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SUMMER 2012

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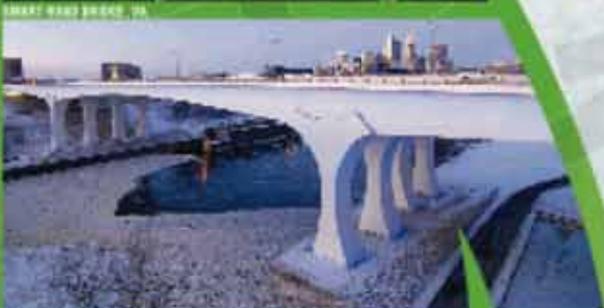
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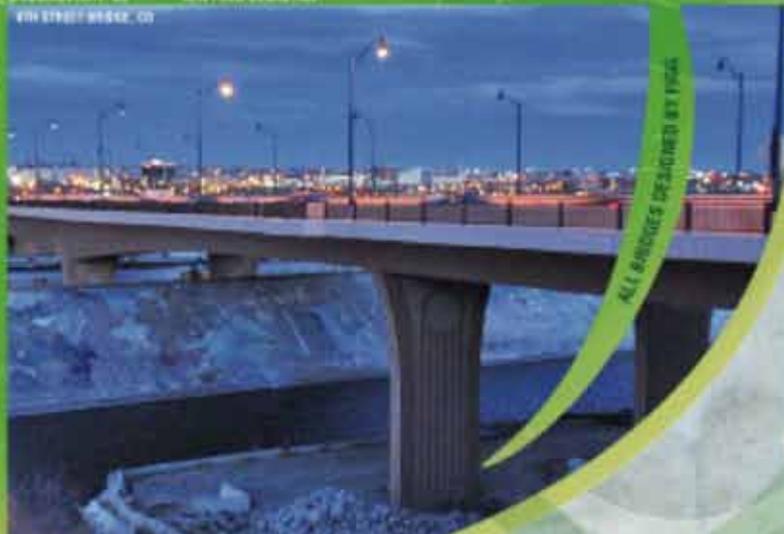
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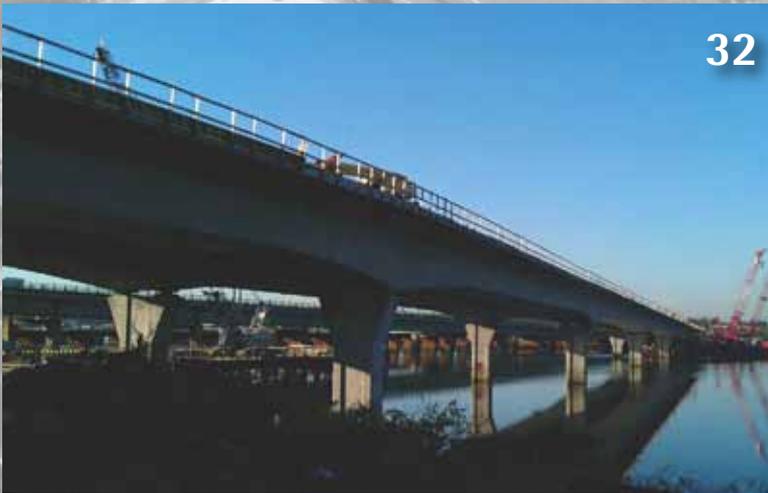
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Photo: Route 52 Constructors.



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Photo: Alan Preston.



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Photo: Reed & Reed Inc.

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Photo: NDOT.

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New Team, New Features

Henry G. Russell, *Managing Technical Editor*

Photo: Ted Lacey Photography.

In every issue of *ASPIRE*[™], we try to present new ideas, new concepts, and new bridges. This issue is no exception.

Firstly, the new *ASPIRE* production team is in place as described on page 15. This team is dedicated to providing a high-quality magazine reporting on the newest concrete bridges.

Secondly, we pay tribute to John Dick, who retired as executive editor with the Spring issue. John would argue that *ASPIRE* is about concrete bridges and not people. But it is people like John who make concrete bridges happen.

