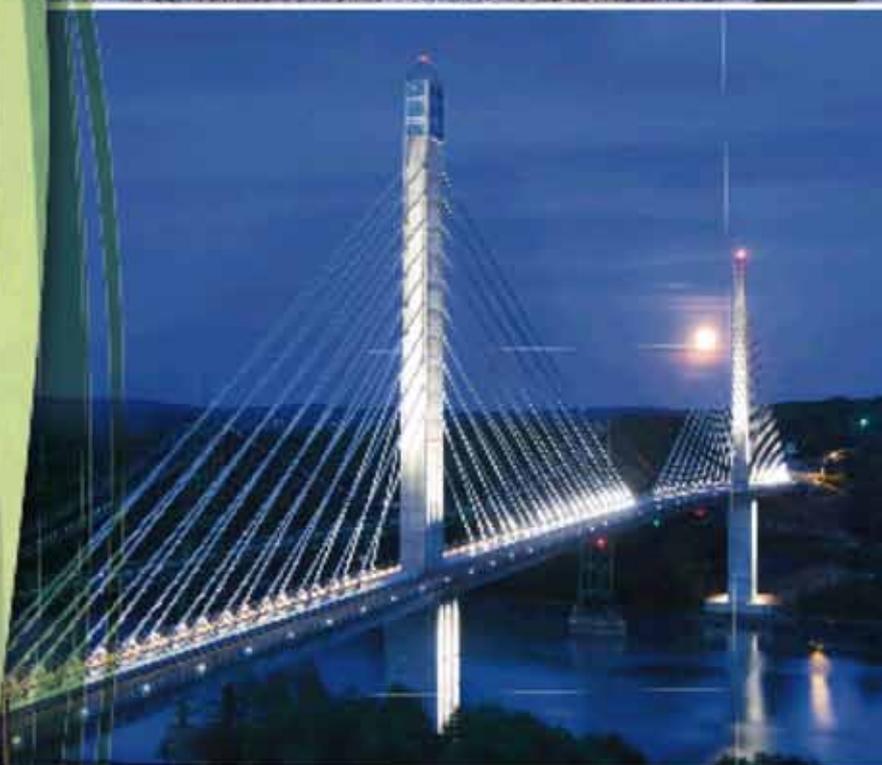
New I-35W Bridge, Minneapolis, Minnesota
504' main span over the Mississippi River
Owner: Minnesota Department of Transportation
Design-Build Team: Flatiron/Manson with FIGG

Penobscot Narrows Bridge and Observatory, Waldo/Hancock Counties, Maine
1,161' cable stayed main span
Owner: Maine Department of Transportation
Owner Facilitated Design-Build:
Cianbro/Reed & Reed (Contractor)
and FIGG (Designer)

Honolulu High-Capacity Transit Corridor Project, Honolulu, Hawaii
11 mile elevated guideway
Owner: City and County of Honolulu
Design-Build Team: Kiewit with HNTB
and FIGG



www.figgbridge.com
1.800.358.3444



Rendering

CREATING BRIDGES AS ART®



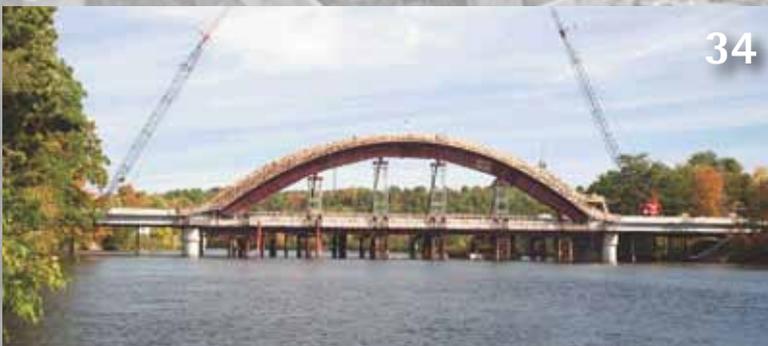
8

Photo: McNary Bergeron & Associates Inc.



22

Photo: California Department of Transportation.



34

Photo: Kleinfelder.

Features

McNary Bergeron & Associates	8
<i>Construction-engineering work helps ensure efficient and cost-effective construction.</i>	
Mon-Fayette Expressway Bridge	14
<i>Value-engineering creates a tall, elegant concrete segmental design for the Pennsylvania Turnpike.</i>	
Northeast 36th Street Bridge over SR 520	18
<i>Creating a level playing field—a bridge and a park built over busy freeway.</i>	
Big Bear Bridge	22
<i>A time to replace—constructing a safer tomorrow.</i>	
Dulles Corridor Metrorail Project Aerial Guideways	26
<i>Connecting the nation's capital with its international airport.</i>	
I-80 Bridges over Echo Dam Road	30
<i>A sliding scale.</i>	
The Covered Bridge over the Kennebec River	34
<i>Re-creating history: modern techniques preserve character of historic bridge.</i>	
Santa Ursula Connector	38

Departments

Editorial	2
Concrete Calendar	4
Reader Response	6
CCC—ARC Wildlife Crossing	12
Aesthetics Commentary	37
FHWA—The Office of Federal Lands Highway	42
Safety and Serviceability	44
STATE—New York State	46
COUNTY—King County, Washington	50
Concrete Connections	52
Buyers Guide	54
AASHTO LRFD—The Fatigue Limit States, Part 2	56

Photo: McNary Bergeron & Associates Inc.

Advertisers Index

Beijing Wowjoint Machinery Co.	41	Hamilton Form Company	17	PCI	7, 29, 45, 53
Bentley Systems Inc.	3	Headwaters Resources.	6	Poseidon Barge	Back Cover
CABA	5	LARSA USA.	21	Reinforced Earth	13
Dywidag-Systems International USA	3	Meadow Burke.	51	T.Y. Lin International	Inside Back Cover
FIGG	Inside Front Cover	Mi-Jack Products.	49		
Flatiron	25	PB	33		



Challenges, Engineers, and Solutions

John S. Dick, *Executive Editor*

Photo: Ted Lacey Photography.

As we review projects for potential use in *ASPIRE*,™ the editorial team can't help but be impressed with how engineers respond to the challenges of envisioning and designing their bridges. This extends to the contractors who execute the designs and the agencies that approve and ultimately accept them. The results are frequently awe-inspiring.

Size doesn't matter: miles of spans or just one, short-spans or long-spans, two lanes or six lanes. We see impressive solutions being used in most bridges around the country these days. The projects described in this issue are no exception.

The Mon-Fayette Expressway Bridge in Pennsylvania saved the owner \$8.5 million with a value-engineering proposal. Sitting on piers up to 200 ft tall, the cast-in-place concrete box girder includes a span of 518 ft. Low-permeability concrete and other measures provide a life expectancy of 100 years. This article begins on page 14.

In Washington State, a unique lid over an expressway connects both parts of a major office complex. It not only provides a vehicular bridge but carries the adjacent landscaping over the freeway with pedestrian-friendly meandering walkways that blend seamlessly into the surrounding environment. Read the article beginning on page 18.

Big Bear Bridge in California comprises a 474-ft-long arch supporting two 237-ft-long equal spans of post-tensioned, cast-in-place concrete box girders. This striking bridge, located near the south branch of the San Andreas Fault, is designed to resist a significant seismic event in part with the use of two 6.5-ft-diameter friction pendulum isolation bearings at the crest of the arch. This feature begins on page 22.

The Dulles Metrorail Aerial Guideway project near the nation's capital is being constructed just feet away from some of the country's heaviest traffic. The first phase of the project is 11.6 miles long, includes 3 miles of aerial guideway, 3 aerial stations, and a 2400-ft-long tunnel. At its highest point, it is 55 ft over

the eight-lane I-495 Capital Beltway. (See page 26)

The twin I-80 Bridges over Echo Dam Road in Echo, Utah, were not built where you will find them today. They were built off line, out of traffic, and then slid into place in a matter of hours each. This permitted the heavily-travelled interstate highway to remain in service except for a brief closure of two lanes. How they did it is explained beginning on page 30.

The Covered Bridge over the Kennebec River in Norridgewock, Me., hasn't been "covered" in many years. The story behind the challenge to create this beautiful structure, only the second major concrete tied arch bridge in the United States, is impressive. The arch spans 300 ft and rises 60 ft above the deck. With a total length of 570-ft, the bridge has no deck joints and incorporates measures that will provide a 100-year service life. The article starts on page 34.

So far, the articles alternate between the east and west coasts. The final featured project is in Texas. The Santa Ursula Connector in Laredo needed to be designed for the condition of being 25 ft below high water level of the Rio Grande River. That required a shallow superstructure and substantial resistance to overturning. The selection of the Texas standard 15-in.-deep, precast, prestressed concrete solid slabs seemed logical. It provided a 22-in.-deep superstructure with a smooth soffit that won't trap debris. But, it was on a sharp horizontal curve. How the designers handled all of the constraints begins on page 38.

Once again, we salute the innovative designers and constructors who have met their challenges head-on. They have provided bridges that not only satisfy the unique site demands but create interesting stories that we are pleased to share in *ASPIRE*. If you have a project that you would like to have considered, whether large or small, please contact us at www.aspirebridge.org and select "Contact Us." We look forward to hearing from you.

Executive Editor

John S. Dick

Managing Technical Editor

Dr. Henry G. Russell

Managing Editor

Craig A. Shutt

Editorial Administration

James O. Ahtes Inc.

Art Director

Paul Grigonis

Layout Design

Tressa A. Park

Ad Sales

Jim Oestmann

Phone: (847) 838-0500 • Cell: (847) 924-5497

Fax: (847) 838-0555

joestmann@arlpub.com

Reprint Sales

Paul Grigonis

(312) 360-3217

e-mail: pgrigonis@pci.org

Publisher

Precast/Prestressed Concrete Institute

James G. Toscas, President

Editorial Advisory Board

William N. Nickas, *Precast/Prestressed Concrete Institute (PCI)*

William R. Cox, *American Segmental Bridge Institute (ASBI)*

Dr. David McDonald, *Epoxy Interest Group (EIG)*

Dr. Henry G. Russell, *Henry G. Russell, Inc.*

John S. Dick, *J. Dick Precast Concrete Consultant LLC*

POSTMASTER

Send address changes to *ASPIRE*

200 W. Adams St., Suite 2100

Chicago, IL 60606.

Standard postage paid at Chicago, IL, and additional mailing offices.

ASPIRE (Vol. 5, No. 4),

ISSN 1935-2093 is published quarterly

by the Precast/Prestressed Concrete Institute

200 W. Adams St., Suite 2100

Chicago, IL 60606.

Copyright 2011, Precast/Prestressed Concrete Institute.

If you have a project to be considered for *ASPIRE*, send information to *ASPIRE*

200 W. Adams St., Suite 2100

Chicago, IL 60606

phone: (312) 786-0300

www.aspirebridge.org

e-mail: info@aspirebridge.org

Cover

SW Line Flyover Bridge, Nalley Valley Interchange, Tacoma, Washington

Photo: Guy F. Atkinson Construction LLC.

Log on NOW at www.aspirebridge.org and take the *ASPIRE* Reader Survey.



Precast/Prestressed Concrete Institute



American Segmental Bridge Institute



Epoxy Interest Group



Silica Fume Association



Expanded Shale Clay and Slate Institute



Portland Cement Association



Bridge Information Modeling – It's *everything* to do with the bridge.

Bridge Information Modeling (BIM) is a compelling new methodology for project delivery that dramatically improves bridge quality and reduces risk. Using the Bentley bridge solution for BIM, engineers develop and employ an unprecedented depth of information about the bridge as they streamline the entire bridge development process, design through construction engineering.

Join the world's top engineering consultancies. Choose the Bentley bridge solution for BIM – and the satisfaction of delivering safe, sustainable bridges on time and on budget.

Only Bentley can take you there. www.bentley.com/ASPIRE



© 2010 Bentley Systems, Incorporated. Bentley, the "B" Bentley logo, and LEAP are either registered or unregistered trademarks or service marks of Bentley Systems, Incorporated or one of its direct or indirect wholly-owned subsidiaries. Other brands and product names are trademarks of their respective owners.



RELY ON DSI

DYWIDAG-SYSTEMS INTERNATIONAL



Local Presence - Global Competence

www.dsiamerica.com



**DYWIDAG-Systems
International USA, Inc.**

320 Marmon Drive
Bolingbrook, IL 60440, USA
Phone (630) 739-1100
Fax (630) 739-5517

DYWIDAG Bonded
Post-Tensioning Systems

DYWIDAG Unbonded
Post-Tensioning Systems

External Prestressing

DYNA Bond® Stay Cable Systems

DYNA Grip® Stay Cable Systems

DYNA® Force Sensor System

Structural Repair and
Strengthening Solutions

Business Unit Post-Tensioning & Reinforcement

320 Marmon Drive
Bolingbrook, IL 60440, USA
Phone (630) 739-1100

2400 N.Hwy 287, Suite 106
Manfield, TX 76063, USA
Phone (817) 473-6161

5139 South Royal Atlanta Drive
Tucker, GA 30084, USA
Phone (770) 491-3790

1591 E. Atlantic Blvd #200
Pompano Beach, FL 33060, USA
Phone (954) 532-1326

Structural Repair and Strengthening
Jason Caravello
Phone (630) 972-7513

2154 South Street
Long Beach, CA 90805, USA
Phone (562) 531-6161

1263 Newark Road
Toughkenamon, PA 19374, USA
Phone (610) 268-2221

dsiamerica@dsiamerica.com

CONTRIBUTING AUTHORS



M. Myint Iwin is director of the FHWA Office of Bridge Technology in Washington, D.C. He is responsible for the National Highway Bridge Program direction, policy, and guidance, including bridge technology development, deployment and education, and the National Bridge Inventory and Inspection Standards.



Dr. Dennis R. Mertz is professor of civil engineering at the University of Delaware. Formerly with Modjeski and Masters Inc. when the *LRFD Specifications* were first written, he has continued to be actively involved in their development.



Frederick Gottemoeller is an engineer and architect, who specializes in the aesthetic aspects of bridges and highways. He is the author of *Bridgescape*, a reference book on aesthetics and was deputy administrator of the Maryland State Highway Administration.

MANAGING TECHNICAL EDITOR



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.

*Photo:
Ted Lacey Photography.*

CONCRETE CALENDAR 2011/2012

For links to websites, email addresses, or telephone numbers for these events, go to www.aspirebridge.org and select "EVENTS."

October 22-25, 2011

PCI Annual Convention and Exhibition and National Bridge Conference

Salt Lake City Marriott Downtown and Salt Palace Convention Center
Salt Lake City, Utah

October 31–November 4, 2011

National Bridge Management, Inspection, and Preservation Conference

Millennium Hotel – Downtown
St. Louis, Mo.

November 1-3, 2011

Concrete and Concrete Repair School

Sponsored by the United States Department of Interior–Bureau of Reclamation
Registration Deadline is October 14, 2011. Limited to 30 participants.
Denver Federal Center
Denver, Colo.

November 7-8, 2011

ASBI 23rd Annual Convention

Washington Marriott Wardman Park
Washington, D.C.

November 14-19, 2011

PCI Quality Control & Assurance Schools, Levels I, II & III

Embassy Suites Nashville Airport Hotel
Nashville, Tenn.

January 22-26, 2012

91st Annual Meeting Transportation Research Board

Marriott Wardman Park, Omni Shoreham, and Hilton Washington
Washington, D.C.

January 23-27, 2012

World of Concrete 2012

Las Vegas Convention Center
Las Vegas, Nev.

February 16-18, 2012

4th International Conference on Grouting and Deep Mixing

Sponsored by the International Conference Organization for Grouting and the Deep Foundations Institute
Marriott New Orleans
New Orleans, La.

March 18-22, 2012

ACI Spring Convention

Hyatt Regency Dallas
Dallas, Tex.

April 16-17, 2012

ASBI 2012 Grouting Certification Training

J.J. Pickle Research Campus
The Commons Center
Austin, Tex.

May 20-25, 2012

14th International Conference on Alkali-Aggregate Reactions in Concrete

Hyatt Regency Austin
Austin, Tex.

June 10-13, 2012

International Bridge Conference

David L. Lawrence Convention Center
Pittsburgh, Pa.

July 7-12, 2012

2012 AASHTO Subcommittee on Bridges and Structures Meeting

Hyatt Regency
Austin, Tex.

July 23-27, 2012 (Tentative)

2012 PCA Professors' Workshop

Skokie, Ill.

September 29-October 3, 2012

PCI Annual Convention and Exhibition and National Bridge Conference

Gaylord Opryland Resort & Convention Center
Nashville, Tenn.

PRESTRESSED CONCRETE BRIDGES



PHOTO OF ROUTE 70 OVER MANASQUAN RIVER IN NEW JERSEY (PHOTO COURTESY ARORA ASSOCIATES).

ALTERNATE STRUCTURE DESIGN UTILIZES PRECAST CAISSONS, PIERS, PIER CAPS, AND PRESTRESSED BEAMS AND WAS OPENED TO TRAFFIC TWO YEARS AHEAD OF AS-DESIGNED SCHEDULE.

AN OPTIMUM SOLUTION TO BENEFIT:

THE PUBLIC - AESTHETIC, DURABLE, AND SAFE

THE OWNERS - LOW MAINTENANCE AND LIFE CYCLE COSTS

THE DESIGNERS - WELL ESTABLISHED STANDARDS - SIMPLE TO DESIGN

THE CONTRACTORS - FAMILIAR MATERIAL - FAST TO CONSTRUCT

THE ENVIRONMENT - LOW ENERGY CONTENT AND SUSTAINABLE SOLUTION



CERTIFIED PLANTS AT YOUR SERVICE IN THE CENTRAL ATLANTIC REGION



Bayshore Concrete Products
1134 Bayshore Road
Cape Charles, VA 23310
Phone: (757) 331-2300
Fax: (757) 331-2501
www.usacivil.skanska.com
Email: Chad.Saunders@skanska.com



Northeast Prestressed Products, LLC.
121 River Street
Cressona, PA 17929-1133
phone: 570-385-2352
fax: 570-385-5898
www.nppbeams.com
Email: info@nppbeams.com



Jersey Precast Corporation
853 Nottingham Way
Hamilton Township, NJ 08638
phone: 609-689-3700
fax: 609-689-3797
www.jerseyprecast.com
Email: jrjprecast@aol.com



Newcrete Products, Inc.
P.O. Box 34
301 Plum Creek Road
Roaring Spring, PA 16673-0034
phone: 814-224-2121
www.newcrete.com
Email: ggorman@nesl.com



Central Atlantic Bridge Associates

1042 North Thirty Eighth Street • Allentown, PA 18104
Telephone: (610) 395-2338

READER RESPONSE

Editor,

We at T.Y. Lin International thank you for including the Stewart Street Bridge, Cypress Avenue Bridge and the article on architectural lighting in the Summer 2011 issue. We have received many communications from colleagues and partners around the country who appreciated the information that ASPIRE™ presented on these projects. The two common comments focused on how the projects are the appropriate scale for the majority of the bridge work in the United States and that aesthetically pleasing structures can be built even with limited budgets.

The staff at ASPIRE, which is dedicated to concrete bridges, should be proud to know that some of the comments were from roadway professionals! This speaks volumes to the diverse readership both geographically and within the vast engineering community in the U.S.

Thank you again for including T.Y. Lin International's projects in ASPIRE.

Michael Fitzpatrick
Associate Vice President
T.Y. Lin International
San Francisco, Calif.

Editor,

Thank you for such a beautiful presentation on our project [SR 519 Intermodal Access Project, ASPIRE Summer 2011].

Alexandra Spencer
AECOM
Los Angeles, Calif.

Editor,

Just saw the Summer Edition on-line and you did a wonderful job of presentation [Stewart Street Bridge, ASPIRE Summer 2011]. Thanks for the article; nice to see the final result! Fred's [Gottemoeller] comments [Aesthetic Commentary] very well represent what we were after as well!

Michael (Mike) A. Avellano
Vice-President
Woolpert
Atlanta, Ga.

Editor,

I wanted to take the time to compliment you and your staff at ASPIRE. I very much enjoy reading ASPIRE. The feature articles are always well chosen, and the quality of the entire publication is excellent. It has been said that the difficult task in creating interesting and informative technical writing is to convey your message as briefly as possible and then allow your readers to do their own further fact finding as needed. Your featured topics are succinctly presented and cover a broad spectrum of bridge engineering and construction.

Keep up the great work. I look forward to receiving the next issue.

William J. Cichanski
Consultant
Tacoma, Wash.



EDITOR'S NOTE

Additional copies of ASPIRE may be purchased for a nominal price by writing to the Editor through "Contact Us" at the ASPIRE website, www.aspirebridge.org. A free subscription can be arranged there using the "Subscribe" tab.

HOW TO
combat global warming,
reduce the
production of greenhouse gases,
and build a
stronger infrastructure.

SPECIFY FLY ASH

(a recovered resource)

as a replacement for cement in concrete.

When you specify fly ash as replacement for cement in concrete, you help reduce CO₂ emissions from cement production, conserve landfill space, and decrease water usage. You also enhance workability and chemical attack resistance, increase strength and produce more durable concrete.

Contact Headwaters Resources for free technical literature and information on how fly ash use benefits the environment and produces better concrete.

HEADWATERS
RESOURCES

1-888-236-6236
www.flyash.com



2012 Call for Papers— Abstracts due February 6, 2012!



PCI Convention and National Bridge Conference September 29–October 3, 2012 Gaylord Opryland, Nashville, Tennessee

PCI is accepting abstracts for technical papers to be presented at the 2012 PCI Convention and National Bridge Conference in Nashville, Tennessee. Abstracts and papers will be peer-reviewed and accepted papers will be published in the conference proceedings.

The PCI Convention and National Bridge Conference is the premier national venue for the exchange of ideas and state-of-the-art information on precast concrete design, fabrication, and construction. The event attracts an average of 1,000 participants each year and provides an outstanding opportunity for networking, education, and sharing of ideas. Don't miss out on this excellent opportunity to share your knowledge—submit your abstract today!

Submission Requirements

Abstracts should be submitted electronically. Visit www.pci.org and click on the Call for Papers button to access the submission site.

The 2012 Call for Papers submission site will open November 14, 2011.

Contact:

Transportation: William Nickas, wnickas@pci.org
Buildings: Brian Miller, bmiller@pci.org



Precast/Prestressed Concrete Institute
200 West Adams Street | Suite 2100 | Chicago, IL 60606-6230
Phone: 312-786-0200 | Fax: 312-621-1114 | www.pci.org

Bridging the Gap

McNary Bergeron's construction engineering work helps ensure efficient and cost-effective construction by Craig A. Shutt



McNary Bergeron provided construction engineering for the cast-in-place arch structure and temporary stay-cable system used to support the Hoover Dam Bypass Colorado River Bridge. It was one of the first high-profile projects for the company, which was founded in 2003. All photos: McNary Bergeron & Associates Inc.