Thirdly, we begin a new series of articles about accelerated bridge construction (ABC). We have heard a lot about how some states have implemented ABC for bridge construction and it certainly represents a change from the traditional method of building bridges. This new series, beginning on page 25, will highlight concrete solutions for ABC and the technology used for their implementation. On page 28, you can read about one implementation involving the sliding of a concrete bridge into place in Nevada. Of course, the use of ABC may not be appropriate for all bridges. On pages 50 and 51, we present a decision-making process that has been developed by the Oregon Department of Transportation.

If those four additions are not sufficient to whet your appetite for what lies ahead in this issue, our regular features, plus reports on four new highway bridges, will surely stoke your imagination. One bridge uses the balanced cantilever method with precast concrete segments (page 32); one features precast, prestressed concrete girders (page 20); and two are unique cast-in-place concrete bridges (pages 16 and 36).

Fourthly, we include the bi-annual feature on concrete bridge preservation beginning on page 52. In this issue, we feature two relatively new bridges rather than the repair or rehabilitation of classic reinforced concrete bridges. One bridge was widened and the other received a new deck using lightweight concrete panels. In the FHWA article beginning on page 40, Myint Lwin and Anwar Ahmad discuss the use of systematic preventative maintenance and effective bridge preservation programs to ensure a longer service life for our existing bridges.

We hope this wide range of articles will provide every reader with something of interest. If not, please let us know as we are **always** looking for ways to improve the magazine. To those of you who have submitted ideas, we say "Thank you."

Enjoy your reading!

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Cover

An ambitious fast-track project undertaken by American Structurepoint at the Keystone Parkway Corridor in Carmel, Ind.
Photo: American Structurepoint.

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

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CONCRETE CALENDAR 2012/2013

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

July 8-12, 2012
2012 AASHTO Subcommittee on Bridges and Structures Meeting
Hyatt Regency
Austin, Tex.

July 23-27, 2012
2012 PCA Professors' Workshop
PCA Headquarters
Skokie, Ill.

September 29-October 2, 2012
PCI Annual Convention and Exhibition and National Bridge Conference
Gaylord Opryland Resort & Convention Center
Nashville, Tenn.

October 3-5, 2012
PTI Committee Days
The Inn at St. John's
Plymouth, Mich.

October 20, 2012
ASA 2012 Fall Committee Meetings
Sheraton Centre
Toronto, Ontario, Canada

October 21-25, 2012
ACI Fall Convention
Sheraton Centre
Toronto, Ontario, Canada

October 29-30, 2012
ASBI Annual Convention
Turnberry Isle Hotel & Resort
Miami, Fla.

January 13-17, 2013
92nd Annual Meeting Transportation Research Board
Marriott Wardman Park, Omni Shoreham, and Hilton Washington
Washington, D.C.

February 4-8, 2013
World of Concrete 2013
Las Vegas Convention Center
Las Vegas, Nev.

April 13, 2013
ASA 2013 Spring Committee Meetings
Hilton & Minneapolis Convention Center
Minneapolis, Minn.

April 14-18, 2013
ACI Spring Convention
Hilton & Minneapolis Convention Center
Minneapolis, Minn.

April 15-16, 2013
ASBI Grouting Certification Training
J.J. Pickle Research Campus
The Commons Center
Austin, Tex.

June 2-5, 2013
International Bridge Conference
David L. Lawrence Convention Center
Pittsburg, Pa.

August 29-31, 2013
PCI Quality Control and Assurance Schools Levels I and II
Four Points Sheraton-O'Hare
Chicago, Ill.

September 21-25, 2013
PCI Annual Convention and Exhibition and National Bridge Conference
Gaylord Texan Resort and Convention Center
Grapevine, Tex.

October 19, 2013
ASA Fall 2013 Committee Meetings
Hyatt Regency & Phoenix Convention Center
Phoenix, Ariz.

October 20-24, 2013
ASA Fall Convention
Hyatt Phoenix Convention Center
Phoenix, Ariz.

October 28-29, 2013
ASBI Annual Convention
Portland Marriott Downtown Waterfront
Portland, Ore.

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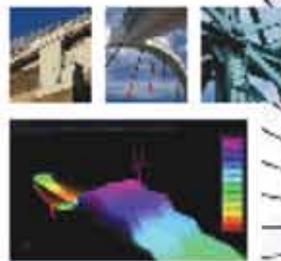
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REDUCING RISK

by Craig A. Shutt

American Structurepoint's attention to detail and design techniques help ensure bridges are constructed quickly and provide long life

American Structurepoint in Indianapolis, Ind., has become well-known to officials at the Indiana Department of Transportation (INDOT) and other clients state-wide, as well as many in Ohio after it opened its Columbus office 10 years ago. Having just celebrated its 45th anniversary in 2011, the firm looks to build on its strong reputation for designing innovative concrete bridges that stand the test of time.

"I think our clients agree that the quality of our work surpasses that of our competition," says Mike Wenning, manager and chief bridge engineer for the Bridge Transportation Group. "Our plans are well thought through, and contractors tell us they require fewer

contingencies with our designs. That's a great compliment."

The firm often works in design-build partnerships, taking advantage of its focuses on constructability, design speed, and responsiveness. "Some of the bridges being built today are constructed in amazing times. With design-build processes, speed is of the essence every step of the way." The company also works in other delivery methods, often with the focus on constructing bridges as quickly as possible.

Fast-Track Marina

An example of the company's fast-track is illustrated by the Hammond

Marina Access Road and Bridge, which was developed for Lake County, Ind., and the city of Hammond. The award-winning project included 1.1 miles of road and bridges featuring cast-in-place prestressed concrete bulb tees over 13 rail lines to provide access to the marina, casino, water works, and a county park.

"The casino was concerned about completing the project on time, so there was a penalty clause of \$1 million per day," Wenning explains. That required plans to be completed in a short timeframe so construction could begin quickly—in the dead of winter. "The snow was flying all around as the contractor was working with the heated forms to build piers."

The Hammond Marina Access Road and Bridge was a fast-track development. All photos: American Structurepoint.



'We can stretch spans longer than we could have 10 years ago and achieve more goals.'

An even more ambitious fast-track project was undertaken at the Keystone Parkway Corridor in Carmel, Ind., where the entire U.S. 431 corridor was relinquished to the city by the state to speed work and create a smoother flow of traffic. The work involved not only creating seven bridges in two years but devising roundabouts at six locations to eliminate all traffic signals. Precast concrete I-beam bridges were used for the structures. See *ASPIRE™* Fall 2010 for more details.

The roundabouts, most of which were double-teardrop designs, have proven extremely effective for moving traffic, says Dave Day, senior project manager for the Bridge Transportation Group. "Each time we removed the traffic lights, traffic in the area got better," he says. At one intersection, a double-teardrop roundabout with a frontage-road system was created.

The design required no realignment, eliminating the original plan to buy 30 adjacent properties. It also created easy pedestrian access through the intersections, which was significant, as the highway separated residential areas from the main commercial district. "The design created intersections unlike any others in the U.S.," Wenning said.

Concrete Designs Rule

These innovative approaches, and others like them, have been created with concrete bridge components, which the designers favor. Wenning estimates that more than 90% of the firm's designs today focus on concrete bridges.

It wasn't always that way, notes Day. "Thirty years ago, we were rehabbing a lot of steel bridges from the original interstate construction, and we used steel. But concrete has become relatively cheaper, and its pricing has been more consistent."



The Keystone Parkway Corridor consists of six intersections that eliminated congestion and lowered emissions while easing access between residential and commercial areas.

Concrete technology also continues to evolve, notes Wenning. "We can stretch spans longer than we could have 10 years ago and achieve more goals." INDOT allows designers to use a semi-lightweight concrete with larger strands, which extends ranges farther, he adds. INDOT has developed new sections, including adapting the typical AASHTO Type IV I-beam to create an Indiana bulb tee with a different top flange.

'The design created intersections unlike any others in the U.S.'