Contractors usually call on McNary Bergeron & Associates only when the going gets tough—and that’s just the way the company’s engineers like it. The firm specializes in taking complex designs and making them more constructible, ensuring the owner and designer’s vision becomes reality. That has led the 8-year-old company into some high-profile and extremely challenging concrete projects.

“We usually get involved in projects that are complex,” says Scott McNary, a principal in the Broomfield, Colo.-based construction engineering firm. “We work on the problem children, the projects that are difficult to build. And we enjoy those challenges.” The company’s goal is simple, adds Principal Jim Bergeron, who heads the firm’s other office in Old Saybrook, Conn. “Our niche is to help contractors and designers be successful.

We can bridge the gap between design and construction because we speak both languages.”

The firm was founded in 2003 by McNary and Bergeron along with Jeremy Johannesen. All three had experience with large engineering firms prior to partnering. “We wanted to get back to our roots of working directly with contractors to help them with the construction of complex bridges,” Bergeron says. Since easily designed projects seldom need construction engineering support, the engineers usually are working on complex projects. Those often involve concrete construction—or ones that become concrete during the value-engineering process, says Johannesen.

“We do some designing, especially when value engineering is required,”

he says. “But 90% of our work is construction engineering of existing designs to make them more efficient to build.”

Fast Start with Hoover Dam

Most commissions result from relationships with designers or contractors with whom the partners have worked on past projects, McNary explains. Those connections helped them become part of a high-profile project shortly after the firm was created: The Hoover Dam Bypass Colorado River Bridge in Nevada and Arizona.

The company provided construction engineering services for the cast-in-place arch structure and the temporary stay-cable system used to support it. That work included design of the anchorages, towers, and cable construction for the arch ribs as well as the rib shop drawings and an independent review of the form-traveler design.

“There were many challenges involved in bringing that design to fruition,” says Johannesen. “We basically worked with the contractor to create a tower and anchorage system that would streamline the concrete construction. The end result worked extremely well.”

The company’s expertise in arch work paid off when it became involved in the Covered Bridge over the Kennebec River in Norridgewock, Maine, which has just been completed. The project features a cast-in-place concrete tied arch spanning 300 ft. McNary Bergeron provided construction analysis for the new arch and erection plans and procedures, as well as design of the temporary arch shoring and a demolition plan for the existing arches. (See the article on this bridge on page 34.)

"There is nothing similar to this in Maine, or even in most of the country," says Bergeron. "It's a complicated arch structure, but it's very distinctive and memorable."

Contractor Modifications

Much of the work the firm does falls under the heading of "contractor modifications," which it performs for most of its projects, rather than value engineering, which it does less frequently, McNary explains. Construction modifications leave the structural engineering as it is, with only some aspects changing. For value-engineering work, the firm changes the shape or materials being used, making substantial alterations to better suit the contractor's needs and expertise.

An example of construction modifications can be seen in the Route 36 Highlands Bridge over the Shrewsbury River in Monmouth County, N.J. The new design, which replaced a worn-out 1932 structure, was designed as a two-span fixed, four-lane, precast concrete segmental box structure with a 65-ft clearance (raising the previous clearance by 30 ft).

McNary Bergeron helped design the precast concrete cofferdams and support systems for the footing construction and provided integrated shop drawings for precast concrete column and superstructure segments. It also developed and designed the falsework, cantilever-stability system, lifting assemblies, and rigging. All of the components were barged to the site because land access was difficult.

"The key to the project was speed of construction," explains Bergeron. Each of the twin bridges had to be erected in a construction season. The total-precast concrete design allowed portions to be cast in advance and floated to the site for erection. Aesthetics also played a role in the structure type, he notes. "It's a very visible structure, so aesthetics were especially important to the owners."

The firm currently is working on the design for a similar project, the Veterans Memorial Bridge Replacement in Portland, Maine, as part of a design-build team. McNary Bergeron created the constructability review of the twin-bridge superstructure, providing recommendations on segment layout, post-tensioning details, fabrication and erection efficiencies, and alternative erection procedures. The bridge features span lengths up to 250 ft, with precast units by the same precaster used on the Route 36 Highlands Bridge. The bridge was designed to replicate some of the Route 36 bridge plans, allowing the precaster to reuse the forms, thereby saving costs.

"There are often many ways to construct a bridge, and we always steer the design to favor repetition of components to take full advantage of precast concrete's capabilities," says McNary. "These ideas help the contractor be more efficient, which saves money."

Value-Engineering Work

Value-engineering projects include the Nalley Valley Interchange on I-5 through Tacoma, Wash. "We assisted

Projects in Aspire

Projects in which McNary Bergeron participated were featured in the following *ASPIRE*[™] articles, which can be viewed in the Magazine section at www.aspirebridge.org:

- San Francisco-Oakland Bay Bridge (Winter 2007)
- Susquehanna River Bridge (Spring 2007)
- Selmon Expressway (Fall 2007)
- Seattle Sound (Spring 2008)
- Maroon Creek (Spring 2008)
- Washington Bypass N.C. (Fall 2008)
- Folsom Lake Crossing (Winter 2009)
- Crosstown Project (Minn.) (Spring 2009)
- Fulton Road Bridge (Spring 2009)
- Galena Creek Bridge (Winter 2010)
- Hoover Dam Bypass, Colorado River Bridge (Spring 2010)
- Route 36 Highlands Bridge (Summer 2010)
- Nalley Valley Interchange (Summer 2011)
- MIC-Earlinton Heights Connector (Summer 2011)

the contractor in procuring the contract by redesigning two expensive steel bridges to more economical concrete structures," says Johannesen. As part of that, the SW Line Bridge was redesigned from a steel tub-girder bridge to a precast concrete segmental box girder design.

"The alignment was well suited to the precast segmental design, so we maintained the alignment but designed the bridge for concrete. We created the basic configuration that best suited the contractor and the precaster for casting and handling the components the whole way through the project." The change also suited the owner because of the extended design life and reduced maintenance.

A dramatic cast-in-place concrete tied arch with steel cable hangers serves as the key visual element on the Covered Bridge over the Kennebec River in Norridgewock, Maine. The design is the first of its type in the state and in the eastern half of the United States. McNary Bergeron provided construction analysis for the new arch, which spans 300 ft.





Speed of construction was a key reason that McNary Bergeron helped create the all-precast concrete design for the Route 36 Highlands Bridge over the Shrewsbury River in Monmouth County, N.J. Each of the twin bridges were cast and erected in a construction season, providing access year round while construction continued.

The temporary bridge that was to provide access while the new bridge was constructed was value-engineered from a steel design into a precast concrete bulb-tee girder design. "Precasters can cast deck bulb tees with specified camber, so we don't create haunched buildup construction," McNary explains. "The owners liked this design, because it simplified the construction and provided the image that the 'temporary' bridge could last as long as needed."

A design-build contractor will often have a construction engineer on his

team. A key reason is the capability to maximize speed of construction, Johannesen adds. "Speed is more important all the time. Owners are looking at all of the costs and realizing that the faster they can complete the project, the more they can save in labor and user costs. We help that by finding ways to do engineering and fabrication of components ahead of time. The more time spent upfront before getting to the site, the more efficient the process will be."

"Speed is a key focus, because almost every project is a replacement project that is in high use already,"

The Nalley Valley Interchange on I-5 through Tacoma, Wash., represents one of the few value-engineering projects that McNary Bergeron has done. The two bridges were redesigned from steel tub-girders to a precast concrete segmental box-girder design. The change reduced costs while maintaining the original alignment.



says Bergeron. "There are few 'new' bridges being built. Almost always, we are taking something down to put up a new structure."

New Techniques Aid Efficiency

The engineers are keeping a close eye on techniques that will help achieve that goal, including the use of self-propelled modular transporters (SPMTs). "There are a number of new pieces of equipment and devices that hold a lot of promise for making it more efficient to construct bridges," Bergeron says.

Advances are being made especially for handling precast concrete components, agrees Johannesen. "Beams and girders are getting larger as creative ways are found to transport and maneuver them," he says. "As soon as cranes get bigger, a new girder is designed to take advantage of their capabilities." Mobile lifting cranes and gantries also are getting more robust, he says.

New equipment will make bridge designs more efficient to build, adds Bergeron. "It always comes down to cost, and if a crane can be used, that's the way to go. So as cranes get more versatile, they become even more popular. Especially when land access is limited, it's important to have other ways to access the site, and better equipment is helping to meet tighter schedules and budgets."

Tendon-grouting with segmental designs has grown in importance, with

new requirements for post-tensioning systems creating more complexities. "The growing use of duct couplers offers a wide-open field for building a better mousetrap," says Johannesen. The couplers are cast into the concrete during match-casting procedures, and then broken apart so the second coupler can be cast into the next component to ensure an air-tight seal.

Higher compressive strengths that provide longer, lighter concrete spans also offer potential, McNary says. The firm is using more 75-ksi reinforcement in its designs as well as looking closely at "superstrand," which provides a 7% larger cross-sectional area for use with post-tensioning.

Such technologies and techniques will add new weapons to McNary Bergeron's arsenal, helping to meet challenges as bridges grow in complexity. "We are advocates for contractors, to ensure bridges are built efficiently and economically," says McNary. "We can have a big impact on the industry as a whole by working closely with contractors to ensure projects go the way the contractor needs them to go. That can create innovative approaches that others can use."

For additional photographs or information on this or other projects, visit www.aspirebridge.org and open Current Issue.



By designing Veterans Memorial Bridge Replacement in Portland, Maine, in a similar style to the earlier Route 36 Highlands Bridge in New Jersey, McNary Bergeron allowed the precaster, who was the same for both projects, to reuse the original forms, saving costs.

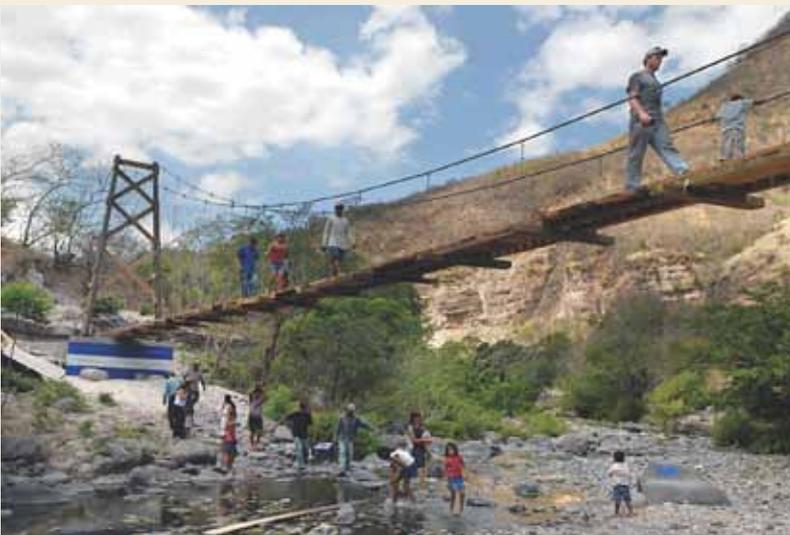
Bridges to Prosperity

The founders of McNary Bergeron believe in giving back to their own community and to the world community. They have maximized the use of their own skills while meeting this goal by working with Bridges to Prosperity Inc. The group literally builds bridges between people in underdeveloped countries, via pedestrian suspension bridges. The work helps connect remote areas, making it easier to access food and medical help.

Although mountainous areas provide easy design opportunities for suspension bridges, about half of the organization's bridges span flat flood plains with no natural features from which to suspend bridges. McNary Bergeron saw an opportunity to help overcome that obstacle in 2005, says Jeremy Johannesen, who serves on the organization's Advisory Board. Scott McNary also serves on the group's Executive Board.

"We work with them to design suspension towers so they can get above the water more easily," Johannesen explains. "When problems arise, we work with the contractors to solve them." Frequently, that has included personnel from Flatiron Construction, which began volunteering with the group in 2008. The firm sends young engineers to help build these bridges to gain real-life experience.

An example is the La Pintada suspension footbridge over the Rio Copan in Honduras, which was constructed in the spring of 2010. The four communities that lay beyond the river can now safely cross the waterway during high-water season. "The challenge was immense, but the product incredibly rewarding," Johannesen says. Based on the relationships built during this project, he adds, future Bridges to Prosperity projects in the area may be on the way.



McNary Bergeron's work with Bridges to Prosperity Inc. has included La Pintada suspension footbridge in Honduras. This bridge connects four formerly inaccessible communities. The firm helped design the structural towers that support the bridge on the low-lying plain, which had been an obstacle to creating the bridge previously.

"hypar-nature" — A precast concrete design for wildlife crossings

by Angela Kociolek, Western Transportation Institute at Montana State University

Concrete, an old material cast in a new way, claimed top position in the ARC International Wildlife Crossing Infrastructure Design Competition. Calling for “New Methods, New Materials, New Thinking,” the competition presented a mighty challenge to the world’s design community: Develop a feasible, buildable, context-sensitive, and compelling design solution for a safe, efficient, cost-effective, and ecologically responsive wildlife crossing structure.

HNTB Engineering with Michael Van Valkenburgh Associates Inc. and Applied Ecological Services Inc. (HNTB+MVVA) responded to the engineering and ecological challenge and won with “hypar-nature”—a hyper (hyperbolic paraboloid) vault. Their design may set the precedent for the next generation of infrastructure that re-connects wildlife habitats bisected by roads.

The “hypar-nature” bridging system consists of precast modules that serve as abutment, beam, and deck—all in one. This single element—created using straight line, commercially available formwork—is the key to cost-effectiveness, speed of construction, and modularity. Two modules are joined at the midspan acting as a three-hinged arch, eliminating the need for a center pier. No on-site concrete work is required. Instead, the hyper modules are optimized for being efficient to transport, erect, combine, and recombine as needed. The same modules, oriented differently, can also incorporate bicycle paths separated from traffic and the wildlife crossing above.*

The five-expert jury, chaired by Charles Waldheim of Harvard University’s Graduate



Model depicting the construction process. Note temporary falsework in place as a central pier, the one-crane operation using a balanced pick point, and maintenance of traffic flow along one side of the roadway. All images: ARC.

School of Design, determined that HNTB+MVVA’s proposal “marries well a simple elegance with a brute force. It effectively recasts ordinary materials and methods of construction into a potentially transcendent work of design. . . it could be credibly imagined as a regional infrastructure across the inter-mountain west.” One juror summed up the jury’s collective thoughts, “The winning proposal by HNTB+MVVA is not only eminently possible; it has the capacity to transform what we think of as possible.”

The ARC Competition concluded in January 2011, but the ARC Partnership continues to collaborate in support of wildlife crossing infrastructure for improved landscape connectivity and highway safety (www.arc-competition.com).

* Specifications about “hypar-nature” were drawn directly from HNTB+MVVA’s submission.

Angela Kociolek is a research scientist with the Western Transportation Institute at Montana State University in Bozeman, Mont., and is the technology transfer initiative leader for the ARC Partnership.

HNTB+MVVA’s winning design offers hope that mobility for people and wildlife does not have to be mutually exclusive.



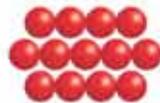
In an artist’s rendition, the “hypar-nature” design appears to seamlessly connect habitats on both either sides of the roadway. Best management practice is to install 8-ft-tall wildlife fencing in combination with crossing structures. This reduces wildlife-vehicle collisions on the roadway while guiding animals towards the structure.



The Reinforced Earth Company has forty years of experience designing structures and supplying materials to contractors and owners for construction of retaining walls, sound walls and precast concrete arches for use in all types of civil engineering applications.

We have a reputation for engineering excellence, architectural creativity, and an unyielding focus on quality and customer support, which is why we are recognized as the market leader.

Make your next project a success by selecting Reinforced Earth®.



REINFORCED EARTH®
SUSTAINABLE TECHNOLOGY

PROJECT

A TALL ORDER

Value-engineering creates a tall, elegant concrete segmental design for the Pennsylvania Turnpike

by Brice Urquhart, FIGG, and James Stump, Pennsylvania Turnpike Commission

Long, arching spans and tall, slender piers create an elegant concrete segmental bridge across the Monongahela River near Brownsville, Pa. Value-engineering the project from a steel plate-girder design saved \$8.5 million while addressing challenges in the planning and construction phases to produce a unique design.

The bridge is part of an extensive expansion to the Mon-Fayette Expressway that supports efforts by the National Road Heritage Park. The project's goal is to provide relief for Route 40, shifting it from a major transportation artery to more of a local

traffic corridor and tourist destination. The bridge accomplishes this by improving access, addressing future capacity requirements and drawing traffic (especially trucks) off Route 40 and onto more modern thoroughways. The project closes a gap in the system between U.S. Route 119 in Uniontown and PA Route 88 in California, Pa.

Filling the gap required approximately 17 miles of new limited-access highway costing \$605 million. The bridge, a major new crossing of the Monongahela River, consists of 12 major sections, with this new structure commonly referred to as Section 51H.

Value-Engineered Savings

The Pennsylvania Turnpike Commission provided the opportunity for an alternate-design concept to the original steel design. That led FIGG to team with Walsh Construction to create a segmental-concrete option that was considerably more efficient. Walsh's personnel had experience with this design type and were confident of their approach.

In part, that was due to their successful construction of a similar design, also produced by FIGG, for the nearby I-76 Allegheny River Bridge in Cheswick, Pa. (See *ASPIRE*,™ Spring 2009.) That project consisted of a 2350-ft-long structure with 100-ft-tall piers and featured the first use of balanced cantilever construction in Pennsylvania. That similarity for a recent design and local accessible expertise ensured an effective and efficient project for the new structure.

The impact of tall piers, limited access, and river, road, and railroad crossings on the construction was minimized by using balanced cantilever concrete segmental construction. To maximize savings, pier locations were adjusted to

This rendering of the Monongahela Bridge, still under construction until next spring, shows the sleek design of the superstructure that complements the piers that are up to 200 ft tall. All photos, drawings, and rendering: FIGG.



profile

MON-FAYETTE EXPRESSWAY BRIDGE / BROWNSVILLE, PENNSYLVANIA

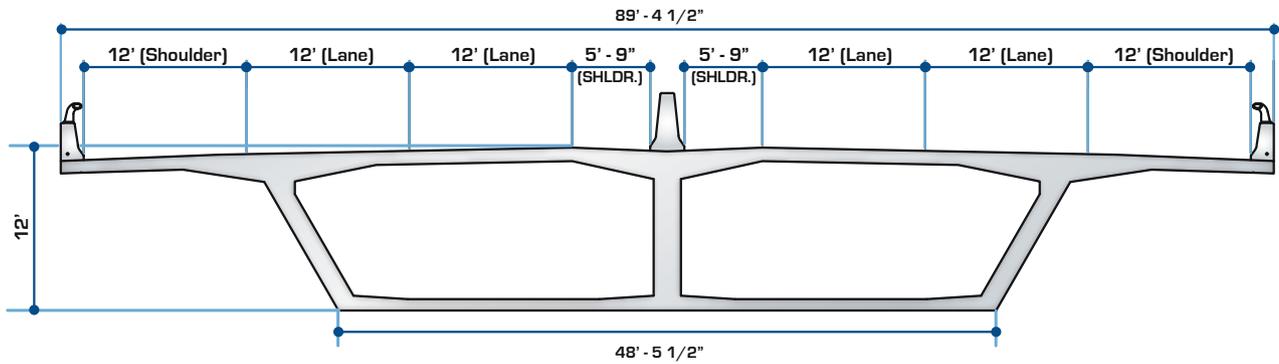
BRIDGE DESIGN ENGINEER: FIGG, Philadelphia, Pa.

CONSTRUCTION MANAGEMENT/CONSTRUCTION INSPECTION: SAI Consulting Engineers, California, Pa.;
Finley Engineering Group, Tallahassee, Fla.

PRIME CONTRACTOR: Walsh Construction Co., Canonsburg, Pa.

CONCRETE SUPPLIER: Stone & Company, Charleroi and Uniontown, Pa.

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



Monongahela River Bridge box girder cross section at mid-span.

eliminate two piers and provide a design more efficient for a concrete segmental bridge. The pier closest to the river bank on both sides was retained in its original position to speed the permitting process.

The design concept was bid by the contractor and approved by the Pennsylvania Turnpike Commission before final design drawings were completed. The project proceeded on a fast-track basis, with initial construction of foundations beginning as later drawings were being completed.

The fast-track process required a close relationship between Turnpike officials and the contractor, so they could work quickly through design-review meetings and facilitate reviews. This communication ensured that approvals were received in a timely manner so the contractor could proceed with foundations, piers, and the superstructure as the plans and project site were ready.

The 3022-ft-long bridge features seven spans, with a configuration of 259, 490, 490, 518, 504, 497, and 264 ft. The concrete segments consist of 89-ft 4½-in.-wide, dual-cell box girders with a center-web thickness of 2 ft and an outside-web thickness of 1.5 ft. The segment depth varies from 12 ft at midspan to 27 ft 2 in. at the river piers

and 26 ft 7 in. at the land piers. The deck has an 11-in. minimum thickness. The bottom slab thickness varies from 3 ft 10 in. at the pier tables to 10 in. at midspan. The dual box design was chosen due to the wide structure, which carries four 12-ft-wide lanes, two 12-ft-wide shoulders, and a 14-ft-wide median.

200-Ft-Tall Piers

The key challenge came in designing the six piers, which range in height from 100 to 200 ft. That significant height required a sleek design that was in keeping with the thin profile of the superstructure, which was minimized further by the tall piers.

The piers were cast with 15-ft-tall jump forms that were advanced upward after each lift of concrete was placed and cured. The specified 28-day concrete compressive strength was 5500 psi. The two piers at the river banks were octagonal in shape with a 50-ft-tall solid concrete base to resist barge impacts, with the remaining 150 ft cast with a hollow center.

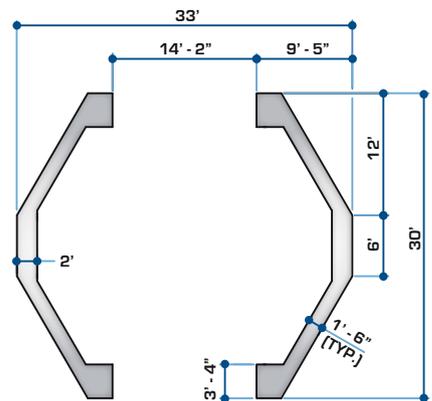
The approach piers further away from the river were designed as two, C-shaped, walled structures. They used the octagonal river pier shape split in two. This design aided flexibility and load-sharing via the twin walls and helped to balance the superstructure

during construction while maintaining a consistent look to all of the piers.