It's also approved a "squat" bulb tee that's shorter and fatter. "It lets us span longer lengths with less depth," says Wenning. "Indiana is pretty flat, so structure depth is important here, as there's little elevation to work with."

The versatile designs have helped make concrete the dominant design choice, Wenning says. "What's proven out over time is that prestressed concrete beams create good, solid, competitively priced bridges that meet all of the client's goals. We look at all sources on every project, but prestressed concrete beams typically are what we end up with."

Jointless Designs Dominate

The firm also has become a proponent of designing jointless structures, which INDOT has encouraged by extending its design limits. Previously, it allowed jointless bridges only up to 250 ft for steel and 300 ft for concrete. Today, either material can be designed to 500 ft. That change in part resulted from American Structurepoint's success with the concept, including the design in 2000 of a concrete bridge nearly 1000 ft long.

The bridge, on State Route 249 over U.S. 12 in Porter County, Ind., consists of a 10-span, continuous, composite, prestressed concrete bulb-tee design without expansion joints. The design was created in conjunction with INDOT and engineers at Purdue University, who conducted initial tests and continued to monitor the bridge to develop new design procedures for jointless bridges.

"At the time, the empirical limit for jointless concrete bridges was 300 ft, and this one was 302 m (991 ft)," Wenning says. Built using standard design and construction techniques, it's still twice as long as today's accepted standard. "This bridge has national significance for its capabilities to show how to eliminate joints and create a durable structure."

Joints are a key concern in any bridge, he says, and techniques to enhance



The 10-span bridge on SR 249 over U.S. 12 in Porter County, Ind., features a continuous composite, prestressed concrete bulb-tee design constructed without any joints.

their abilities continue. “But the best joint we can have is no joint. With more salt used every year, any joint failure can allow moisture into the ends and bearings and create problems.”

The key to jointless success is to provide limber end abutments or bents that allow movement. INDOT has encouraged this approach by adding a semi-integral, end-bent detail as a design alternative. It resembles an integral bent but separates the lower portion of the cap from the pile so it doesn’t induce pile bending, Wenning explains. A bearing pad under the beam at the end bent accommodates expansion. Concrete at the tops of the end bents is placed around the beam ends as is typical with an integral bent, eliminating the joint but allowing for movement.

“We try to do every bridge we can without joints,” Wenning says. Today, about nine out of ten of the firm’s designs feature jointless bridges.

Concrete Durability

Jointless construction enhances durability, which already is significant with concrete designs, the designers say. “One reason we prefer concrete is that the beams are larger and heavier,” Day explains. “They don’t take the beating that steel bridges do. There are a number of older concrete structures in counties where less salt is used that still look very good today. That’s important, because counties have low maintenance budgets and need to extend bridge service lives.”

The designers seldom use additives in their concrete to add durability, they note, as they don’t find them necessary. They did perform QC/QA tests on superstructures of six of the bridges involved in the I-80/94 revamp at SR 912 in Hammond, Gary, Highland, and Griffith, Ind.

The project involved a new directional interchange with 18 bridge structures, 8 ramps, and replacement of all signs and lighting. The intersection had the highest traffic count in Indiana’s interstate highway system and was rated the worst prior to construction. The project was separated into seven contracts spanning a seven-year period



The new directional interchange on I-80/94 at SR 912 in Indiana includes 18 bridges, 8 new ramps, and all new signs and lighting.

to construct all of the bridges, which consisted of precast concrete beams.

“We easily can achieve concrete compressive strengths of 5000 to 8000 psi, and can go higher, but we need approval from the client,” says Day. “Higher strength concrete is becoming pretty routine these days.”

Rehabilitation Work Grows

The need for added durability also has led to more rehabilitation work, as more states look to minimize construction costs. “States and counties don’t have the budget to replace their bridges if they have any other choice that will last,” Wenning says. Rehabilitation not only cuts demolition and material costs but can save further by eliminating road realignments and property acquisition.

Rehabilitation also preserves details communities identify with. “We often work closely with the community to ensure we retain the key portions,”

The need for added durability also has led to more rehabilitation work, as more states look to minimize construction costs.