The bridge is on a tangent alignment, and the deck is cast with cross-slopes to allow for drainage in both directions. Turnpike officials also had concerns with sulfate levels in the soils due to a local mining quarry. To alleviate those concerns, the footing and first lift of Pier 6 and Abutment 2 concrete elements were cast with moderate sulfate-resistant concrete using Type II cement.

The pier design was created to enhance the efficient and sleek appearance of the segmental superstructure. The goal was to eliminate wasted concrete and

Monongahela River Bridge pier cross section for C-shaped piers on land.



CAST-IN-PLACE CONCRETE SEGMENTAL BOX-GIRDER BRIDGE BUILT IN BALANCED CANTILEVER ON CAST-IN-PLACE CONCRETE PIERS / PENNSYLVANIA TURNPIKE COMMISSION, HARRISBURG, PENNSYLVANIA, OWNER

BRIDGE DESCRIPTION: Seven-span, 3200-ft-long, two-cell concrete segmental box-girder bridge with spans of 259, 490, 490, 518, 504, 497, and 264 ft, and with concrete piers 100 to 200 ft tall

STRUCTURAL COMPONENTS: Variable-depth, two-cell cast-in-place concrete segments that vary from 12 ft to 27 ft 2 in. deep with an 89-ft 4-in.-wide deck, two octagonal concrete piers at the river, and other piers shaped like the river piers split apart into twin walls

BRIDGE CONSTRUCTION COST: \$95 million

minimize the structure in the piers, pier caps, or superstructure to ensure no disruptions to the smooth lines. The piers provide a look that respects the context of the site, creating a different appearance from every perspective owing to their geometric shapes.

Limited Site Access

The balanced cantilever method was used on the project due to the limited access at the site. Using cast-in-place concrete with form travelers minimized equipment on the ground and equipment to lift components 200 ft in the air. However, the remote project area and tall piers created challenges for concrete placement for the superstructure. Concrete was pumped from the ground to the forms.

The box girders feature low-permeability concrete with a specified compressive strength of 6000 psi. Close communication with the contractor and the ready-mix concrete supplier ensured there was a steady flow of concrete for segment casting requiring as much as 180 yd³. This portion of the work was fairly typical except for the exceptional heights involved. The bridge is located in a fairly remote portion of the state, with few concrete plants in the area, so logistics were a key part of the planning for the project.

The concrete superstructure was cast year round, including the harsh winters of western Pennsylvania. This required more attention to curing methods, which consisted of using enclosures, heating elements and wet burlap on the deck. Epoxy-coated reinforcement was used in the deck as well as any bars extending into the deck, including diaphragm and web reinforcement.

Four Form Travelers Used

Construction of the superstructure, which is nearing completion, is being accomplished with four form travelers, two per cantilever, allowing two cantilevers to be constructed simultaneously. Cantilevers 2 and 5 were cast first, followed by 3 and 6. Cantilevers 1 and 4 are being completed this fall, with finishes and other detail work expected to be completed by spring 2012.



The bridge is constructed using balanced cantilever construction, with seven spans including a main span of 518 ft and piers up to 200 ft tall. Construction of the final cantilevers at Piers 1 and 4 are underway as bridge construction enters the final stages.

In all, 51,000 yd³ of concrete, 7 million lb of reinforcing steel and 3 million lb of post-tensioning tendons are being used in the project. After each pair of segments is completed, they are post-tensioned both transversely and longitudinally with cantilever tendons within the deck. Once the spans are closed between the cantilevers, the continuity tendons along the bottom slab and draped tendons that extend from pier to pier are stressed to complete the span.

When the bridge is completed in the spring, users will benefit by having a distinctive concrete structure set against a lush environment and constructed at low cost. The bridge will ease access in the area well into the future. Even better, it provides a best-value solution for the Pennsylvania Turnpike and a durable bridge that will benefit users for 100 years or more.

Brice Urquhart is regional director with FIGG in the Northeastern regional office near Philadelphia, Pa., and Jim Stump is the Bridge Engineering Manager at the Pennsylvania Turnpike Commission in Harrisburg, Pa.

For additional photographs or information on this or other projects, visit www.aspirebridge.org and open Current Issue.



Pier tables begin the balanced cantilever superstructure construction.



Form for a 114' Haunch Girder for the Indian Street Bridge connecting Stuart and Palm City in Florida.

If precast was this simple...

Anyone could build forms.



But precast/prestressed concrete is not simple at all. It's a highly engineered, complex product with strict specifications, tight tolerances and superior strength, making it one of the most durable and long lasting building materials known to man.

To produce precast/prestressed concrete you need carefully engineered, long lasting, high quality forms. That's why more and more precast producers turn to the experience, expertise and innovation that is Hamilton Form.

When your next project demands custom solutions that are practical, versatile and long lasting, trust the experts at Hamilton Form. We've got a proven track record for designing and fabricating hardworking forms and plant production equipment that solve even the most sophisticated manufacturing challenges.

Precast/prestress... it's not that simple. Until it is, depend on Hamilton Form.

Custom forms. Custom equipment. Practical solutions.



Hamilton Form Company, Ltd.

7009 Midway Road • Fort Worth, Texas 76118

sales@hamiltonform.com • 817-590-2111

Creating a Level Playing Field

A BRIDGE AND A PARK BUILT OVER BUSY FREEWAY

by Robert L. Fernandes, Ross A. French, and S. Ping C. Liu, BergerABAM

The Northeast 36th Street Bridge and roundabout intersection in the city of Redmond, Wash., located 15 miles northeast of Seattle, was completed and opened to traffic in December 2010. The new bridge, a landscaped lid offering many pedestrian amenities, provides an overcrossing of State Route 520, which includes the well-known “floating bridge” that connects Redmond, the home of Microsoft World Headquarters and the University of Washington campus.

The new 414-ft-long bridge measured along the travelled way, connects

two sides of the expanding Overlake neighborhood in Redmond, over SR 520, and adjoins a recently expanded Microsoft campus. The two arterials connected by the Northeast 36th Street Bridge are some of Redmond’s most congested roadways. The new bridge will help to alleviate bottlenecks on nearby interchanges and the impacts of the projected population and employment growth in the Overlake area. Without the new bridge, the existing connections over SR 520 would be overwhelmed. The project is expected to reduce vehicle miles travelled by approximately 135,000 miles per year.

In keeping with Redmond’s designation as the “bicycle capital of the Northwest,” the Northeast 36th Street Bridge is optimized for pedestrian access and bicycle connections. It provides one traffic lane in each direction, bike lanes, sidewalks, and intersection improvements. It also accommodates the future Sound Transit Link Light Rail alignment and a connecting pathway that offers pedestrian access to the nearby Transit Center.

Double-Diamond Plan

The bridge passes diagonally over SR 520 and, according to Redmond’s project manager, Dennis Apland, “is the product of a lot of clever engineering.” The roadway crosses the highway at a 44-degree angle, rather than the more typical 90 degrees. The project is essentially two offset adjoining landscaped lids—a unique and innovative solution that prevented the project from becoming a much more costly tunnel project. The length of each lid along SR 520 is approximately 300 ft, just shy of the length that would trigger expensive fire suppression and ventilation systems for a tunnel designation.

The double-diamond design allowed the bridge to be built using standard construction methods, producing a much more cost-effective project overall. This solution also yielded minimal construction impacts on the major highway below.

The signature design of the Northeast 36th Street Bridge is the unique double-diamond shape, approximately 50,000 ft² landscaped lid spanning SR 520. All photos: BergerABAM.



profile

NORTHEAST 36TH STREET BRIDGE OVER SR 520 / REDMOND, WASHINGTON

BRIDGE DESIGN ENGINEER: BergerABAM, Federal Way, Wash.

GENERAL CONTRACTOR: Tri-State Construction Inc., Bellevue, Wash.

PRECASTER: Concrete Technology Corporation, Tacoma, Wash., a PCI-certified producer

REINFORCEMENT SUPPLIER: Pacer Steel Inc., Pacific, Wash.

BRIDGE DESCRIPTION: Two spans (150 and 164 ft by 300 ft wide) providing a traveled way bridge length of 414 ft supported on cast-in-place concrete abutments and a concrete center pier

A key challenge for the structural design was the center pier and the structure's seismic demands.

Design Challenges and Alternatives

The alignment was originally planned to cross SR 520 at approximately a 60-degree skew. This skew, combined with limited space for a bridge pier in the median of SR 520 and the need to keep the abutments out of the 280-ft-wide right-of-way, created some unique challenges—and opportunities—for the project participants. At a 60-degree skew, a new bridge constructed parallel to the proposed roadway alignment would have been a two-span structure, approximately 560 ft long with spans of approximately 280 ft. Structure depth and profile issues would have required radical changes to property access on either side of the crossing.

The arrangement of offset landscaped lids reduced the overall deck area that would have been required for a conventional continuous lid. It reduced the roadway alignment skew to about 45 degrees and allowed the lid to cross SR 520 at approximately 25 degrees. The resulting span lengths were 150



Excavation of the 250-ft-long central pier occurred during live traffic. During the setting of the center pier columns and the concrete placement for the center pier footing, up to two lanes of SR 520 were closed in each direction.

ft and 164 ft for the westbound and eastbound lids, respectively, which allowed the use of precast, prestressed concrete beams for the superstructure. This solution provided a vibrant urban connection for users, and was architecturally compatible with the other nearby crossings.

Structural Design Features

The framing consists of 56, WSDOT WF83G, precast, prestressed concrete bulb-tee beams. The beams are 83 in. deep and feature a 49-in.-wide top flange. The beams were spaced at about 6 ft 4 in. in the 150-ft-long westbound lid and at 5 ft 0 in. in the 164-ft-long eastbound lid, almost flange to flange. The close spacing was a direct result of the need to design the landscaped areas of the lid for a total load of 510 lb/ft², in addition to the standard highway loadings under the roadway portion. The specified concrete compressive strength was 10,000 psi. The beams used 0.6-in.-diameter strands for the 38 or 42 straight strands and 22 or 24 harped strands.

Completion of the cast-in-place concrete deck was complicated by the

Construction of the center pier in the median of SR 520 required a 16-ft-deep shored excavation for the spread footing foundations.

geometry of the project. In order to simplify the casting, an unbroken planar surface was specified. The deck over the beams varied in thickness from 8 to 10.5 in. The top mat of reinforcing steel was epoxy coated. The roadway crown section was accomplished with asphalt, varying in thickness from 2 to 6 in. The remainder of the deck was covered with soil up to 36 in. deep.

A key challenge for the structural design was the center pier and the structure's seismic demands. To maintain WSDOT standards for shoulder widths and sight distance on SR 520, the width of this pier could not exceed 6 ft. This constraint, combined with the need to let the offset beams rotate freely and independently due to the deck weight and landscape surcharge, required the introduction of an expansion joint at the center pier where the two offset lids overlapped. This joint allows rotation, but was detailed to prevent horizontal movement of the superstructure, relative to the pier, in both the transverse and longitudinal direction. This, in-turn required the abutments to be founded on a series of fourteen 6-ft-diameter drilled shafts. The shafts were not required for vertical load but were required to create a deep abutment wall capable of developing the passive pressure required to limit the longitudinal movement of the two spans in a seismic event. The center pier

TWO DIAMOND-SHAPED OFFSET LIDS OVER A DIVIDED FREEWAY USING PRECAST, PRESTRESSED CONCRETE BULB-TEE BEAMS AND CAST-IN-PLACE CONCRETE DECK WITH CENTER PIER USING PRECAST CONCRETE COLUMNS PROVIDING A DIAGONAL ROADWAY AND UNIQUE MEANDERING PEDESTRIAN WALKWAYS / CITY OF REDMOND, WASHINGTON, OWNER

STRUCTURAL COMPONENTS: Fifty-six WSDOT bulb-tee beams, 83 in. deep with 49-in.-wide top flanges with cast-in-place composite concrete deck 8 to 10.5 in. thick and 14 precast concrete columns, 4 ft by 4 ft by 29 ft 5 in. tall in the center pier

BRIDGE CONSTRUCTION COST: Bridge: approximately \$10 million; Total: \$21.4 million

Respecting the Environment through Innovative Engineering

The Northeast 36th Street Bridge prioritized environmental design and is optimized for pedestrian and bicycle access and an enhanced user experience. Its features include the following:

- Reduced the amount of impervious surface that blends seamlessly into the surrounding environment.
- The illusion to the user of not being on a bridge as views and noise are blocked by the attractive landscaping and bridge barrier.
- Park-like amenities and ample lighting installed for public safety, comfort, and enjoyment.
- Wide, meandering sidewalks separated from the automobile zone by planter strips and connected to all major access points and local businesses including the use of ramps, crosswalks, and handrails.
- A direct connection to a multiuse path and popular 5-mile interurban trail system to maximize community and sustainability elements.
- Bridge barrier raised by approximately 3 ft relative to a typical barrier. Raised planted islands block noise and visual distractions. Undulating sedimentary walls constructed at the sidewalk edge provide seating and a barrier from the landscaped beds. These plantings reduced the area of impervious surface and absorb storm water before adding to runoff. A bridge drain system, including a waterproofing membrane, drainage mat, and an inlet and pipe system collects additional water on the bridge and delivers it to the city's stormwater system.
- The number of trees removed from the site was minimized. Extensive plantings restored the site to its pre-built condition. No new roadways were created as part of the project.
- On-site rocks were re-used to create new rock walls adjacent to the roadways.
- Shallower beams were used than if the structure was built on a larger skew. This avoided the need for special cranes and larger equipment. It led to reducing the size of walls and the quantity of fill at the ends of the bridge, which also reduced the cost of the project.



The Northeast 36th Street Bridge includes one through-lane in each direction. Bicycle lanes, generous sidewalks, and lush landscaping are included. The roadway crosses SR 520 at a 44-degree angle, rather than the more typical 90 degrees.

Precast columns . . . recovered about 4 weeks of the original 6-week delay.

itself was approximately 260 ft long, consisting of 14 columns supported on a 10-ft-wide spread footing. The center pier provides only vertical support for the structure, as its lateral movements are limited.

Precast Concrete Columns

Construction of the center pier spread footing in the median of SR 520 required a 16-ft-deep shored excavation. Because WSDOT was paving SR 520 at the time the project was bid, construction of this pier was delayed by 6 weeks. Because the beam supplier was extremely busy at this time, the 6 week delay was projected to have a ripple effect on the delivery and erection of the beams, and the subsequent completion of the deck construction and approach paving. The weather-sensitive approach paving and substantial completion of the project would be delayed by as much as 6 months. In order to expedite the construction of the center pier and recover the schedule, a decision was made to redesign the 14 columns to be precast concrete rather than cast-in-place. The columns were cast on site and erected in the median where

footing cages had been assembled. This recovered about 4 weeks of the original 6-week delay, allowing the remainder of the pier construction and beam erection to proceed in accordance with the contractor's original plan to pave the approaches and complete the project in the fall.

Robert L. Fernandes is vice-president, Ross A. French is project engineer VI, and S. Ping C. Liu is communications manager, all with BergerABAM in Seattle, Wash.

For additional photographs or information on this or other projects, visit www.aspirebridge.org and open Current Issue.



Fourteen columns were precast and erected in the median, recovering 4 weeks of potential project delays.



LARSA4D

DESIGN CONSTRUCTION ANALYSIS

The Complete Software for Bridge Design, Analysis, & Construction

BRIDGE SERIES

4D BRIDGE PLUS | 4D BRIDGE | 4D BRIDGE pLT

The trusted company standard at ATKINS, FIGG, HDR, International Bridge Technologies, Parsons Brinckerhoff, T.Y. Lin International, and many other leading firms around the world.

I-280 Veteran's Glass City Skyway
FIGG Engineering Group

For a free trial license visit us at www.LARSA4D.com

1.800.LARSA.01 New York

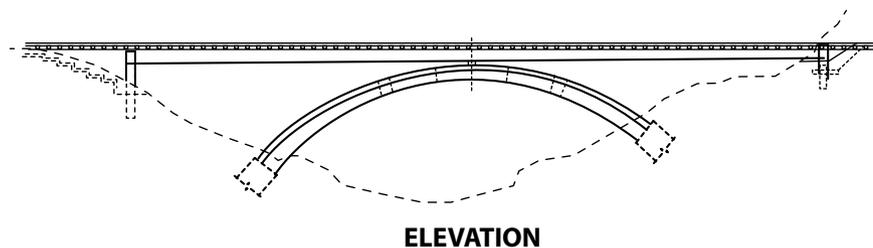


A TIME TO REPLACE— Constructing a Safer Tomorrow

by Raymond W. Wolfe and Ali Asnaashari, California Department of Transportation,
and Bill Jahn, city of Big Bear Lake



The Big Bear Bridge nears completion.



All photos and drawings: California Department of Transportation.

The San Bernardino Mountains have long provided a key recreational outlet for the millions of residents populating the valleys and coastlines of sunny southern California. Big Bear Lake is situated approximately 100 miles east of Los Angeles in the San Bernardino National Forest at an elevation of 6752 ft. It is an idyllic mountain resort community and a major destination for year-round recreation. Fishing, boating, hiking, and camping are abundantly available during the warmer seasons, while skiing and other snow related activities are a real favorite of winter enthusiasts.

Big Bear was established as a local resort destination in 1884, after construction of the first dam and the subsequent establishment of a lake in a valley surrounded by picturesque mountain peaks. A larger capacity dam, impounding a 73,000 acre-ft lake, was constructed in 1912 and still stands today.

History of the Bridge

San Bernardino County completed a concrete highway bridge crossing the dam to provide access directly to the resorts from the San Bernardino valley floor in 1924. The 351-ft-long, 21-ft-wide bridge carried two lanes of traffic with one narrow sidewalk. The bridge comprised 12 spans of four girders each. The girders were haunched concrete T-beams resting atop arched ribs attached to the face of the concrete dam. The girder depth varied from 2.5 ft at the center of the spans to 3.5 ft at the simply supported ends.

During the Great Depression, the highway network crossing the San

profile

BIG BEAR BRIDGE / SAN BERNARDINO MOUNTAINS AT BIG BEAR LAKE, CALIFORNIA

BRIDGE DESIGN ENGINEER: California Department of Transportation, Sacramento, Calif.

PRIME CONTRACTOR: Flatiron West Inc., San Marcos, Calif.

CONCRETE SUPPLIER: Robertson's Ready Mix, Corona, Calif.

POST-TENSIONING CONTRACTOR: AVAR, Fremont, Calif.

ABUTMENT BEARINGS: D.S. Brown, North Baltimore, Ohio



Falsework and forming for the arches.

The Big Bear valley . . . is underlain with numerous faults, including the south branch of the San Andreas Fault.

crest of the arch. Each isolation bearing carries 4600 kips and has a longitudinal movement capacity of 18 in. Two 72-in.-diameter, cast-in-drilled-hole piles support each corner of the abutments. These piles along with isolation bearings provide the necessary lateral strength required to meet the seismic demand of the bridge.

The exterior webs of the girders are sloped at a 45-degree angle. The 12-in.-thick interior webs are spaced at 9-ft centers. The top slab thickness is 8 in. and the soffit slab is 6¼ in. thick. The design concrete compressive strength is 5000 psi. All of the top slab reinforcement including the reinforcement for the barrier railings is epoxy coated.

The superstructure is post-tensioned with 4200 kips of force in each web for a total jacking force of 33,600 kips. A typical group of tendons has three 4-in.-diameter ducts and one 4¾-in.-diameter duct. The 4-in. ducts contain twenty-two, 0.6-in.-diameter strands while the 4¾-in. duct has twenty-seven, 0.6-in.-diameter strands. All of the ducts were fully grouted after the structure was stressed.

Cast-in-Place Arch

The arch consists of two cast-in-place reinforced concrete legs separated at the two bases and connected at the crest of the arch. The arch cross-section

is hollow and has a trapezoidal shape with a depth that varies from 10 ft at the crest to approximately 15.5 ft at the base. From the crest, it splits into two legs. The top width of each leg of the arch is 22.5 ft at the base and 45 ft combined width at the crest. The bottom width of each leg varies. There are four circular continuous reinforcement cages at each corner of each half of the arch connected with 18-in.-thick reinforced concrete top and soffit slabs and 24-in.-thick webs. The specified concrete compressive strength of the arch ribs was 3500 psi.

Seismic Safety

The new bridge meets current seismic design criteria, lending a dramatic improvement over the old structure. The Big Bear valley and surrounding landscape is underlain with numerous faults, including the ominous south branch of the San Andreas Fault. The latter is presumed capable of a maximum credible event exceeding 8.0MMS on the Richter scale. The other lesser faults in the region may produce events ranging from 6.0 to 7.5MMS.

Capacity, Operations, and Maintenance

The new structure provides one 12-ft lane in each direction for traffic, a right-turn lane for westbound traffic heading onto SR 38 around the west side of Big Bear Lake, and two 10-ft shoulders. The shoulders facilitate snow

A dramatic improvement over the old structure.

removal by accommodating temporary snow storage. A black-tinted polyester concrete deck overlay reduces icing potential, thus minimizing the need for damaging deicing chemicals.

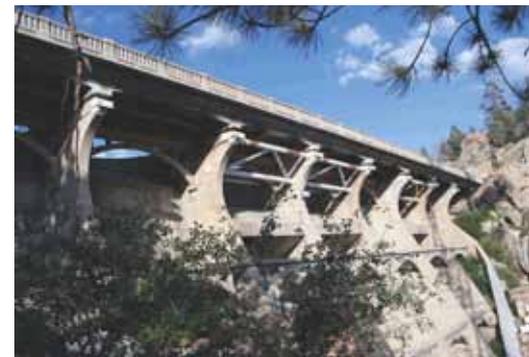
A Community Identifier

The new bridge is a testament to a road well traveled. When visitors ascend SR 18 and reach the entrance of Big Bear Lake, the site of the new bridge tells them they have arrived, that they have made it to Southern California's only four-season resort. The opening of the bridge was accomplished with great fanfare on June 24, 2011. The bridge has created a resurgence of pride in the local community as its aesthetically pleasing architecture is certain to win accolades and draw tourists and bridge enthusiasts for the next century to this pristine alpine resort community. The timing of its opening during a protracted recession is certain to help revive the local economy.

Raymond W. Wolfe is the District 8 director for the California Department of Transportation in San Bernardino, Calif., managing operations throughout San Bernardino and Riverside Counties; Ali Asnaashari is a senior bridge engineer for the California Department of Transportation in Sacramento, Calif., and the designer of record for the bridge; Bill Jahn is the mayor of Big Bear Lake, Calif.

For additional photographs or information on this or other projects, visit www.aspirebridge.org and open Current Issue.

The Big Bear Dam and existing bridge.





As one of the largest design-build contractors in North America, Flatiron is your single source of responsibility for quality, budget and schedule. We have strong relationships with many of the nation's design firms and partner with designers best suited for your project. Our teams are recognized with the nation's top design-build awards for innovation, and our ideas often lead to higher quality, faster schedules and reduced environmental impacts. Learn more about how Flatiron helps clients deliver successful design-build projects:

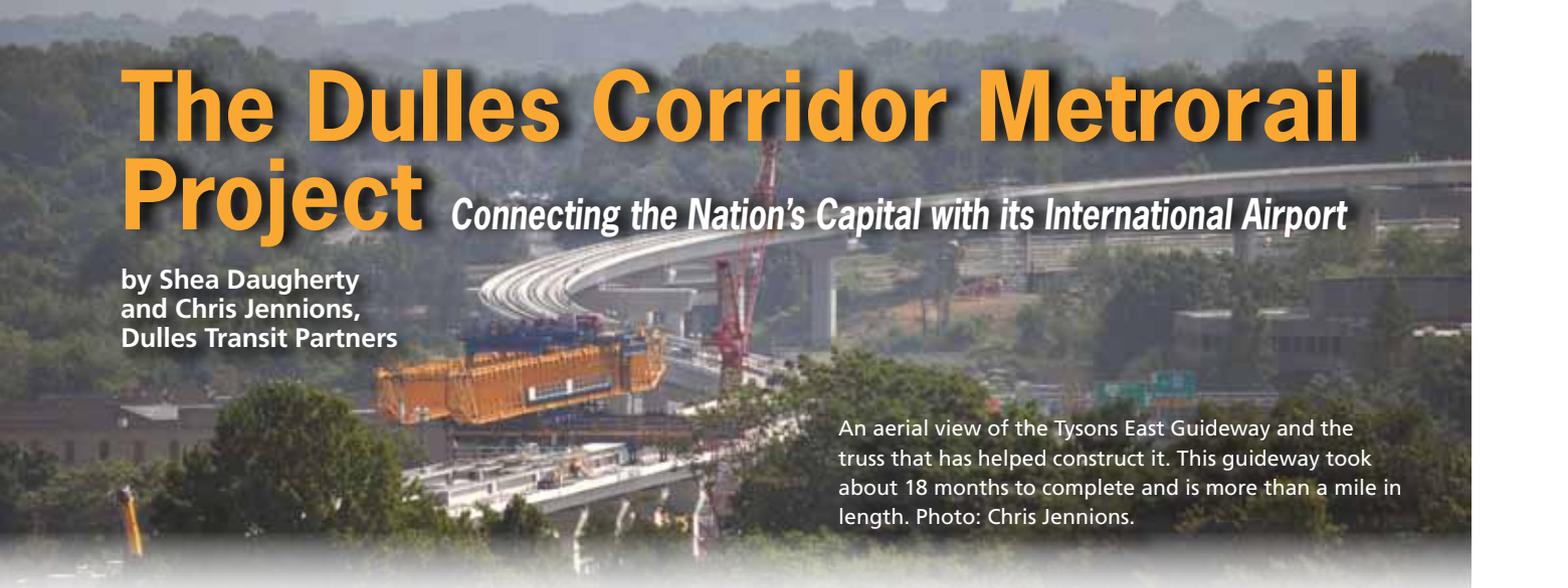
www.flatironcorp.com/designbuild

A HOCHTIEF Company

The Dulles Corridor Metrorail Project

Connecting the Nation's Capital with its International Airport

by Shea Daugherty
and Chris Jennions,
Dulles Transit Partners



An aerial view of the Tysons East Guideway and the truss that has helped construct it. This guideway took about 18 months to complete and is more than a mile in length. Photo: Chris Jennions.

The Dulles Corridor Metrorail Project, a two-phase, 23-mile extension of the existing 106-mile Metro rail system, will connect the nation's capital, Tysons Corner, and Washington Dulles International Airport. Construction of Phase 1, the first 11.6 miles, is nearly 50% complete. It will include five stations and multiple auxiliary power facilities and environmental controls.

One of the project's biggest challenges has been working in and around this heavily congested area. Work sites are limited and narrow, mostly in the medians of the area's most traveled thoroughfares where traffic moves just feet away. "The safety of the traveling public and our employees is the top priority of this project," said George Morschauer, executive director for the project's design-build contractor.

Project Orientation

Phase 1 features nearly 3 miles of aerial guideway. The rest of the alignment will run at-grade except for a 2400-ft-long tunnel between two of the stations. There are three guideway sections in this new alignment: "O-1," "Tysons East," and "Tysons West."

The O-1 begins at the eastern end of the project, where the new line will split

from the existing Metro Orange Line. It features two parallel, 1600-ft-long guideways that fly over I-66, a major interstate highway.

The other two guideways, Tysons East and Tysons West, are precast segmental concrete box girder bridges constructed using highly-visible trusses—massive machines that are unlike anything most of the area's traveling public has ever seen.

The congestion of Tysons Corner was a main reason to use trusses for the majority of the guideway work instead of ground-based cranes. "We're using overhead trusses because they are the most efficient method," said Shawn MacCormack, the project's task manager for aerial structures. "They are ideal in dense urban environments like Tysons Corner because they use a 'top-down' construction method and have little impact on the traveling public."

Traveling from east to west, once over the O-1 guideway, the rail line will descend to grade level for about 2 miles in the median of the Dulles Connector Road (Route 267). Then, the Tysons East guideway begins, crossing over into Tysons Corner, and into the first of the four Tysons Corner stations. From there,

the rail will continue at an elevated level, ascend to its highest point—approximately 55 ft—over the eight-lane I-495 Capital Beltway and then descend into the second station where the rail line briefly goes underground.

The alignment resurfaces in the median of Route 7 at the third station, which is partially underground. From there, the Tysons West guideway begins, running for about a mile and through the fourth station. One final flyover takes the guideway westward into the median of the airport access highway, descending to grade for the rest of the alignment. The fifth station is located approximately 4 miles west of Tysons Corner.

How They're Built

The Tysons East and West guideways are being constructed using more than 2700 precast concrete segments that are fabricated in an off-site facility on Dulles Airport property. All segments are match cast. The short-line casting method is used for the typical main guideway segments and the shallower station segments use the long-line casting method.

The segmental box is approximately 7 ft 6 in. wide by 8 ft deep, with a top flange approximately 16 ft wide for the

profile

DULLES CORRIDOR METRORAIL PROJECT AERIAL GUIDEWAYS / TYSONS CORNER, VIRGINIA

SUBSTRUCTURE DESIGN ENGINEER: Bechtel, Vienna, Va.

SUPERSTRUCTURE DESIGN ENGINEER: Corven Engineering Inc., Tallahassee, Fla.

CONSTRUCTION ENGINEER AND ERECTION TRUSSES MANUFACTURER: Deal, Pozzuolo del Friuli, Italy

PRIME CONTRACTOR: Dulles Transit Partners, Vienna, Va.—a team of Bechtel and URS

CONCRETE SUPPLIER: DuBROOK Concrete Inc., Chantilly, Va.

PRECASTER: Rizzani de Eccher USA, Bay Harbor Islands, Fla.



A completed span in a span-by-span construction area showing the cross section of the guideway girder. Photo: Chris Jennions.

together, and aligned. Segments are approximately 10 ft long depending on the radius of the alignment at that location. Span lengths are generally dictated by the availability of ground for locating the cast-in-place concrete piers, but where support is required in a road, straddle bents are constructed to avoid permanent road diversions.

Support piers across the project vary in both footprint and height, ranging from 10 ft tall atop hills in the middle of an intersection cloverleaf to 55 ft tall between two road bridges. In plan, most piers are rectangular with rounded corners. Plan dimensions range from 6 by 7 ft to 7 by 12 ft.

Concrete

Specified concrete compressive strength for the columns and pier caps is 5000 psi. The concrete strength is increased where the substructure pier caps require post-tensioning due to their span lengths; in these cases, the concrete strength requirement is 6000 psi.

Column and pier cap concrete includes a calcium nitrite corrosion inhibitor to protect the reinforcement from corrosion from deicing salts from road splash.

Concrete compressive strengths for the precast segments range from 6000 to 8500 psi depending on their location. Both simple spans of roughly 130 ft and station spans have used 6000 psi, while the larger spans and balanced cantilever structures have required 8500 psi. The mixes use ground-granulated blast-furnace slag as a supplemental cementitious material.

Concrete maturity meters were used for the in-place strength of the cast-in-place substructure concrete where post tensioning was not required. This enabled the aerial crews to strip both column and pier cap formwork systems earlier and reuse them elsewhere. The client approved the use of these meters for stripping formwork, but not for verification of strength prior to post-tensioning. Curing compound was used on fresh concrete when the formwork was stripped before 7 days or less than 70% of the design strength was achieved.

typical guideway sections. The boxes change to 7 ft wide by 5 ft deep with a 16-ft-wide top flange through the stations, where the spans are about 50% shorter. Guideway spans have slightly thinner webs and slabs at 9 in. thick, while station segment webs and slabs are 10 in. thick.

Segments are trucked one-by-one to their locations and hoisted into place by the truss, where their match-cast faces are coated with epoxy, joined

The Tysons East Guideway as it curves westward toward Tysons Corner. Photo: Shea Daugherty.



THREE MILES OF AERIAL GUIDEWAY THAT INCORPORATES FOUR DIFFERENT TYPES OF BRIDGE CONSTRUCTION / METROPOLITAN WASHINGTON AIRPORTS AUTHORITY, OWNER

POST-TENSIONING MATERIALS: VSL, Hanover, Md.

FORMWORK SUPPLIER: Symons of Dayton Superior, Des Plaines, Ill.

EXPANSION JOINT SUPPLIER: D.S. Brown, North Baltimore, Ohio

BEARING SUPPLIER: R.J. Watson, Amherst, N.Y.

GUIDEWAY DESCRIPTION: AASHTO precast, prestressed concrete box beams and steel plate girders, all with cast-in-place concrete decks; segmental concrete box girders erected using both span-by-span and balanced cantilever methods built on cast-in-place concrete substructures

BRIDGE CONSTRUCTION COST: Approximately \$170 million

Guideways by the Numbers

O-1 Guideway

- Two parallel, 1600-ft-long guideways in the median of Interstate 66 and the Dulles Connector Road (Route 267)
- 23, 88-ft-long spans with 48-in. by 48-in. AASHTO box beams
- 16 spans with steel plate girders
- All decks are 9-in.-thick cast-in-place concrete

Tysons East Guideway

- Two aerial stations
- 6178 lin. ft of segmental guideway along the northern shoulder of Route 123, a major roadway in Northern Virginia
- 75 spans, including five balanced cantilever spans and three precast, prestressed AASHTO box beam spans with cast-in-place concrete decks
- 1333 lin. ft of station guideway
- Three segmental erection trusses operating concurrently
- Typical span-by-span length of 130 ft with balanced cantilever spans up to 174 ft. Station spans 66 ft long

Tysons West Guideway

- One aerial station
- 5715 lin. ft of segmental guideway along the median of Route 7, a major Northern Virginia highway
- 55 spans, including three balanced cantilever
- 600 lin. ft of station guideway
- Two segmental operations working concurrently

A completed span has been post-tensioned together before being placed in its final position in the Tysons East Guideway alignment. Photo: Chris Jennions.



Upon completing a span, the truss prepares to launch to the next pier on the Tysons East Guideway. Photo: Igor Scherbakov.

Post-Tensioning

Post-tensioning is used throughout the project. In the stations, it is used in the substructure pier caps, straddle bents, and precast concrete mezzanine beams. The precast concrete box beams in the O-1 guideway use 1¼-in.-diameter lateral post-tensioning bars at six locations in each span. The standard design of the segmental concrete box girders for locations both inside and outside the stations contains six tendons per span. With minor exceptions, these comprise four 19-strand tendons at 750 kips each, and two 15-strand tendons at 600 kips each—totaling 4200 kips of post-tensioning in each span. Tendons in the longest cast-in-place concrete straddle bents use up to 31 strands. All post-tensioning strands are 0.6 in. diameter.

Grout for the post-tensioning ducts is produced from one of two dedicated mobile grout trailers. Each trailer contains a storage area for the grout and water, and the colloidal mixer, and a shelter area for the workers. Grouting

operations are done in accordance with standard American Segmental Bridge Institute practices.

The steepest grade is 4% at the I-495 crossing, and almost none of the guideways is perfectly level, with the exception of the stations. The decks and segments do not have any superelevation because the concrete rail plinth, which is cast on the deck after erection, provides this slope.

For safety reasons, bridge construction is not allowed over active roadways, so a large amount of the work is being done overnight. This time constraint on the aerial team required intense planning and coordination with the project's maintenance of traffic team, as well as the Virginia Department of Transportation (VDOT) and the project owner.

Phase 1 construction has about a year and a half to completion. The aerial guideways are scheduled for completion by May 2012. Once the system is turned over to Metro, approximately 6 months of pre-revenue testing and integration with the existing system will occur, with the first new riders boarding by the end of 2013.

Shea Daugherty is construction communications manager and Chris Jennions is aerial lead field engineer, both with Dulles Transit Partners in Vienna, Va.

For additional photographs or information on this or other projects, visit www.aspirebridge.org and open Current Issue.

What Certification Program are you betting on?



Certification is more than inspections, paperwork, and checklists! It must be an integrated and ongoing part of the industry's

Body of Knowledge! PCI is the technical institute for the precast concrete structures industry and as such, PCI Certification is an integrated and ongoing part of the industry's body of knowledge.

Specify PCI Certification and hold the winning hand.



Precast/Prestressed Concrete Institute
200 West Adams Street | Suite 2100 | Chicago, IL 60606-5230
Phone: 312-786-0300 | Fax: 312-621-1114 | www.pci.org

Bridges **LIFE**[™]
for

To learn more, visit www.pci.org/certification or contact
Dean Frank, PE., PCI director of quality programs,
at dfrank@pci.org or (312) 583-6770.

A Sliding Scale

THE I-80 BRIDGES OVER ECHO DAM ROAD

by Hugh Boyle, Michael Baker Jr. Inc.



New I-80 Bridge over Echo Dam Road in place and complete.

Just outside the tiny community of Echo, in Summit County, Utah, thousands of motorists drive by on I-80 every day. In this area, I-80 is a smooth, easy route—a portion of one of the longest interstate highways in the country carrying people and products coast-to-coast for 2900 miles.

Two deteriorating bridges on I-80 in this area threatened to shut down this important corridor as the Utah Department of Transportation (UDOT) needed to replace the structures. The agency estimated that any disruption to I-80 would detour the high volume of interstate truck traffic for 90 miles.

UDOT is recognized as a leader in innovative accelerated bridge construction (ABC). They challenged the consulting and construction industry to find a way to minimize impact to the traveling public as part of the replacement of the I-80 bridges over

Echo Dam Road. The agency stipulated that the design-build team must remove existing bridges and approach ramps and construct new bridges within 135 calendar days after the notice to proceed. Additionally, the closure of I-80 at Echo Dam Road was limited to 16 hours. To receive the full incentive, the road needed to be open to traffic in less than 11 hours. The contract also stipulated incentive/disincentive pay for every 15 minutes that I-80 was opened or closed as measured against the allowable time window.

The design-build (D-B) contract was awarded in April 2009. The team then developed the first project in the United States to move a bridge span into place, including the approach slabs, in just a matter of hours using hydraulic rams and slide rails. This resulted in another new first for UDOT and their innovative methods for ABC, and for a cost of approximately 60% of the state's estimate.

Design Basics

The original three-span, I-80 twin bridges over Echo Dam Road were approximately 40 ft wide and 101 ft long including fill slopes under the approach spans that rested on stub abutments. The span lengths were 30.5, 44, and 26.5 ft.

The new twin bridges are each 44 ft 10 in. wide with a single 80-ft-long main span and 25-ft-long approach slabs at either end. The approach slabs are designed to span their full length to allow for bridge settlement at the abutments. After reaching their final location, flowable fill was used beneath the approach slabs. There is a special joint between the deck and approach slabs that allows rotation if the approach slabs settle.

To meet the tight timeline and vertical clearance requirements, the D-B team opted to use economical, single-span

profile

I-80 BRIDGES OVER ECHO DAM ROAD / ECHO, UTAH

BRIDGE DESIGN ENGINEER: Michael Baker Jr. Inc., Midvale, Utah

PRIME CONTRACTOR: Ralph L. Wadsworth Construction Company, Draper, Utah

PRECASTER: EnCon Utah LLC, Tooele, Utah, a PCI-certified producer

CONCRETE SUPPLIER: Geneva Concrete, Park City, Utah

AASHTO Type II precast, prestressed concrete beams for the main span. The beams use 8500 psi compressive strength, normal weight concrete and contain prestressing strand and epoxy-coated reinforcement as required by the UDOT standard specifications. The beams are spaced at 6 ft 8 in. on center. Cast-in-place, lightweight concrete with a unit weight of 113 pcf is used in the 8-in.-thick deck, approach slabs, and 42-in.-tall parapets. The lightweight concrete reduced the sliding weight and temporary shoring cost. It allowed the Type II beams to reach the required 80-ft span, some 10 ft more than typically used.

The bridge foundations incorporate 16-in.-diameter, high-capacity pipe piles driven into the bedrock. These piles are located outside the footprint of the existing structure to allow them to be driven without affecting the existing structure.

The ABCs of the Slide

During design, the project team evaluated several proven ABC techniques.

Self-propelled modular transporters (SPMTs) were investigated. But, at this location, SPMTs would have required extensive soil nail walls and grading to accommodate access. Further, it would have been necessary to shorten the new bridge and move the new abutments closer to the road, or the abutment slopes and approach slopes would have had to be cut out and soil nailed to allow the SPMTs to support the bridge closer to its ends.

Shortening the bridge and moving the new abutments was not a viable option. After the new bridge was moved into place, a large amount of backfill,

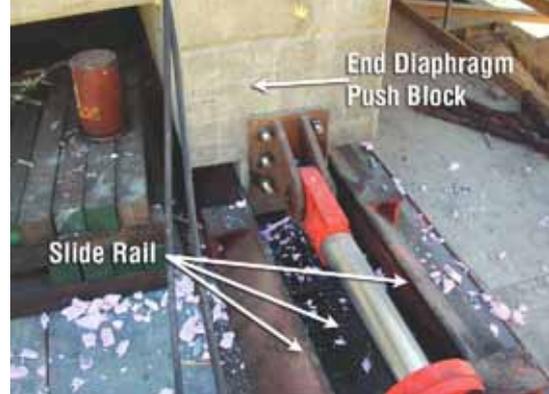
approach slab construction, and paving would need to be done—too much work to complete in 16 hours.

Instead, the engineers opted to construct the new bridge adjacent to the existing bridge and then use hydraulic rams and slide rails to move the new bridge and approaches into place after demolishing the existing structures. New abutments were built between the existing abutments and the intermediate columns and just below the existing bridge superstructure. While this method required the construction of temporary abutments as an extension of the new abutments, it eliminated the need for extensive backfill after moving the new bridge into place.

The slide rail option would also work well for the approach slabs. The D-B team had considered precast concrete approach slabs, but realized that the time needed to install the slabs, align and grout them would be too long to meet the requirements of the contract. A key advantage of the slide option was the ability to slide the approach slabs with the bridge, thus eliminating the additional time associated with separate panels. This also eliminated additional joints and assured a smoother transition to the bridge.

Sliding Scheme

The slide rail system relies on two hydraulic rams, each mounted on a sliding rail to push the superstructure into final position. Each ram had a working capacity of 200 kips, which turned out to be more than twice the force necessary to move the structure. On this project, the new permanent abutments provided lateral stability to the temporary abutments, by anchoring them to the permanent abutments with cast-in anchor bolts.



The hydraulic ram used to push the structure was mounted on the end diaphragm push block. Slide shoes rest on transfer plates in the slide rail.



The westbound bridge is in place as crews prepare for partial demolition of the eastbound bridge.

To facilitate sliding the superstructures, two concrete shoes surfaced with stainless steel were cast on the underside of each end diaphragm. In the final condition, the shoes transfer the vertical loads to the abutments. The temporary abutments were designed with a small platform in front of the end diaphragms at every other beam. At these locations, screw jacks were used to raise the superstructure.

With the superstructure raised just slightly, the slide rail, or “ladder beam,” was inserted the length of the temporary abutment and connected to the abutments via link plates to the transfer plates. The transfer plates were attached to a base plate embedded and anchored to the concrete with

UDOT is recognized as a leader in innovative accelerated bridge construction.

TWIN, PRECAST, PRESTRESSED CONCRETE BEAM BRIDGES WITH LIGHTWEIGHT CONCRETE DECKS AND APPROACH SLABS, SLID INTO FINAL POSITION ON NEW CONCRETE ABUTMENTS / UTAH DEPARTMENT OF TRANSPORTATION, OWNER

BRIDGE DESCRIPTION: Twin Interstate bridges, 80 ft long and 44 ft 10 in. wide with Type II precast, prestressed concrete beams, lightweight concrete decks and 25-ft-long lightweight concrete approach slabs that rest on precast concrete sleeper slabs and cast-in-place concrete abutments

BRIDGE CONSTRUCTION COST: \$3.1 million

AWARDS: 2011 PCI Design Award, Best Bridge with Main Span between 76 and 150 ft



Beam erection is complete on the temporary abutment.

shear studs. Once the slide rail was in place and connected to the abutment, elastomeric bearing pads with a polytetrafluoroethylene (PTFE) surface were placed evenly spaced along the slide rail and the superstructure was lowered onto the pads. The jack pushed the bridge about 3 ft, then a lock tab on the jack was lifted and the jack pulled itself along the "ladder;" the lock tab was set and the bridge pushed another 3 ft.

Precast concrete sleeper slabs were used at the roadway ends of the approach slabs; two sections per end, with one for each phase of the move. These act as grade beams to support the slabs. Shaped like an inverted "tee," the base is 5 ft wide and the upturned stem is 12 in. thick and varied in depth from 14 to 24 in. to accommodate a sloping roadway. The sleeper slabs used concrete with a specified compressive strength of 4000 psi. A weathering steel tee shape was embedded with about 1/4 in. of the flange of the tee protruding above the top of the slab for a sliding surface.

At the ends of the approach slabs, a weathering steel tee shape was embedded in the bottom of the approach slab. The dead load reactions at the ends of the approach slabs were much less than at the end diaphragms. Block outs at each corner of the approach slabs under the parapet, allowed the contractor to jack the approach slab a few inches into the air, grease the steel-to-steel sliding surfaces and install the 1/8-in.-thick PTFE pads to further reduce friction.

Let it Slide

The westbound bridge was moved into place on September 29, 2010, 4½ months after receiving the notice-to-proceed. On that day, crews closed one lane for the day while a section of the existing structure was demolished and

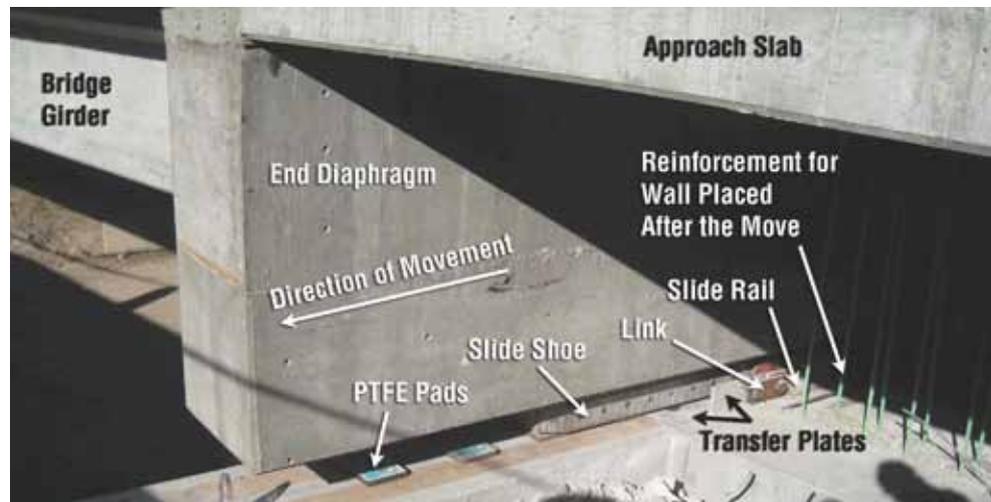
the first section of the precast concrete sleeper slabs was moved into place at both ends of the bridge. During this single-lane closure, the bridge was pushed the first 10 to 12 ft to test the procedures and make necessary adjustments.

At 10:00 p.m. the same day, the entire westbound bridge was closed. Two hours later, the crews had demolished the remainder of the westbound structure. During this time, crews were installing guardrail and the last two pieces of the precast sleeper slabs. Once the precast sleeper slabs were in place, the hydraulic jacks began pushing the bridge into place. Approximately 3 hours later, the bridge was in its final location. When in motion, the bridge traveled at about 2 ft/min. Additional time was required to reset the jacks and align the bridge.

The approach slab compression seals were installed in the joint at the sleeper slab stem, the roadway approaches were paved, and the bridge was open to traffic by 4:47 a.m.—less than 7 hours later and 4 hours faster than required to receive full incentive. Several weeks later, the eastbound bridge was slid into place and opened to traffic 7 hours after full closure.

Hugh Boyle is senior project manager—bridge services lead with Michael Baker Jr. Inc. in Midvale, Utah.

For additional photographs or information on this or other projects, visit www.aspirebridge.org and open Current Issue.



Seen during the move, the slide shoe on the bottom of the abutment wall glides across PTFE pads onto the permanent abutment.

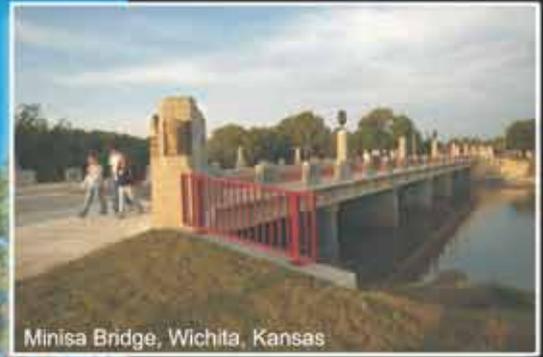


New westbound structure in place and complete. The push block and slide shoes can be seen.

*Delivering Top Quality
Concrete Bridges
for our Clients
around the
Globe*



I-10 Escambia Bay Bridge, Pensacola, Florida



Minisa Bridge, Wichita, Kansas



Mattaponi River Bridge, West Point, Virginia

I-95/I-295/SR 9A Ramp,
Jacksonville, Florida

pbworld.com

*...Changing
tomorrow
today...*

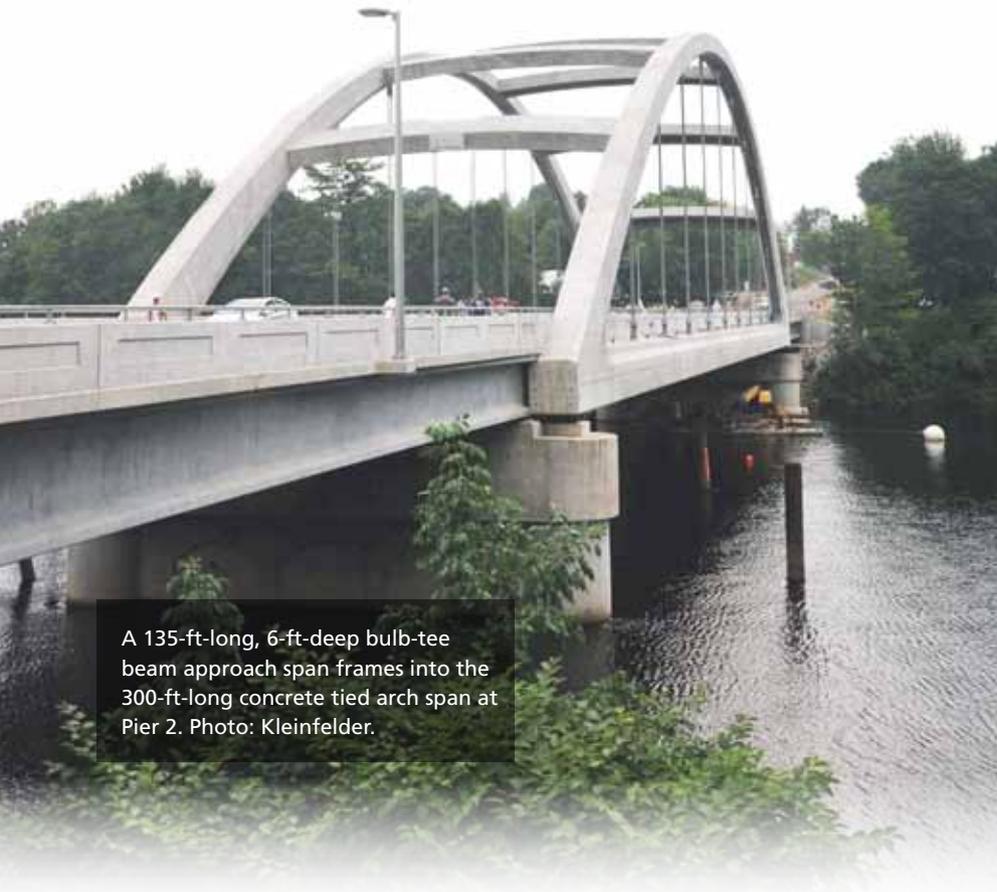
PB **PARSONS
BRINCKERHOFF**
125 YEARS

With over 125 Years of Engineering Excellence

SR 9A Ramp Photo Courtesy of Superior Construction Company, Inc.

Re-Creating History: Modern Techniques Preserve Character of Historic Bridge

by Craig Weaver, Kleinfelder



A 135-ft-long, 6-ft-deep bulb-tee beam approach span frames into the 300-ft-long concrete tied arch span at Pier 2. Photo: Kleinfelder.



Early photo of the four consecutive concrete tied arch spans of the Covered Bridge in Norridgewock, Maine, constructed in 1928. Photo: Maine Department of Transportation.

Built in 1928, the 570-ft-long, eight-span, tied-arch Covered Bridge over the Kennebec River in Norridgewock, Maine, was named one of Maine's most significant twentieth century bridges by the Maine Historic Preservation Commission. It was a visible landmark, an integral part of Norridgewock's identity reflected on the town's logo and letterhead—and, unfortunately, it had outlived its service life.

Rehabilitating or replacing the structure divided a community that was proud of the structure's historic significance. It was up to the Maine Department of Transportation (MaineDOT) and its engineering team to come up with a feasible, prudent solution that would satisfy the more than 3000 residents of this community and many others interested in historic preservation.

Community Connections

To ensure community support, the agency formed a 10-person committee to determine the new bridge's look and feel. The committee included the Norridgewock town manager, prominent residents, as well as representatives from the Maine Historic Preservation Commission, the MaineDOT and the Federal Highway Administration.

The committee considered the sentiment attached to the 80-year-old bridge and resolved to build another landmark-type structure. Ultimately, they wanted a "modern" historic bridge that would match the aesthetic and historic appearance of the original bridge with a service life of 100 years and a clearance sufficient for a 50-year flood.

profile

THE COVERED BRIDGE OVER THE KENNEBEC RIVER / NORRIDGEWOCK, MAINE

BRIDGE DESIGN ENGINEER: Kleinfelder, San Diego, Calif.

PRIME CONTRACTOR: Reed & Reed Inc., Woolwich, Maine

CONSTRUCTION ENGINEER: McNary Bergeron & Associates, Broomfield, Colo.

FLOOR BEAM PRECASTER: J.P. Carrara and Sons Inc., Middlebury, Vt., a PCI-certified producer

DECK PANEL PRECASTER: Oldcastle Precast Inc., Auburn, Maine, a PCI-certified producer

BULB-TEE BEAM PRECASTER: Strescon Limited, Bedford, NS, Canada, a PCI-certified producer

CONCRETE SUPPLIER: Mattingly Products Co. Inc., North Anson, Maine

POST-TENSIONING SUPPLIER: VSL, Hanover, Md.



The tie girder reinforcement being installed. The tubes in the foreground will receive the hanger rods from the arch. Photo: Kleinfelder.

To meet the committee's challenge, engineers incorporated key aspects of the old structure, particularly the old bridge's arch design. The new bridge's tied-arch span contains two parallel 300-ft-long arch ribs consisting of cast-in-place concrete with six cast-in-place transverse braces. The arches rise 60 ft above the deck. A 135-ft-long approach span is provided at each end of the arch.

The bridge is 46 ft wide and includes two 12-ft-wide travel lanes. Since the bridge lies along the Interconnected Trail System, a series of snowmobile trails throughout Maine, it includes a 7-ft-wide multi-use lane that will remain unplowed in the winter for snowmobiles and serve horseback riders and bicycles the balance of the year. It has one 4-ft-wide shoulder, one 6-ft-wide shoulder, and a 5-ft-wide sidewalk opposite the side with the multi-use lane.



Into the Bedrock

Once the original crossing and its piers were removed, crews constructed cofferdams for the new piers and abutments to support the arch span and the two 135-ft-long approach spans. Unlike conventional arch bridges that are commonly anchored into bedrock at each end, the Norridgewock Bridge tied arch rests on pile-supported, concrete column piers in the river.

Reinforced, concrete-filled pipe piles are socketed 10 ft into bedrock approximately 40 ft below the riverbed using H-pile tips. The concrete seal measures 70 ft 4 in. by 18 ft 0 in. by 12 ft 0 in. thick. The distribution slab for the piers is 66 ft 4 in. by 14 ft 0 in. by 5 ft 0 in. thick.

There are two 10-ft-diameter columns at each pier. The pier columns are connected by a curtain wall that prevents ice from forming between them, which would impose additional lateral loads on the bridge.

Overarching Demands

After the approach spans and piers were complete, crews began work on the main span, starting with the construction of six cast-in-place concrete end floor beams and four cast-in-place arch end connections. The three floor beams at the ends of the arches are 3 ft 0 in. wide by 5 ft 9 in. deep and form the connection between the arch rib and tie girder. They are post-tensioned to the tie girder. The arch ribs required concrete with a design compressive strength of 5000 psi. Tie girders and arch end connections use 6000 psi concrete.

As seen from below the bridge, precast, prestressed concrete floor beams frame into the edge tie girders, which are, at this stage of construction, supported on temporary intermediate piers. Photo: Kleinfelder.

Design for 100-Year Life

The bridge has no deck joints over its 570-ft length. The new Covered Bridge uses precast concrete floor beams and precast deck panels, at the urging of the MaineDOT. While improving durability, these elements helped speed construction, improve quality, and eased construction. The design allows for easy replacement of the steel cable hangers, when needed, with traffic on the bridge. The hangers are the only primary members of the new structure that are made of steel. Concrete main members were chosen as the primary material in the bridge for durability, consistency with the design elements, and overall aesthetics of the original historic structure. Increased concrete cover on the reinforcement was specified beyond code minimums. Also, reinforcing steel meeting ASTM A1035 was used in the deck and parapet. Elastomeric bearings were used and jacking points provided should replacement of the arch bearings be necessary. The design of the substructure provided for the scour potential of the Kennebec River.

Self-consolidating concrete was used for the anchor zone of the arch end connection due to the congestion of the reinforcement and post-tensioning ducts and anchorages.

The arch ends connect the base of each arch rib to the tie girder. After the arch ends were complete, crews placed six temporary piers in the river approximately 47 ft apart. Temporary piers were used to support the formwork needed to construct the arch ribs and tie girders. The formwork was constructed in such a way as to permit the concrete structure to shorten and camber due to shrinkage and post-tensioning forces.

THREE-SPAN BRIDGE WITH CAST-IN-PLACE CONCRETE TIED-ARCH CENTER SPAN AND PRECAST, PRESTRESSED CONCRETE BULB-TEE BEAM APPROACH SPANS / MAINE DEPARTMENT OF TRANSPORTATION, AUGUSTA, MAINE, OWNER

HANGAR SUPPLIER: WireCo WorldGroup, Kansas City, Mo.

SHORING SYSTEM SUPPLIER: A.H. Harris & Sons, Newington, Conn.

BRIDGE DESCRIPTION: A 570-ft-long by 46-ft-wide, three-span bridge with a 300-ft-long, 60-ft-high arch span and two 135-ft approach spans

STRUCTURAL COMPONENTS: Two parallel 300-ft-long, 60-ft-high, cast-in-place concrete arch ribs; six cast-in-place concrete transverse braces; two longitudinal post-tensioned concrete edge tie girders; 19 precast, prestressed concrete floor beams; precast, prestressed concrete deck panels; two approach spans with 6-ft deep, 135-ft-long bulb-tee beams; replaceable steel cable hangers; and concrete parapet with a steel pedestrian rail

BRIDGE CONSTRUCTION COST: \$21.5 million



Formwork and reinforcement are nearly complete for transverse braces No. 2 and 5. Falsework and forms for transverse braces No. 3 and 4 have been removed. There are a total of six braces. Photo: Kleinfelder.

Crews erected 19 intermediate precast, prestressed concrete floor beams, 4 ft 0 in. wide by 3 ft 0 in. deep that were connected and post-tensioned to the base section of the concrete tie girders. The tie girders were supported on the six temporary piers and were post-tensioned longitudinally using eight tendons. Each tendon, with a jacking force between 1200 and 1250 kips, incorporates twenty-seven, 0.6-in.-diameter, 270 ksi strands. Round corrugated high-density polypropylene ducts were used.

Ribs and Braces

The next step was to construct the cast-in-place arch ribs and six transverse braces using arch falsework that extends from the six temporary piers. The arch ribs measure 4 ft square with large chamfers at midspan and increase in size uniformly to 8 ft 6 in. at the arch ends. The transverse braces are shaped as inverted “U”s and are 6 ft 9 in. wide x 2 ft 10 in. deep. The concrete was placed in one continuous operation for each rib. Once the arch ribs were complete, the general contractor installed two steel cable hangers at nine locations on each rib to connect them to the cast-in-place, post-tensioned tie-girders. Construction workers then removed the six temporary piers, beginning with the middle pier and moving outward, and began construction of the deck diaphragms, the top sections of the tie girders, and the deck. The completed tie girders measure 5 ft 2 in. wide by 6 ft 0 in. deep.

The majority of the entire bridge deck is formed with 3.5-in.-thick precast, prestressed concrete panels over which a 4.5-in.-thick composite concrete

topping is placed. The precast panels used were 8 ft 0 in. by 5 ft 10¾ in. on the approach spans and 8 ft 0 in. by 10 ft 6½ in. and 7 ft 0 in. by 10 ft 6½ in. on the arch span.

The tie girders’ post-tensioning tendons were installed and tensioned in three stages during the construction of the main span. Stage 1 applied 30% of final stressing forces 3 days after the concrete placement in the base section of the tie girders. The full specified forces for the base section were applied after 7 days from concrete placement or when concrete had reached a minimum strength of 5000 psi. Stage 2 tensioning occurred 3 days after the upper portions of the tie girders were placed and Stage 3 tensioning was applied 3 days after the composite topping of the deck was placed.

The two, 135-ft-long approach spans each use six bulb-tee beams,

approximately 6 ft deep (NEBT 1800), spaced at 8 ft 10 in. on center.

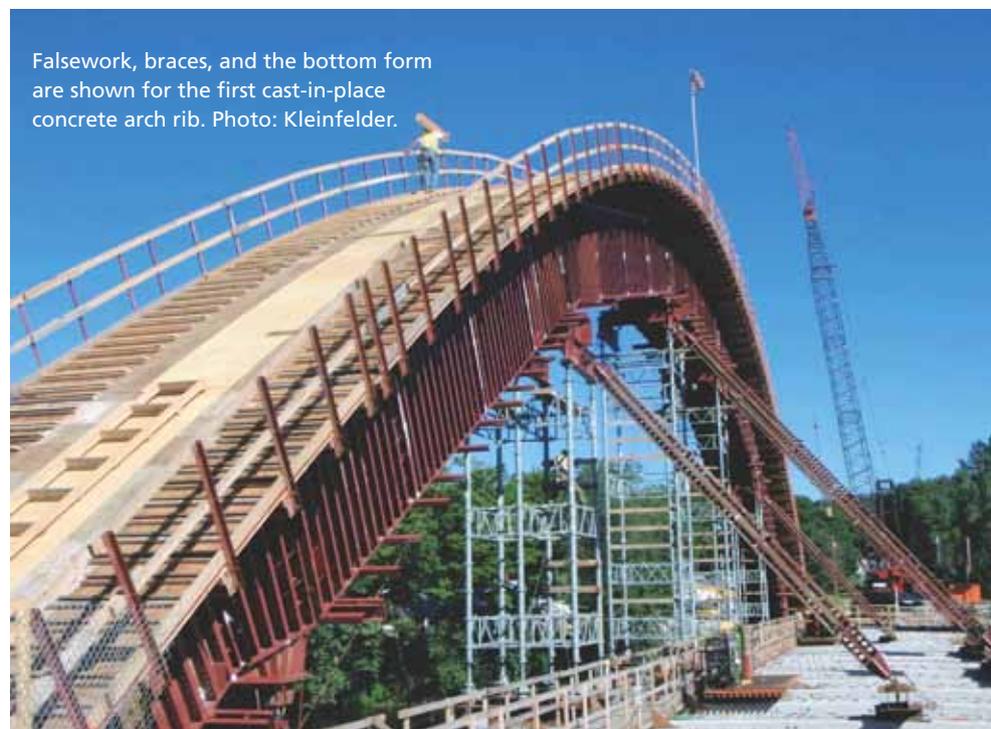
Another innovative feature is that the bridge has no deck joints. To manage the range of thermal expansion and contraction expected from along the arch deck and two approach spans, engineers incorporated durable elastomeric bridge bearings reinforced with steel. Four large 3-ft 6-in. square and 9-in.-tall bearings were located beneath each of the rib ends and atop the piers to support the arch span. Smaller bearings are located under each end of the bulb-tee beams. The bearings will require less maintenance compared to pot or disk bearings.

Opening with Character

The Covered Bridge opened to traffic July 21, 2011. It is only the second modern concrete tied arch bridge in the United States. The Depot Street Bridge in Oregon is the other. The Covered Bridge is twice the width of the original, with new shoulders and a multi-use lane, and all the modern advancements to help it last for the next 100 years or more—and, according to the community, it looks extraordinary.

Craig Weaver is a project manager with Kleinfelder in Augusta, Maine.

For additional photographs or information on this or other projects, visit www.aspirebridge.org and open Current Issue.



Falsework, braces, and the bottom form are shown for the first cast-in-place concrete arch rib. Photo: Kleinfelder.



AESTHETICS COMMENTARY

by Frederick Gottemoeller

Simplicity is usually a virtue in bridge aesthetics, particularly in a natural environment. At such sites, bridges are usually a small part of a much larger scene. Simple, easily understood shapes make a strong impact where fussy details would be lost in the background. Unfortunately, simplicity can also equal boredom. Those simple shapes must be refined in ways that add interest and grace. The Covered Bridge over the Kennebec River in Norridgewock, Maine, achieves that goal.

The shapes, including the cross bracing, are about as simple as they could be. At the same time, there is a lot of refinement here. The arch ribs taper from their thinnest point at midspan to match the tie girders at deck level. The cross braces have a subtle arch of their own. The dimensions and proportions are so thin that it's hard to believe that this is a concrete bridge. And the concrete allows simplicity at the joints, particularly at the arch rib-tie girder joint, that no other material could match. Finally, the thin cable hangers contrast dramatically with the concrete members of the bridge, giving the whole structure a light and open appearance.

A final refinement is the way the parapets carry in a continuous line across the whole bridge. They are inside the arch but outside the approach girders. Their overhang above the approach girders creates a shadow line that literally underlines the difference.

Concrete tied arches once appeared frequently along American roads. It is great to see that tradition revived with such a straightforward and graceful example.

Epoxy-Coated Reinforcing Steel
PROTECTION AGAINST CORROSION

STAY INFORMED...
www.epoxyinterestgroup.org

EIG CRSI
EPOXY INTEREST GROUP

© Photo courtesy of EIG, photo by Tim Duma

The Santa Ursula Connector

by David T. Covarrubias, David A. Rocha, and Jesse S. Covarrubias, Structural Engineering Associates Inc.



The completed Santa Ursula Connector in Laredo, Tex., curves downward towards the Rio Grande River front. All photos and drawing: Structural Engineering Associates Inc.

As part of a plan to revitalize riverfront commercial development, the city of Laredo, Tex., required a solution to provide easier access to the area. To reach the riverfront, commuters had to negotiate a route of heavily congested, narrow, streets through business and residential areas. The idea was proposed to build an elevated connector from Santa Ursula Avenue, an access road from I-35, to the riverfront and thereby avoid the congestion of the city streets.

The Santa Ursula Connector was proposed to be 31 ft wide and 1155 ft long. The bridge would be required to connect the higher elevation Santa Ursula Avenue to the flood plain. It required spanning over federal property between two international bridges on the Texas-Mexico border. Because the majority of the bridge is below the design high water level by as much as

25 ft, it was necessary to design the bridge to withstand the flood forces of the Rio Grande River.

The engineer's first task consisted of a feasibility study. The study was followed by the layout and design for the bridge, and coordination with the city of Laredo, Webb County, local utility companies, and federal agencies including the General Services Administration, Customs and Border Protection, and the International Boundary and Water Commission (IBWC).

The IBWC regulates construction within the floodplain; in order to gain their project approval, the impact to the river had to be minimized. Therefore, the bridge required a shallow superstructure to reduce the impact on the river during a flood event. Additionally, a sharp horizontal

curve was required to allow space for a future "up ramp" connector to be built. Finally, methods were needed to resist forces from a flood.

Design Challenges

The project presented several design challenges. The requirement for a future "up ramp" adjacent to the Santa Ursula Connector down ramp, necessitated a very sharp horizontal curve with a radius equal to 340.5 ft. It was desired to expedite construction within the federal property. Security within federal property (especially areas at border crossings) is extremely stringent. Workers required being on federal property needed to go through a lengthy federal security background check. Completing construction in secure areas as quickly as possible was a critical aspect of the design.

Finally, due to the bridge's location, an aesthetically pleasing structure was necessary.

Design Solutions

The Texas Department of Transportation's (TxDOT's) 15-in.-deep slab beam was selected to provide the minimum superstructure depth. The slab beam has a rectangular cross section and is available in both 4 and 5 ft widths. The typical cross section was framed with four, 5-ft-wide slabs and two, 4-ft-wide slabs. The slab beam provides a superstructure total depth of just 20 in. including a 5-in. deep cast-in-place composite concrete deck. Because the beams are abutted side-by-side, debris could not become lodged under the bridge during high water.

profile

SANTA URSULA CONNECTOR / LAREDO, TEXAS

BRIDGE DESIGN ENGINEER: Structural Engineering Associates Inc., San Antonio, Tex.

PRIME CONTRACTOR: Concho Construction Co. Inc., Garland, Tex.

PRECASTER: Bexar Concrete Works Inc. Ltd., San Antonio, Tex.

AWARDS: 2010 PCI Bridge Design Award, Best Bridge with Main Span up to 75 ft; 2011 Texas CEC Engineering Excellence Awards, Silver Medal Winner, Category C: Structural Systems



From the flood plain, the Santa Ursula Connector reaches upward to Santa Ursula Avenue.

A lateral load analysis of the entire structure was performed including the foundation. Using geotechnical data, the required embedment length of the drilled shafts was determined. The capacity of an extreme event loading was then checked.

The slab beam is seldom used on curved structures. When horizontal and vertical curves are combined, the bearing seats for these very wide, rectangular beams require special details to ensure that torsion is not introduced into the beams. A roadway cross slope adds complexity as well. The engineer determined that it was possible to overcome these hurdles without significant additional cost. The complex geometry was handled with a bridge geometry computer program using a modified and detailed input model.

Aesthetically, the straight-sided, chords of the slab beam were overcome by using a cast-in-place concrete overhang. The slab overhang was formed and cast with the bridge deck. The bottom of the overhang projected below the top of the exterior slab beams. It was connected laterally to the beams with mechanical couplers placed in the exterior edges during fabrication. The cast-in-place concrete overhang provides a very attractive horizontal curvature to the edge and the “drop-down” detail gives the superstructure the appearance of being thinner.

The location of the bridge, between two heavily used international bridges, required a method to ensure that the bridge would remain in place during a flood event. The owner was concerned about the possibility of the new bridge becoming dislodged and damaging or destroying the downstream international bridge. The slab beams are usually restrained from horizontal movement with the use of upturned ear walls on the ends of the bent caps. In addition to the ear walls, a nonstandard strand pattern allowed slotted vertical holes to be formed at the ends of the exterior beams. Hold-down anchors were provided in the tops of the bent caps. The exterior beams were erected with the slotted holes over the hold-down anchors. A

steel plate was placed over the beam and clamped in place with a nut. Fiberboard was placed over the plate to allow for the superstructure movement after the deck was cast.

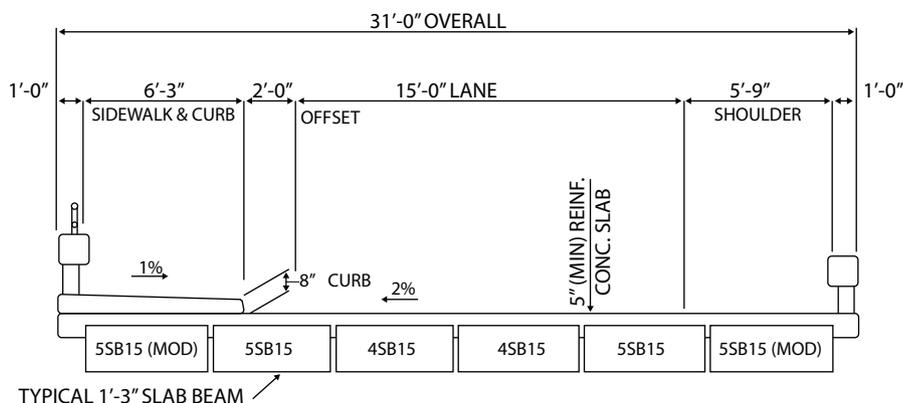
In addition to the shallow depth, the precast slab beams expedited construction over the federal property. Since slab beams are erected and placed side-by-side, they also act as a stay-in-place form for the cast-in-place deck slab. This feature saved valuable time, allowing the contractor to minimize the time of construction.

Design Innovations

The project resulted in innovations and accomplishments that can be considered for future projects with similar constraints. These innovations include:

- Using precast, prestressed TxDOT slab beams for sharp horizontal curves
- Using a nonstandard strand pattern to accommodate slotted holes to be formed in the beam ends for hold-downs to the pier cap
- Anchoring the precast superstructure to the substructure without resorting to cast-in-place concrete connections

The typical section of the single-lane Santa Ursula Connector superstructure.



PRECAST, PRESTRESSED CONCRETE SOLID SLAB BEAM BRIDGE WITH 25 SPANS TOTALING 1155 FT WITH A 5 IN.-THICK CAST-IN-PLACE CONCRETE COMPOSITE DECK SLAB / CITY OF LAREDO, TEXAS, OWNER

BRIDGE DESCRIPTION: A precast, prestressed concrete slab beam bridge 31 ft wide with 25 spans totaling 1155 ft and with cast-in-place composite concrete deck slab supported on a substructure comprising single-column bents and drilled shafts

STRUCTURAL COMPONENTS: Adjacent precast, prestressed concrete slab beams, 4 or 5 ft wide and 15 in. deep with cast-in-place composite deck slab and cast-in-place single column bents with single drilled shafts

BRIDGE CONSTRUCTION COST: Bridge cost \$3.16 million (\$89/ft²); Total Cost \$4.20 million (including approach work)



The upper portion of the bridge spans over federal property. This is the overflow inspection station used at the border during busy holiday periods. One of only two, 2-column bents on the project is visible.



Less than a year after completion, the Rio Grande River submerged the bridge under 23 ft of water during a flood in July 2010.

Construction

The bridge comprises 25 spans, ranging in length from 41.5 to 48.4 ft., for a total length of 1155 ft. The foundations are predominantly 6-ft-diameter, single drilled shafts, 45 to 50 ft deep. Two bents required double drilled shafts to straddle underground utilities. All foundations and bents required a 28-day concrete compressive strength of 3600 psi. All but one of the bents are single column or hammerhead bents. The tallest bent is about 30 ft high. The slab beams required concrete with a minimum compressive strength of 5000 psi. The bridge deck has a minimum thickness of 5 in. at midspan. Continuity is provided in the deck across the transverse construction joints using typical TxDOT details, which are specifically designed to not provide full continuity for live load. The slab overhang depth varies due to the haunch thickness but has an 8.5 in. minimum depth at midspan. The

deck concrete required a minimum compressive strength of 4000 psi.

Construction occurred between February 2008 and August 2009. The project construction schedule required adjustments for several local events including an unscheduled flood. Because the connector crossed over a federal inspection station used for overflow border traffic during busy times such as holidays, construction was stopped when use of the station was required.

Conclusion

The Santa Ursula Connector has successfully served the needs of the city of Laredo. It has provided quick and easy access to the riverfront as intended, and has generated interest from developers with concepts for revitalizing the area. Additionally, the connector has shown it can withstand the flood forces of the Rio Grande River when it was tested by the flood of July 2010.



The two edge slab beams have slotted holes through the ends that will receive anchor bolts from the bent caps. Cover plates and nuts will prevent the slabs from being displaced during high water.

David T. Covarrubias is vice-president and senior project manager, David A. Rocha is project engineer, and Jesse S. Covarrubias is president, all with Structural Engineering Associates Inc., in San Antonio, Tex.

For additional photographs or information on this or other projects, visit www.aspirebridge.org and open Current Issue.

Segment lifter
With variable cross section
Used in Florida,U.S.A.



Beijing Wowjoint Machinery Co.

A leading innovative infrastructure solutions provider of customized heavy duty lifting and carrying machinery used in large scale projects such as railway, highway and bridge construction.



BEIJING WOWJOINT MACHINERY CO.
1108 A Block TIANCHENG MANSION,
2# XINFENG Road DESHENG MENWAI Street,
XICHENG Dist. Beijing P.R.China, 100088
Tel: 86-10-89579330/82273390
Fax: 86-10-89579553/82273117
Ph: (530) 475-2793 (office in U.S.A.)
Fax: (949) 209-2685 (office in U.S.A.)
E-mail: cn@email.wowjoint.com
mail@wowjoint.com
aubrye@wowjoint.com (office in U.S.A.)
[Http://www.wowjoint.com](http://www.wowjoint.com)



The Office of Federal Lands Highway



by Gary Jakovich, Hratch Pakhchanian, and M. Myint Lwin, Federal Highway Administration



The Mike O'Callaghan–Pat Tillman Memorial Bridge over the Colorado River at Hoover Dam. Photo: McNary Bergeron & Associates Inc.

The Office of Federal Lands Highway (FLH) provides program stewardship and transportation engineering services for planning, design, construction, and rehabilitation of the highways and bridges that provide access to and through federally owned lands. The federal government has title to about 650 million acres—roughly 30% of the total area of the United States. There are more than 300,000 miles of federally owned roads.

FLH has four offices—Headquarters, and Eastern, Central, and Western Divisions—to provide services to the FLH partners. FLH works closely with the federal land management agencies (FLMAs) and many state and territorial partners. FLMAs include the Bureau of Indian Affairs (BIA), U.S. Forest Service (USFS), National Park Service (NPS), Fish and Wildlife Service (FWS), Bureau of Land Management (BLM), Military Surface Deployment and Distribution Command (SDDC), U.S. Army, U.S. Army Corps of Engineers (USACOE), U.S. Navy, Tennessee Valley Authority, and the Bureau of Reclamation (BOR).

The Federal Lands Highway Program

The primary purpose of the Federal Lands Highway Program (FLHP) is to provide financial resources and technical assistance for a coordinated program of public roads that service the transportation needs of federal and Indian lands. One of the major factors associated with the success of the program is the Federal Highway Administration's strong relationship with our federal, state, local, and tribal partners.

The FLH Bridge Office

Within FLH, each of the three Divisions (Eastern, Central, and Western) has a Bridge Office. The Eastern (EFLHD) Office is the largest of the three Divisions with 29 people. The Central (CFLHD) and the Western (WFLHD) Offices are made up of nine and three people, respectively.

The FLH Bridge Program

The FLH Bridge Office performs bridge engineering in three program areas: Bridge

Inspection, Bridge Asset Management, and Bridge Design and Construction.

The Bridge Inspection Program (BIP) Team based in EFLHD performs bridge safety inspections for eight federal agencies across a nationwide geographic area. The BIP unit inspects nearly 2000 structures with the National Park Service (NPS) structures accounting for approximately 95% of the total. The WFLHD staff also performs safety inspections for a select portion of the Bureau of Land Management's inventory in the State of Oregon.

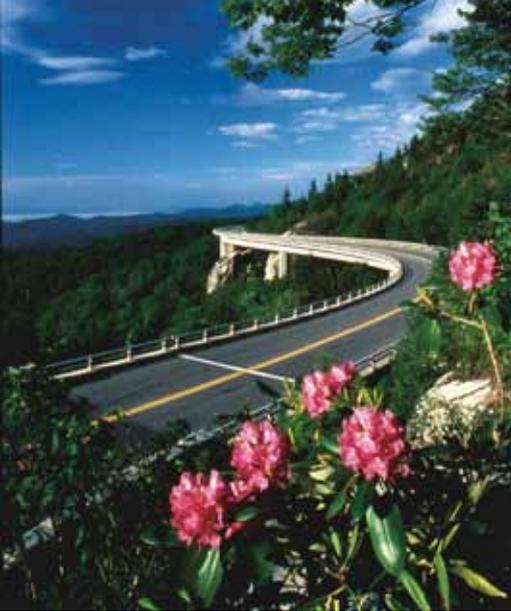
The Bridge Asset Management team, located in EFLHD, works with all three FLH Divisions and in partnership with the NPS to assist in developing their bridge rehabilitation/replacement program. Evaluative and predictive tools are used to formulate recommended work priority lists for each of NPS's seven geographic regions.

The Bridge Design and Construction Program is carried out by staffs in the three FLH Divisions. The FLH Bridge Office is focused on designing bridges in-house, providing review expertise for structures designed by others, and providing technical support for the building of these structures.

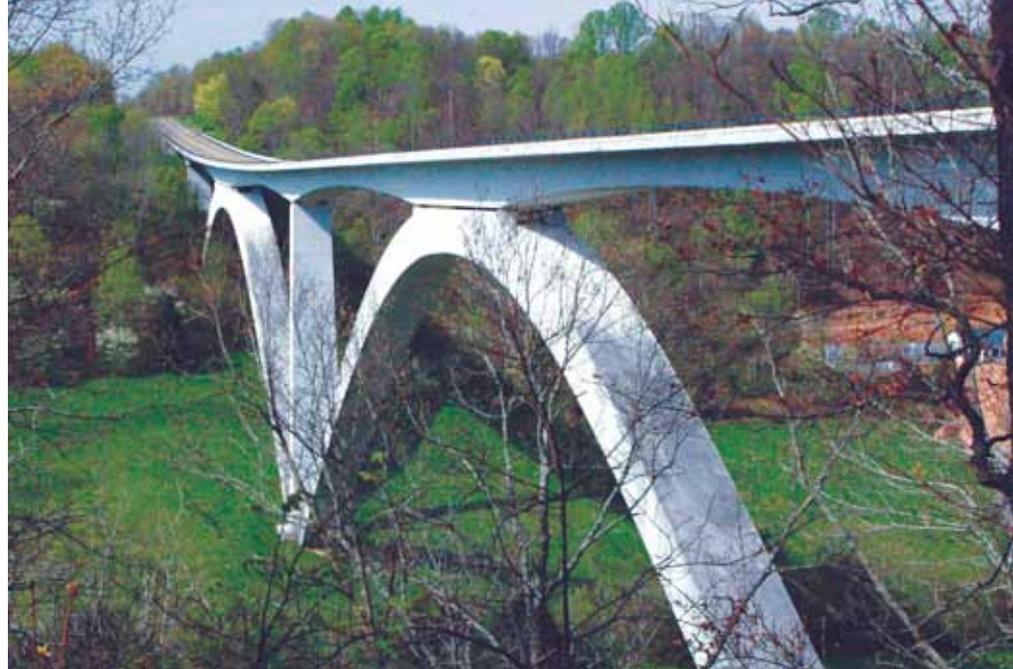
Concrete Bridge Projects

Over the years, FLH has often been tasked with building bridges in sensitive sites where aesthetic and environmental considerations greatly influence the choice of structure type and construction method. In many cases, concrete has offered the preferred solution. Several notable examples are; the O'Callaghan-Tilman Memorial Bridge, which bypasses the Hoover Dam and employs a segmental concrete arch as the main supporting component; the Blue Ridge Parkway Viaduct—a precast segmental concrete box girder with very severe horizontal alignment challenges that was erected using top-down construction; and the Natchez Trace Arch Bridge—a segmental concrete box girder that is supported on segmental concrete arches and pier columns.

A current challenging project is the design and construction of Bridge No. 2 on the Foothills Parkway in Tennessee. The EFLHD Bridge staff provided the conceptual engineering for this project and is now providing technical assistance to help administer its final design and



Blue Ridge Parkway or Linn Cove Viaduct in North Carolina. Work began on the viaduct in June 1979 and was completed in November 1982 at a final cost of \$9.8 million. Photo: FHWA.



Natchez Trace Parkway Arch Bridge located in Williamson County, Tenn., is the first segmentally constructed concrete arch bridge in the United States. Photo: FHWA.

construction. The Foothills Parkway is located in the mountainous foothills of the Tennessee Valley adjacent to the Great Smoky Mountains National Park. Bridge No. 2, in Blount County, is a significant precast segmental single-cell box girder bridge currently under construction for the NPS. The design-build project is led by EFLHD and funded by the American Recovery and Reinvestment Act. The EFLHD is working in partnership with the NPS to administer the design and construction of the Parkway.

The bridge length is 790 ft with five spans (125, 180, 180, 180, and 125 ft). The mountainous terrain required a complex alignment for the bridge. The geometry of this bridge includes a reverse horizontal curve alignment with spirals and a vertical alignment that includes a sag curve on a steep 8% grade.

Precast segments are being used for both the piers and superstructure with the intent of enabling this work to proceed simultaneously while the construction of foundations and temporary erection structures takes place at the site. The foundations require micropiles that vary in length due to variable geotechnical conditions. The erection of segments will be done from the top down for the piers and will use the balanced cantilever method for the superstructure.

The superstructure consists of 92 segments

and the substructure consists of 20 segments. The typical superstructure segment has a constant depth of 9 ft 0 in. and a width of 36 ft 10 in. weighing 100 kips each. The top slab is transversely post-tensioned. The substructure segment widths vary from 10 ft 0 in. to 13 ft 8 in., are hollow, and will also be post-tensioned. Difficult site constraints of steep terrain and extremely limited access from only one end of the bridge prevents the contractor from erecting precast segments with traditional cranes and overhead erection trusses. A temporary trestle/falsework system, supporting an elevated rail system that will be used by a gantry crane to erect the bridge, is being constructed to gain access to the site and construct the bridge. The temporary trestle is supported by micropiles that will be cut down 2 ft below the ground line after the falsework is removed.

The last of the segments was cast in August. Erection of the segments will begin in October and is scheduled to be completed in spring 2012. Finally, a high-performance concrete overlay will be placed in early spring. The completion of this bridge will grant the contractors access to the other bridge sites on the “Missing Link” of the parkway. The Foothills Parkway target opening date for the public is 2016.

Gary Jakovich is division bridge engineer and Hratch (Richard) Pakhchanian is senior bridge design specialist, both with Eastern Federal Lands Highway in Sterling, Va.; and M. Myint Lwin is director, Office of Bridge Technology at the FHWA in Washington, D.C.



On the project site, a temporary trestle is in place as work gets started on Foothills Parkway Bridge No. 2. Photo: FHWA.

Column and girder segments are shown stored in the casting yard for Foothills Parkway Bridge No. 2 in Tennessee. Photo: FHWA.



Guidelines for Inspection and Acceptance of Epoxy-Coated Reinforcing Steel

by David McDonald, Epoxy Interest Group

Epoxy-coated reinforcing bars have been used to protect against chloride induced corrosion since 1973. The most commonly used bars are green and meet AASHTO M 284¹ (ASTM A775); however, certain agencies use purple or gray colored products that meet ASTM A934². Epoxy-coated reinforcing bars continue to be the most commonly specified and researched corrosion-resistant products.

Jobsite inspection of epoxy-coated reinforcing steel prior to concrete placement is critical to ensure that optimum corrosion protection is provided. The following provides an outline of procedures to minimize damage:

- Coated bars should be lifted using a spreader bar or at multiple pickup points to minimize sag and should never be dragged. Bare chains or cables should not be used for lifting and coated bars should be stored on timber cribbing.
- Forms should be oiled prior to placement of the reinforcing bars and bars should not be placed directly on the oiled forms, but rather, placed on epoxy-coated or nylon supports.
- Bars should be tied using coated tie wire.
- Bars must not be flame cut and may only be bent at the jobsite with the permission of the engineer. Only reinforcing bars meeting AASHTO M284 (ASTM A775) may be bent after coating.
- If mechanical splices are used, they should be epoxy-coated and welding should only occur with the permission of the engineer.
- Prior to concrete placement, bar spacing, clear cover, bar size, and bar type should be evaluated along with lap

lengths. Bends should be inspected and not exhibit any unrepaired cracking or fractures and all damage should be repaired. If the bars exhibit greater than 2% damage in any 1 ft section, they may be rejected. Note that this limit does not include sheared or cut ends. Welds should also be cleaned and patched with repair materials.

- Avoid placing concrete hoses directly on the coated steel, as couplers may damage the coating as they are moved. A runway should also be considered. Concrete pump lines should be fitted

with an “S” bend to prevent free fall of concrete directly onto the coated bars and plastic headed concrete vibrators should be used to consolidate the concrete.

- Bars that are partially cast in concrete, and then exposed for extended periods, should be protected against exposure to UV, salts, and condensation. If stored bars are exposed for more than 30 days, they should be covered with an opaque material that minimizes condensation.

Further information on the use and handling of epoxy-coated reinforcing steel is available in a document titled “*Guidelines for Inspection and Acceptance of Epoxy-Coated Reinforcing Steel at the Jobsite*” available at www.epoxyinterestgroup.org. This eight-page document provides procedures for inspection of epoxy-coated reinforcing steel during construction and prior to concrete placement, and is valuable to anyone involved in the placing and inspection of concrete containing epoxy-coated bars.

Standards

1. AASHTO M 284, Standard Specification for Epoxy-Coated Reinforcing Bars: Materials and Coating Requirements
2. ASTM A934, Standard Specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars

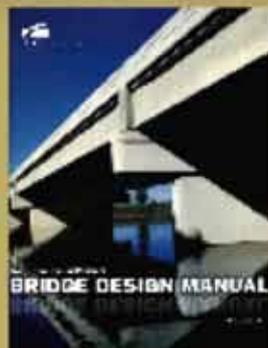
David McDonald is managing director of the Epoxy Interest Group, Concrete Reinforcing Steel Institute in Schaumburg, Ill.



Epoxy-coated reinforcement shown in the Indian River Inlet Bridge. Photo: AECOM.

AT THE PCI
**Winter
2012!**
BOOKSTORE

Third Edition of the *PCI Bridge Design Manual*



This manual is updated to conform to the fifth edition of the *AASHTO LRFD Bridge Design Specifications*, and the *2011 Interim Revisions*. Featuring 11 new design examples, this manual provides solutions using various precast/prestressed concrete bridge beams and products. These examples illustrate the various new alternate code provisions including prestress losses, shear design, and transformed sections.

This first release of the third edition includes one new chapter – Chapter 1 on Sustainability and revised chapters, including: Chapter 2 on Materials; Chapter 3 on Production; Chapter 4 on Economy; Chapter 5 on Aesthetics; Chapter 6 on Preliminary Design with all new LRFD Preliminary Design Charts and tables; Chapter 7 on Loads; Chapter 8 on Design; Chapter 9 on Design Examples; and a completely rewritten Chapter 10 on Bearings explaining the new method B simplified approach.

This third edition is a must-have manual for all design and load-rating engineers, owner agencies, contractors, specifiers, precasters, and suppliers.

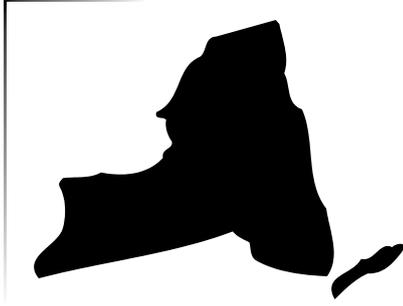
List Price	\$490.00
Member Price	\$245.00
Registered Manual Holders Upgrade.....	\$122.50
Student (electronic version only)	\$104.00



Precast/Prestressed Concrete Institute

200 West Adams Street | Suite 2100 | Chicago, IL 60606-5230
Phone: 312-786-0200 | Fax: 312-621-1114 | www.pci.org

STATE



Concrete Bridges in NEW YORK STATE

by Matthew C. Royce, New York State Department of Transportation

NYS DOT started building prestressed concrete bridges in the 1950s.

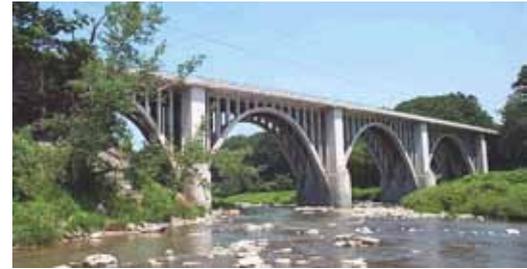
Concrete bridges play a significant role in the transportation infrastructure of New York State. Since the early part of the twentieth century, methods for both designing and building concrete bridges have undergone many changes. Generally, concrete bridges have served the state well. There are some cases, however, where early methods that were used have resulted in deterioration.

The New York State Department of Transportation (NYS DOT) has developed, and is currently using, technology in concrete bridge design and construction that will significantly reduce corrosion-related deterioration. NYS DOT is in the forefront of utilizing the latest advancements in concrete technology such as high-strength, high-performance concrete (HSHPC), self-consolidating concrete (SCC), ultra-high-performance concrete (UHPC), and internal curing concrete (ICC) for building concrete bridges that are more durable as well as cost effective.

Reinforced Concrete Bridges

Many of New York State's aesthetically pleasing open spandrel concrete arch bridges built in the first half of the twentieth century are still in service today and, with proper maintenance, should continue to be for quite some time. One such structure, currently under rehabilitation, is Route 5 over Eighteen Mile Creek in western New York State. This bridge was completed in 1931 and is expected to have at least an additional 25 years of service life after the current rehabilitation is completed. Based on the proven durability and aesthetic appeal of these structures, NYS DOT continues to build reinforced concrete arch bridges whenever appropriate. Two such bridges, recently completed, are Route 5S over Wallkill and Route 30 over Minekill. Both bridges have cast-in-place, reinforced concrete arches and precast, prestressed concrete superstructures, made using self-consolidating HSHPC, above the arch.

Even though concrete arch bridges are both durable and attractive, they are relatively expensive to build. NYS DOT built a significant number of less expensive, yet still attractive, reinforced concrete earth-filled arch frame bridges for grade separations during the construction of parkways during the mid-twentieth century. These bridges have been very



Route 5 over Eighteen Mile Creek in western New York, is an open spandrel cast-in-place, reinforced concrete bridge completed in 1931.

All photos: NYS DOT.

durable and the vast majority of them are still in service. Some of these bridges have been recently replaced with adjacent precast, prestressed concrete box beams with curved soffits to replicate the bridges they replaced.

Prestressed Concrete Bridges

NYS DOT started building prestressed concrete bridges in the 1950s, with a few post-tensioned T-beam bridges. Most of the T-beam bridges have already been replaced due to the corrosion of the post-tensioning tendons—a result of insufficient grouting methods in use at that time. The grout, with high water content, left voids in the ducts, which when infiltrated by chloride contaminated deck drainage, led to significant corrosion of the post-tensioning tendons.

One remarkable bridge that was completed in 1960, I-81 over Oneida Lake, is worthy of special recognition. From the time of its completion until 2010, this bridge held the record for the longest main span in the world for a precast, prestressed concrete spliced girder bridge at 320 ft. The structure is in good condition overall except that the fascia girders have the bottom tendons corroded at locations where the girders were exposed to deck drainage. The weakened girders are being strengthened with external

The Route 5S over Wallkill bridge uses cast-in-place, reinforced concrete arches with precast concrete spandrel columns, cap-beams, and a precast, prestressed concrete adjacent box beam superstructure. All precast components were made using self-consolidating HSHPC.





I-81 over Oneida Lake is a precast, post-tensioned concrete, spliced girder bridge. At 320 ft, it was the longest concrete spliced girder span in the world from 1960 until 2010.

York today have the highest corrosion resistance possible, while still using conventional steel reinforcement.

NYS DOT has also been using high-performance concrete (HPC) in cast-in-place applications mainly for concrete bridge decks, for the last 15 years. The main focus is durability, rather than high strength. With the use of epoxy-coated reinforcement, along with HPC, these decks are expected to last much longer than decks with conventional concrete. One area of concern for NYS DOT, as well as many other states, is cracking of the concrete in the cast-in-place decks. NYS DOT has two ongoing experimental programs in this area. Based on various completed studies, the cause for these cracks has been determined to be tension in concrete resulting from restrained autogenous, drying, and thermal shrinkage.

Deck with Internal Curing Concrete

NYS DOT has recently completed 10 bridge decks with ICC. The concrete mix is produced with a 30% substitution of fine aggregate with saturated lightweight aggregate fines which act as internal storage for moisture. The primary benefit of the mixture is that the autogenous shrinkage of concrete will be nearly eliminated and thereby reduce the tension in the hardening concrete deck. Evaluations on the decks built with ICC are ongoing and the results will be published at the conclusion of the study.

post-tensioning to restore their lost capacity. It is expected that this unique structure, which is eligible for entry into the registry of historic bridges will continue to be in service for many years after its rehabilitation.

Since the 1960s, pretensioned beams, predominantly adjacent box beam superstructures, have been the main stay for concrete bridges in New York; however, some AASHTO I-beam bridges were also built. Adjacent box beam bridges are a very cost-effective solution for short-to-medium span bridges; they are particularly appropriate where superstructure depth is limited. These superstructures also provide a smooth bottom, which is beneficial for stream crossings with low freeboard. Until the early 1990s, these bridges utilized a partial-depth shear key between beams. These shear keys had a tendency to crack and these cracks reflected through the deck, allowing drainage containing deicing chemicals to leak through joints between beams. This leaking led to the exposure of the sides and bottoms of the beams which, made with conventional concrete of the time, had relatively high permeability compared to today's HSHPC. Corrosive chemicals, mainly chlorides, seeped into the concrete resulting in corrosion of the prestressing strands and conventional reinforcement. A significant number of these bridges are nearing the end of their service life due to this problem and are expected to be replaced in the near future.

Full-Depth Shear Keys and Enhanced Concrete

Starting in the mid-1990s, NYS DOT introduced full-depth shear keys between the box beams, along with higher transverse post-tensioning forces and increased reinforcement in the 6-in.-

thick, cast-in-place concrete decks over the beams. These changes significantly reduced the reflective cracking above the shear keys. Even though some random shrinkage-related hairline deck cracking persisted, leakage through joints between the beams was practically eliminated. In order to further improve the durability of the prestressed concrete beams, NYS DOT started using high-strength (10 ksi), high-performance concrete for all precast, prestressed bridge components. This higher performance with regard to durability includes low permeability, better freeze-thaw resistance, and better scaling resistance. In addition, calcium nitrite corrosion inhibitor at a rate of 5.4 gal/yd³ is being used in the concrete to improve the corrosion resistance even when some chloride manages to permeate the concrete. As additional insurance, all the beams are sealed with penetrating type sealers (silane) to stop any moisture and chloride intake by the beams via microcracks in the concrete. Overall, prestressed concrete beams used in New



Route 31 over Canandaigua Outlet shown during construction, is a precast, prestressed concrete deck bulb tee ready for the field-cast UHPC joints to be filled.



The twin, 2300-ft-long, I-390 bridges over the Genesee River, built in the 1970s, were some of the first cast-in-place, post-tensioned segmental concrete bridges in the United States.

Low Cement Concretes

Another study that has been started is on concrete decks made with lower cement content mixes. The lower cement content is made possible through the adjustment in large aggregate gradation with the primary benefit being lower heat of hydration. This reduces the tension in decks resulting from restrained thermal and drying shrinkage. That study is expected to be completed in 2 to 3 years, and should the results prove positive for both studies, development of concrete mixes incorporating the beneficial aspects of both approaches is anticipated.

Accelerated Bridge Construction

NYSDOT is at the forefront of developing enabling technologies for accelerated bridge construction (ABC). The use of precast concrete bridge elements is an efficient way to accelerate bridge replacements; however an area of concern is the durability of the joints between the members. NYSDOT, with the assistance of the Federal Highway Administration and the concrete industry, has developed and tested joints using UHPC. These joints need only be 6 in. wide since the reinforcing bars up to size No. 6 can be fully developed within a joint of that size. These joints are also highly durable and crack resistant. The first use of the UHPC joint was for the superstructure for Route 31 over Canandaigua Outlet in Lyons, N. Y. With a short schedule, this project used deck bulb tees (DBT) with UHPC joints between them. It was completed in 2008 (for more information, see *ASPIRE*[™], Fall 2009, page 28). There are two ongoing projects utilizing DBTs and

UHPC joints: Staten Island Expressway over Fingerboard Avenue and Route 248 over Bennets Creek.

Route 23 over Otego Creek used UHPC in joints between precast, prestressed concrete full-depth deck panels. This is another beneficial application this technology. The project was completed in 2009. UHPC joints eliminated the need for the commonly used longitudinal post-tensioning of the deck panels. Precast concrete decks with UHPC joints and haunches are an alternate to cast-in-place decks for some of NYSDOT's upcoming bridge replacement projects.

Segmental Concrete Bridges in New York

The 2300-ft-long, I-390 twin bridges over Genesee River were among the first post-tensioned segmental bridges in the country. These cast-in-place segmental bridges were built using the balanced cantilever method during the 1970s. The two bridges are performing very well with minimal maintenance. NYSDOT continues

to use segmental concrete bridge construction where appropriate and cost effective. In addition to the concrete segmental structure for the JFK light rail link built under public-private partnership, NYSDOT completed the Marcy Avenue ramp to Williamsburg Bridge in 2001 and the Roslyn Viaduct in 2011. For the Roslyn Viaduct, precast, segmental match-cast concrete construction was used for the piers, in addition to the balanced cantilever superstructure (see *ASPIRE* Fall 2009, page 32). Both superstructure and substructure used self-consolidating HSHPC with corrosion inhibitors. The grouting of the post-tensioning ducts, performed by American Segmental Bridge Institute-certified technicians, under stringent quality control-quality assurance and using pre-packaged, no-bleed grout is expected to perform well, long into the future.

Conclusion

In general, concrete bridge building in New York State is a thriving industry. The concrete bridges that are being built today are focused on durability. Accelerated construction, at reasonable cost and with equal or better durability compared to conventional construction, is another area where the NYSDOT has made significant strides.

Mathew C. Royce is associate civil engineer with the New York State Department of Transportation in Albany, N.Y.

For more information on New York State's bridges, visit www.nysdot.gov/ index.

The Roslyn Viaduct used precast concrete segmental construction for both piers and superstructure.

HSHPC was used for all precast concrete components.



Saves You Space For Live Traffic...

Mi-Jack Travelift® MJ Series RTG Cranes

Bridge Repair is easier when using the Mi-Jack Travelift® RTG cranes to quickly set your load, without the need for a large area required by conventional cranes.

Call Today, to find out more about how the Mi-Jack Travelift® RTG crane can save you time and money on your next Bridge Repair project...

see us at the PCI Booth #303

(800) 6-MI-JACK
www.mi-jack.com



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.

Building in the 'Fish Window'

by Jim Markus, King County Department of Transportation

King County, Wash., can disrupt waterways only from June to October, creating challenges that necessitate longer bridge spans and efficient designs

King County, Wash., offers spectacular scenery with many rivers running through a densely populated developed landscape. This creates challenges for maintaining bridges. Most of the bridges span salmon-bearing waterways, which can't be disrupted during spawning season. That "fish window" limits construction of most bridges from June until early October, marking the number-one challenge to keeping roadways open and infrastructure up to date.

The county replaced 33 bridges in the 14 years between 1995 and 2008. Another nine bridges were rebuilt, adding more construction. These nine projects were all uniquely able to make use of the existing structure. Seldom does such rebuilding make sense. Due to our high seismic zone, foundations often must be brought up to code, at which point it's difficult to save the rest of the bridge and achieve any life-cycle cost savings.

In 2008, the county also completed a 14-year, \$20 million, comprehensive Bridge Seismic Retrofit Program, upgrading 115 of the county's 184 bridges, five of which are co-owned with neighboring cities.

The "fish window" restriction requires any work done over the waterway, including girder placement and deck placements, to be completed during that period. The key concern is concrete spills into the water, which can kill fish in an instant. As a result, we no longer build bridges with piers in the water, leading us to continually seek new ways to span the waterways. One approach has been to extend concrete clear-span designs to 200 ft or more. A project to be completed in November 2011 features a 210-ft span with spliced precast concrete Washington State supergirders, our longest simple-span concrete bridge to date.

Replacing longer spans also requires dramatically increased deck area. An example is the new York Bridge, a partnership between the county and the city of Redmond, which replaced a simple-span, narrow 50-year-old bridge vulnerable to earthquake damage. The 220-ft-long, four-span, precast, prestressed concrete replacement features Washington State W42G girders with a shallow cast-in-place concrete arch and inclined columns supporting two center spans.

The project won the Silver Award for Structural Systems from the American Council of Engineering Companies and features artwork



The York Bridge in King County, Wash., features a cast-in-place arch supporting a four-span precast concrete superstructure. The combination allowed the design to be consistent with other bridges in the area while maintaining the required structural integrity. Photos: King County DOT.



The Wynaco Bridge spanning Covington Creek was extensively rehabilitated to upgrade its load capacity, seismically retrofit it, and strengthen its rails. The 195-ft-long bridge reused some precast concrete girders with a more efficient spacing, saving time and money. The project won two awards from the local American Society of Civil Engineers.

by Cliff Garten, paid for by King County and Redmond's public-art programs. In noting the bridge's consistency with other bridges in the area, the judges cited the design's ability to overcome challenges that included soft soil, an unusual arch design, and concern for the environment and neighbors.

The county continues to look for creative approaches to meeting its challenges. Because detours can be significant, we continually look for techniques that will speed construction,

such as geosynthetic reinforced abutments that can replace drilled shafts. Those concepts can minimize user costs and help us to complete work inside the "fish window."

Jim Markus is managing engineer for the King County Road Services Division of the King County Department of Transportation in Washington State.

Your Road & Bridge Source

We've long been a leader in road and bridge product innovation. But **Meadow Burke's** newest revolutions do more than greatly reduce labor costs and construction time. Through innovative engineering and product design, we make it possible for you to build stronger, sustainable road & bridge concrete structures.

Meadow Burke. Innovating concrete construction

To learn more, call toll free at **877.518.7665** or visit www.MeadowBurke.com



MeadowBurke



Washington Marriott Wardman Park

AMERICAN SEGMENTAL BRIDGE INSTITUTE **ASBI**

November 7-8

2011 Annual ASBI CONVENTION

Washington, DC

2011 Bridge Awards of Excellence
SELECTION



Promoting Segmental Bridge Construction

in the United States, Canada and Mexico



April 16-17

2012 Grouting Certification TRAINING

J.J. Pickle Research Campus
University of Texas, Austin

For Membership Information
or for further details visit
www.asbi-assoc.org

CONCRETE CONNECTIONS

Concrete Connections is an annotated list of websites where information is available about concrete bridges. Fast links to the websites are provided at www.aspirebridge.org.

IN THIS ISSUE

www.dullesmetro.com

Visit this website for more details on the Washington, D.C. to Dulles Airport Metrorail project described on page 26. Click on Construction for a series of photographs.

www.mfe-union-to-brown.com

This project website contains information about the Uniontown to Brownsville Expressway project of the Pennsylvania Turnpike Commission. Click on the Photos tab for two Monongahela River Bridge construction cameras, a video, and the latest photographs for Section 51H. (See page 14.)

www.dot.ca.gov/dist8/projects/san_bernardino/sr18bear/

This California Department of Transportation website provides more details about the Big Bear Bridge described on page 22.

www.flh.fhwa.dot.gov/

More information about Federal Lands Highway described on page 42 is available at this website.

www.arc-competition.com/welcome.php

This is the official site for ARC—the International Wildlife Crossing Infrastructure Competition. ARC selected five teams to develop concept designs for a wildlife crossing at Colorado's West Vail Pass along I-70. The designs, including the winning entry described on page 12, can be viewed at this website.

Environmental

<http://environment.transportation.org/>

The Center for Environmental Excellence by AASHTO's Technical Assistance Program offers a team of experts to assist transportation and environmental agency officials in improving environmental performance and program delivery. *The Practitioner's Handbooks* provide practical advice on a range of environmental issues that arise during the planning, development, and operation of transportation projects.

www.environment.transportation.org/teri_database

This website contains the Transportation and Environmental Research Ideas (TERI) database. TERI is the AASHTO Standing Committee on Environment's central storehouse for tracking and sharing new transportation and environmental research ideas. Suggestions for new ideas are welcome from practitioners across the transportation and environmental community.

Sustainability

<http://sustainablehighways.org>

The Federal Highway Administration has launched an internet-based resource designed to help state and local transportation agencies incorporate sustainability best practices into highway and other roadway projects. The Sustainable Highways Self-Evaluation Tool, currently available in beta form, is a collection of best practices that agencies can use to self-evaluate the performance of their projects and programs to determine a sustainability score in three categories: system planning, project development, and operations and maintenance.

www.pewclimate.org/docUploads/Reauthorization-and-HTF-Primer.pdf

If you have never understood the Federal Surface Transportation Authorization and the Highway Trust Fund, this primer may help you.

Bridge Technology

www.aspirebridge.org

Previous issues of *ASPIRE*TM are available as pdf files and may be downloaded as a full issue or individual articles. Information is available about subscriptions, advertising, and sponsors. You may also complete a reader survey to provide us with your impressions about *ASPIRE*. It takes less than 5 minutes to complete.

www.nationalconcretebridge.org

The National Concrete Bridge Council (NCBC) website provides information to promote quality in concrete bridge construction as well as links to the publications of its members.

www.hpbridgeviews.org

This website contains 68 issues of *HPC Bridge Views*, an electronic newsletter published jointly by the FHWA and the NCBC to provide relevant, reliable information on all aspects of high-performance concrete in bridges. Sign up at this website for a free subscription.

<http://international.fhwa.dot.gov/pubs/pl10014/pl10014.pdf>

The U.S. Federal Highway Administration's Office of International Programs has released a report titled *Assuring Bridge Safety and Serviceability in Europe*. The report describes a scanning study of Europe that focused on identifying best practices and processes designed to help assure bridge safety and serviceability. The scan team gathered information on safety and serviceability practices and technologies related to design, construction, and operations of bridges. A summary of the study was provided in *ASPIRE* Winter 2010, page 50.

NEW www.trb.org/Publications/PubsNCHRPResearchResultsDigests.aspx

Research Results Digest 355 summarizing key findings from NCHRP Project 10-71 titled *Cast-in-Place Concrete Connections for Precast Deck Systems* is now available from this National Cooperative Highway Research Program website.

www.fhwa.dot.gov/Bridge/ABC

Visit this website for more information about the FHWA Accelerated Bridge Construction Program.

www.fhwa.dot.gov/bridge/abc/prefab.cfm

If you missed the FHWA webinars about Prefabricated Bridge Elements and Systems held in four sessions on August 16 and 17, 2011, the webinar is now available at this website. Under Webinars, click on one of the sessions. The concrete industry role is included in Session 3.

NEW www.wsdot.wa.gov/research/reports/fullreports/759.1.pdf

The Washington State Department of Transportation has published a report titled *Investigating Longevity of Corrosion Inhibitors and Performance of Deicer Products under Storage or after Pavement Application* that is available at this website.



PCI Announces Two State-of-the-Art Reports

Adjacent Box Beam Bridges



November
1st

The Precast/Prestressed Concrete Institute is proud to share a new publication on adjacent box beam bridges. NCHRP Synthesis number 393 discusses issues with the longitudinal joint and overlay. This 12 chapter report offers suggested details, practices and case studies. The document also includes a summary of conclusions addressing design, fabrication and construction. [SOA-02-2011]

State-of-the-Art Report Pricing

List Price.....	\$70.00
Member Price.....	\$35.00

Bridge Deck Panels



Available
NOW!

The new Bridge Deck Panel Report is a state-of-the-art guide for selecting, designing, detailing, and constructing precast full-depth deck panels for bridge construction.

The report consists of four parts:

1. An introduction to the relatively new technology of full-depth precast bridge deck panel systems
2. Information on typical practice including transverse and longitudinal design and including design examples
3. Examples of successful detailing including transverse joints, horizontal shear connection, leveling and temporary support, and haunch details between beam and deck
4. Information on the production, handling, and construction of full-depth precast deck panels including quality control, construction operations, and wearing and protection systems

This informative report is relevant for new bridge deck construction or bridge deck replacement.

[SOA-01-1911]



Precast/Prestressed Concrete Institute

200 West Adams Street | Suite 2100 | Chicago, IL 60606-5230
Phone: 312-786-0300 | Fax: 312-621-1114 | www.pci.org

BUYERS GUIDE

The companies listed on these pages have supported *ASPIRE*™ magazine during 2011. Each produces a high-quality product or service targeted to the bridge industry and is worthy of your consideration. In choosing *ASPIRE* as the way to communicate with you, they show enormous confidence in us.

These companies share in the significant success achieved by *ASPIRE*. Advertisers put their money where their mouths are, and they can rightfully be proud of *ASPIRE*'s success and

our ambitious plans for 2012. They enable us to move ahead with confidence to better serve our readers.

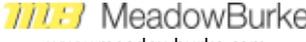
Just as important, the advertisers create valuable messages for our readers. Their announcements and product information supplement our own presentations to keep readers current with new ideas.

Whenever an opportunity arises, please contact an *ASPIRE* advertiser, ask them for

more information, and thank them for their investment in the bridge community. For an easy way to make a contact, go to www.aspirebridge.org and select "Advertisers." Clicking on any listing will take you to their home page.

We appreciate their support, and yours, for making *ASPIRE* the most read and talked about bridge magazine!

	DESCRIPTION	ADDRESS/PHONE
 BASF The Chemical Company www.basf.com	The Building Systems business of BASF is an industry leader in the manufacture of building products for the construction industry. Since 1902, contractors and design professionals have depended upon BASF to repair and protect their structures.	889 Valley Park Drive Shakopee, MN 55379 800.433.9517
 Bentley www.bentley.com/BrIM	Bentley offers comprehensive bridge software solutions for design, analysis, and construction engineering: LEAP Bridge and RM Bridge.	685 Stockton Dr. Exton, PA 19341 800.BENTLEY
 www.bridgescape.net	Bridgescape, LLC. Principal, Frederick Gottemoeller, is considered America's most distinguished bridge architect. His award-winning Woodrow Wilson Bridge in Washington, D.C., has received universal acclaim. His book Bridgescape is a 'bible' for bridge designers.	5425 Vantage Point Road Columbia, MD 21044 301.490.6088
 www.caba-bridges.org	Central Atlantic Bridge Associates. Promoting the benefits, advantages, and performance of prestressed concrete bridges in the Central Atlantic region.	1042 North 38th St. Allentown, PA 18104 610.395.2338
 www.cmeengineering.com	CME Associates is a multi-disciplinary civil engineering consulting firm that specializes in bridge engineering and accelerated bridge construction technologies.	333 East River Drive, Ste. 400 East Hartford, CT 06108 860.290.4100
 www.dywidag-systems.com	DYWIDAG-Systems International USA. Experts in the design, manufacture, supply, and installation of THREADBAR®, multistrand, and cable-stay post-tensioning systems.	320 Marmon Dr. Bolingbrook, IL 60440 630.739.1100
 www.enerpac.com	Enerpac. Manufacturer of integrated systems for bridge building and rehabilitation using high force, hydraulic products and solutions. Enerpac products provide high forces with safety and efficiency.	6100 N. Baker Rd. Milwaukee, WI 53029 262.781.6600
 www.figgbidge.com	FIGG specializes exclusively in the design and construction engineering of American bridge landmarks.	424 North Calhoun Street Tallahassee, FL 32301 850.224.7400
 www.flatironcorp.com	Founded in 1947, Flatiron is one of the leading providers of transportation construction and civil engineering in North America. Its core competencies include major bridge, highway, and rail projects.	10188 E. I-25 Frontage Rd. Firestone, CO 80504 303.485.4050
 www.pile.com/grl	GRL Engineers services range from investigating unknown foundations to monitoring and analysis of hundreds of test piles. GRL's seven offices allow it to maintain a quick, cost-effective responsiveness to client needs throughout the world.	30725 Aurora Road Cleveland, OH 44139 216.831.6131
 Hamilton Form Company, Ltd www.hamiltonform.com	Hamilton Form Company produces custom steel forms and plant production equipment for the prestressed, precast concrete industry.	7009 Midway Road Fort Worth, TX 76118 817.590.2111
 www.hardesty-hanover.com	Hardesty & Hanover is a full-service bridge engineering firm with more than 120 years of experience steeped in solving complex engineering challenges on the world's most unique projects.	1501 Broadway New York, NY 10036 212.944.1150

DESCRIPTION	ADDRESS/PHONE
 <p>Headwaters Resources manages and markets CCPs, including fly ash. Fly ash use improves concrete performance and creates significant benefits for our environment.</p> <p>www.flyash.com</p>	<p>10653 S. River Front Parkway, Ste. 300 South Jordan, UT 84095 888.236.6236</p>
 <p>Helsel Industries designs and manufactures steel forms for producing precast and prestressed concrete components for numerous commercial applications.</p> <p>www.helsel.com</p>	<p>10750 SW Tualatin Rd, P.O. Box 1569 Tualatin, OR 97062 503.692.6909</p>
 <p>Holcim is one of the world's leading suppliers of cementitious materials including our eco-efficient Envirocore products delivering innovation and greener building solutions to your customers.</p> <p>www.holcim.us</p>	<p>201 Jones Road Waltham, MA 02451 888.646.5246</p>
 <p>LARSA Inc.'s software for bridge analysis and design addresses specialized needs of a variety of bridge structures, including cable, segmental, curved, box, and other types, and is a standard in leading U.S. firms.</p> <p>www.larsa4d.com</p>	<p>Melville Corporate Center 105 Maxess Rd., Ste. 115N Melville, NY 11747 800.LARSA.01</p>
 <p>Mapei a global corporation, has been supplying residential and major commercial projects with total installation solutions for tile and stone, floor covering, and decorative concrete as well as concrete restoration for 75 years.</p> <p>www.mapei.com</p>	<p>1144 E. Newport Center Drive Deerfield Beach, FL 33442 800.426.2734</p>
 <p>Meadow Burke is a premier manufacturer and distributor for the concrete construction industry serving architects, engineers, and contractors with a superior line of concrete reinforcing products, concrete forming accessories, road and bridge products, and products for precast construction.</p> <p>www.meadowburke.com</p>	<p>531 S. US Highway 301 Tampa, FL 33619 813.248.1944</p>
 <p>Mi-Jack Products Inc. is recognized as an industry leader and innovator in Travelift® and Translift™ rubber tire gantry crane manufacturing, sales, service, and support</p> <p>www.mi-jack.com</p>	<p>3111 W. 167th Street Hazel Crest, IL 60429 708.596.5200</p>
 <p>Olson Engineering Inc. has provided state-of-the-art structural and infrastructure NDT condition assessment services since 1985. The staff of Olson Engineering has been carefully assembled to have world class expertise in NDT&E consulting services.</p> <p>www.olsonengineering.com</p>	<p>12401 W. 49th Ave. Wheat Ridge, CO 80033 303.423.1212</p>
 <p>PB is a leader in infrastructure development around the world, dedicated to meeting the needs of clients and communities.</p> <p>www.pbworld.com</p>	<p>One Penn Plaza New York, NY 10119 212.465.5000</p>
 <p>Poseidon Barge Corporation manufactures, sells, and rents Portable Sectional Barges to the Heavy Highway and Marine Construction Industry. We have distribution in Indiana, Arkansas, Florida, California, and Massachusetts.</p> <p>www.poseidonbarge.com</p>	<p>3101 New Haven Ave. Fort Wayne, IN 46803 866.992.2743</p>
 <p>The Reinforced Earth Company has forty years of experience designing and supplying materials to contractors for retaining walls, sound walls, and precast arches used in civil engineering applications.</p> <p>www.reinforcedearth.com</p>	<p>8614 Westwood Center Dr., Ste. 1100 Vienna, VA 22182 800.446.5700</p>
 <p>SPLICE SLEEVE. The <i>original</i> grout-filled mechanical splice for rebar used for moment-resisting connections in precast concrete.</p> <p>www.splicesleeve.com</p>	<p>38777 W Six Mile Rd., Ste. 106 Livonia, MI 48152 949.861.8393</p>
 <p>Transpo Industries Inc is a manufacturer of roadway safety products—breakaway supports and specialty polymer concrete materials for the rehabilitation, maintenance and preservation of bridge and concrete structures—since 1968.</p> <p>www.transpo.com</p>	<p>20 Jones Street New Rochelle, NY 10801 800.321.7870</p>
 <p>T.Y. Lin International is a full-service infrastructure consulting firm recognized worldwide for its long-span and signature bridge design services, as well as seismic analysis and retrofit expertise.</p> <p>www.tylin.com</p>	<p>Two Harrison St., Ste. 500 San Francisco, CA 94105 415.291.3700</p>
 <p>Beijing Wowjoint is a leading provider of customized heavy duty lifting and carrying machinery used in large scale infrastructure projects such as railway, highway, and bridge construction. Wowjoint's main product lines include launching gantries, tire trolleys, special carriers, and marine hoists.</p> <p>www.wowjoint.com</p>	<p>1055 Colorado Blvd., Ste. 500 Pasadena, CA 91106 530.475.2793</p>

The Fatigue Limit States, Part 2



by Dr. Dennis R. Mertz

The fatigue limit states of Article 5.5.3 of the *AASHTO LRFD Bridge Design Specifications* include two distinct checks: one for metallic reinforcement in members subjected to tension, the other for concrete of fully prestressed concrete members subjected to compression.

The fatigue limit-state function for metallic reinforcement in concrete members subjected to tension is:

$$\gamma(\Delta f) \leq (\Delta F)_{TH}$$

where:

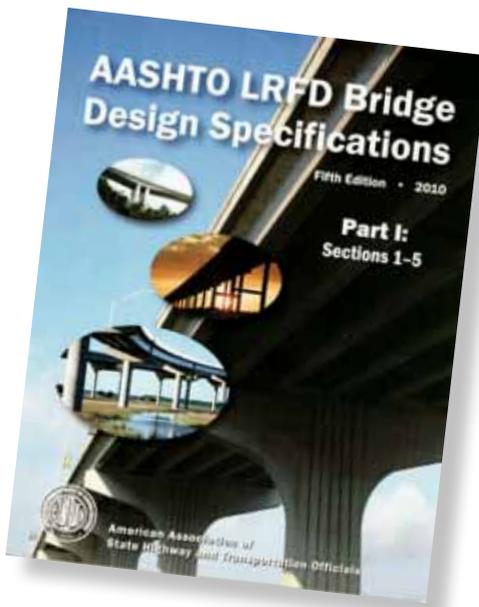
γ = load factor specified for the Fatigue I load combination discussed in Part 1 of this article (*ASPIRE*TM, Summer 2011)

Δf = force effect, live load stress range due to the passage of the fatigue truck, as specified in LRFD Article 3.6.1.4

$(\Delta F)_{TH}$ = constant-amplitude fatigue threshold for the metallic reinforcement being considered

As discussed in the previous article, the constant-amplitude threshold is a threshold value of stress range below which the metallic reinforcement will not crack during the expected life of the bridge. In this case, metallic reinforcement in a concrete member is said to theoretically exhibit an infinite fatigue life.

The metallic reinforcement to be checked for fatigue includes nonprestressed reinforcing bars, prestressing strands, and welded or mechanical splices of reinforcement. It is of paramount importance to point out that fully prestressed concrete components designed to have an extreme fiber tensile stress due to the Service III Limit State within the tensile stress limit specified in LRFD Table 5.9.4.2.2-1, are specifically exempted from the fatigue check of their metallic reinforcement. Further, for reinforced concrete members, fatigue needs be considered only in regions where the permanent compressive stress is less than the maximum



tensile live-load stress resulting from the Fatigue I load combination; in other words, only if the Fatigue I live-load stress overcomes any permanent compression due to dead load and prestressing.

Reinforcing Bars

For nonprestressed reinforcing bars, the constant-amplitude fatigue threshold specified in LRFD Article 5.5.3.2 is:

$$(\Delta F)_{TH} = 24 - 0.33f_{min}$$

where f_{min} = minimum live-load stress resulting from the Fatigue I load combination, combined with the more severe stress from either the permanent loads or the permanent loads, shrinkage, and creep-induced external loads; positive if tension, negative if compression.

For welded wire reinforcement without a cross weld in the high-stress region:

$$(\Delta F)_{TH} = 24 - 0.33f_{min}$$

For welded wire reinforcement with a cross weld in the high-stress region:

$$(\Delta F)_{TH} = 16 - 0.33f_{min}$$

For flexural reinforcement, the high-stress region is one third of the span on each side of the section of maximum moment.

Prestressing Tendons

For prestressing tendons not satisfying the exemption above, the constant-amplitude fatigue thresholds specified in LRFD Article 5.5.3.3 are:

$(\Delta F)_{TH} = 18.0$ ksi for radii of curvature in excess of 30.0 ft.

$(\Delta F)_{TH} = 10.0$ ksi for radii of curvature not exceeding 12.0 ft.

For radii of curvature between 12.0 and 30.0 ft, linear interpolation is permitted.

Finally, for welded or mechanical splices, the constant-amplitude fatigue thresholds are given in LRFD Table 5.5.3.4-1.

Concrete

The fatigue limit-state function for concrete of fully prestressed concrete members subjected to compression is specified in LRFD Article 5.5.3.1 as:

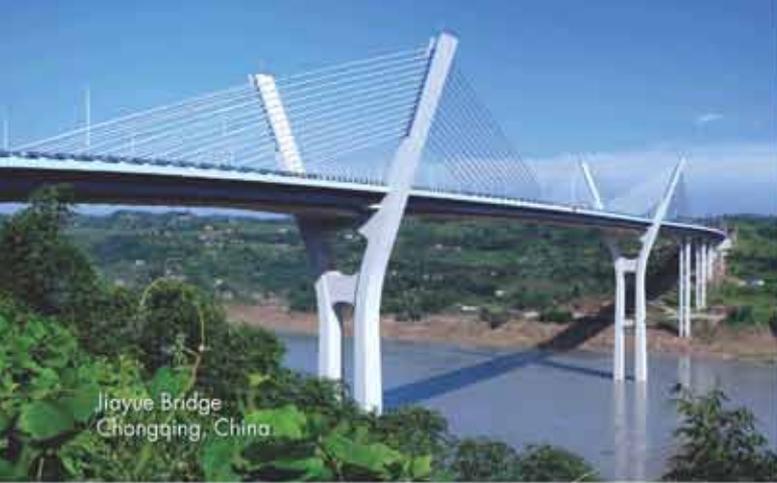
Fatigue I compressive stress + $\frac{1}{2}$ (effective prestress + permanent loads) $\leq 0.40 f'_c$

Previously, this compressive stress-limit check was not explicitly specified as a fatigue check.

A future article will discuss the determination of Δf , the force effect, live load stress range due to the passage of the fatigue truck, in more detail.

EDITOR'S NOTE

If you would like to have a specific provision of the *AASHTO LRFD Bridge Design Specifications* explained in this series of articles, please contact us at www.aspirebridge.org.

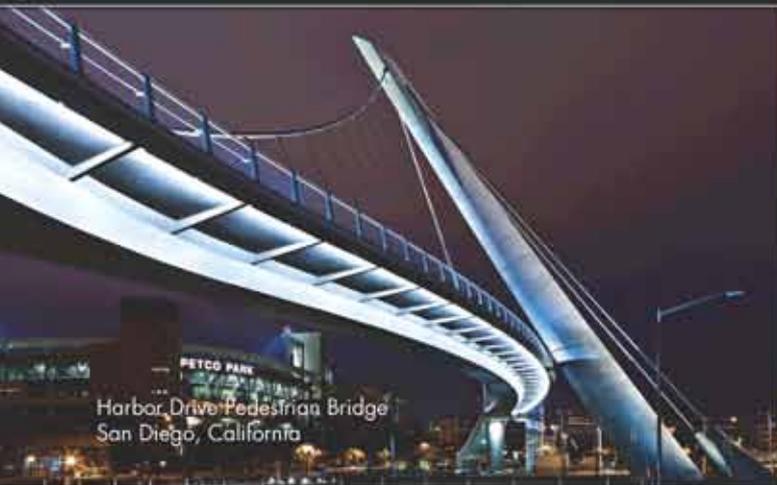


Jiayu Bridge
Chongqing, China



Port Mann Bridge
Vancouver, British Columbia, Canada
in collaboration with IBT

C R E A T I N G

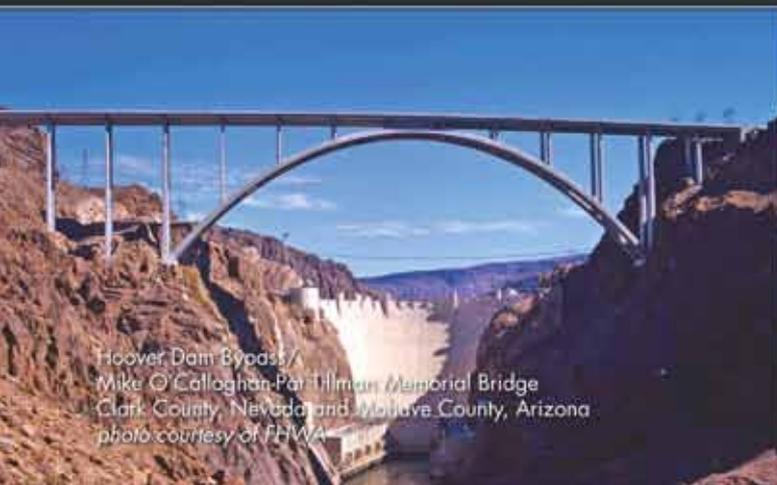


Harbor Drive Pedestrian Bridge
San Diego, California

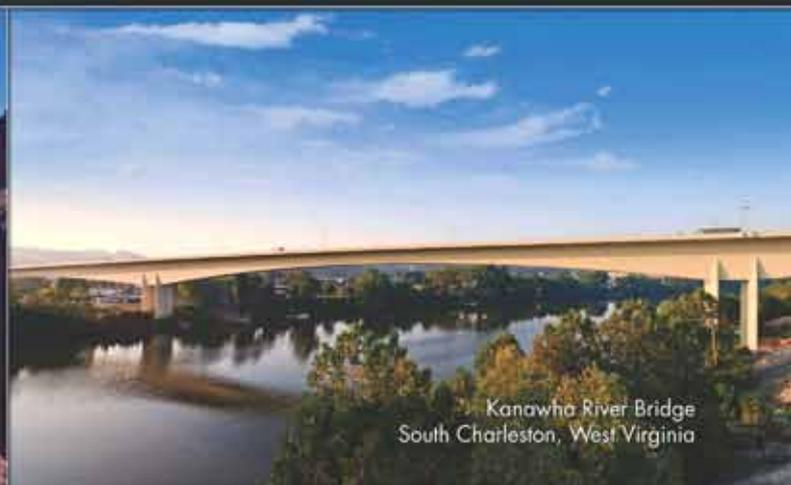


San Francisco-Oakland Bay Bridge East Span
Oakland, California

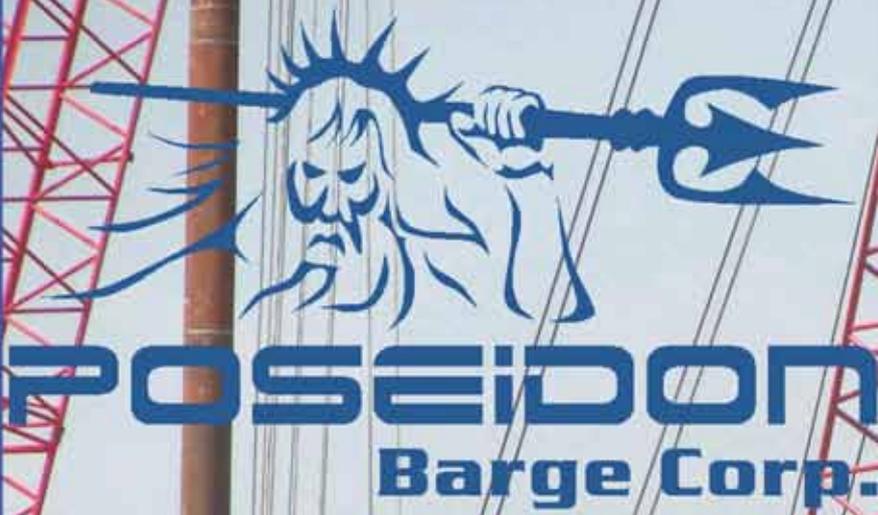
L A N D M A R K S



Hoover Dam Bypass /
Mike O'Callaghan-Pat Tillman Memorial Bridge
Clark County, Nevada and Mohave County, Arizona
photo courtesy of FHWA



Kanawha River Bridge
South Charleston, West Virginia



**POSEIDON BARGE
STANDARD EQUIPMENT
OVER OUR COMPETITION:**

- 20,000 PSF POINT LOAD CAPACITY (PATENT PENDING)
 - ZINC ANODES
 - HATCHES FOR EASY INTERIOR INSPECTION
 - WATER BALLAST CAPABILITIES
 - INTERIOR RUST INHIBITOR COATING
 - HAUL 2-40'x10'x5' UNITS / TRUCK
 - HAUL 2-40'x10'x5' UNITS / TRUCK
 - HAUL 2-40'x10'x5' UNITS / TRUCK
- COST SAVINGS EVERYTIME YOU MOBILIZE TO AND FROM THE JOB SITE!!**

MOBILIZATION COST SAVINGS:

- 8 - 40'x10'x 5' BARGES
- 2 - 20' x 10' x 5' BARGES
- 2 - 40' x 18" SPUDS WITH POCKET
- DBL DRUM WINCH & ACCESSORIES
- 300 MILES, 2 STATES

POSEIDON BARGE

5 - STEPDECKS FOR BARGES: \$7,250
TOTAL ROUNDTRIP: \$14,500.00

COMPETITION:

8 - TRUCKS: \$14,400.00
TOTAL ROUNDTRIP: \$28,800.00

**YOU SAVE \$14,300.00
ON EVERY PROJECT!!**

**WHY WOULD YOU CONSIDER
USING ANYONE ELSE?**

WWW.POSEIDONBARGE.COM

POSEIDON BARGE CORPORATION, 3101 NEW HAVEN AVE, FORT WAYNE, IN 46803
PH: 866-992-2743 FX: 260-424-8635 EMAIL: INFO@POSEIDONBARGE.COM WEB: WWW.POSEIDONBARGE.COM
STOCK LOCATIONS: FORT WAYNE, IN; BLYTHEVILLE, AR; LK PANASOFFKEE, FL; NEW BEDFORD, MA; VALLEJO, CA; ROCKINGHAM, NC; HOUSTON, TX; KAPOLEI, HI; DEALER SEATTLE, WA