45 Years of Success

Co-founders James A. Wurster and William E. Gervasio opened the doors of American Structurepoint in Indianapolis, Ind., in November 1966, working from Wurster's home. Originally called American Consulting Engineers (ACE), its two-person staff has grown to more than 300 employees, including 18 bridge engineering experts.

The firm designed a variety of concrete slab bridges in the 1970s and 1980s but now primarily focuses on prestressed concrete bridges. Its designers have participated in improvements to the INDOT Design Manual, with Mike Wenning serving on the committee to rewrite the 1975 manual and Dave Day serving on the committee to create the 2011 version.

In 2011, the firm was ranked No. 180 in *Engineering News-Record's* listings, up from 462 in 2002. *Midwest Construction* named the firm the top-performing Indiana design firm in 2010, and the *Indianapolis Business Journal* named American Structurepoint the largest engineering firm in the region in 2011 and 2012. Average revenues per year exceed \$50 million, up from just \$3 million in 1987.

Day says. "That can get us involved with some of the accessories and the project architecture." The designers take advantage of old postcards and other documents from local historical societies to research the original design. "Whenever we get the chance to enhance a bridge's aesthetics, we take it," Wenning says.

A prime example is Jefferson Boulevard Bridge over the St. Joseph River in South Bend, Ind. Built in 1913, the four-span bridge, an earth-filled concrete Melan-arch design, originally was determined to be unsalvageable, requiring a \$4-million replacement. American Structurepoint was asked for a second opinion and determined that it could be repaired. "The other consultants didn't have our experience to see the potential," Wenning explains.

Some of the bridge's problems resulted from its original design, "so we had to design around that," he says. The firm spent two years ensuring the bridge was structurally sound and then replaced most of the superstructure as well as a small steel railing added at later date with a more imposing and authentic concrete design that accommodated the lookouts at each pier.

The project saved millions of dollars in both replacement and demolition costs, plus savings in property purchase for realignment. "We are very proud of the

result," Wenning says. "There's often a lot more life in these bridges if they can be rehabbed, because they were over-engineered when they were built."

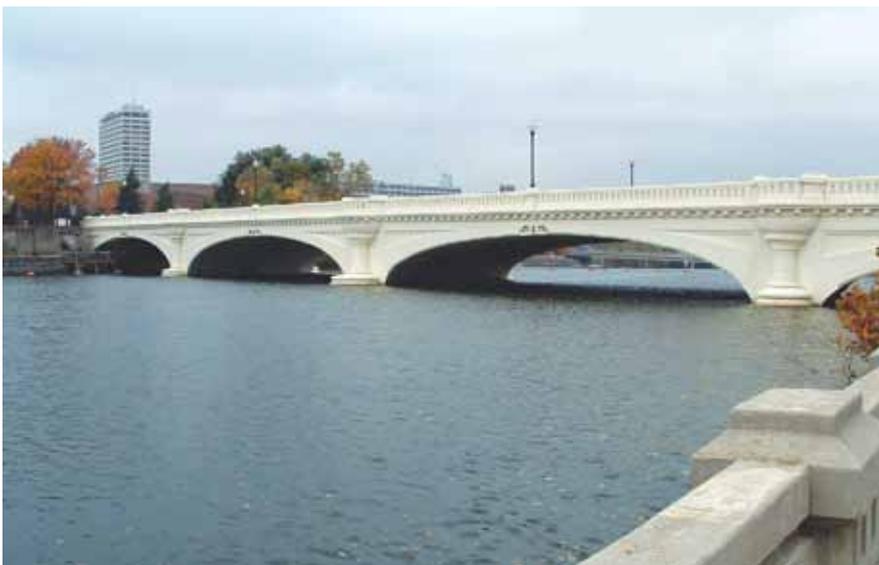
Each rehabilitation project is unique, he notes, and the designers learn many lessons about the history and unique approaches to bridge design through the years. "Some of the aggregates used in the concrete didn't perform as well as others, but many of the bridges still stand up today, especially the arched bridges," he says. "Concrete arched bridges are inherently stable and very solid."

The Future

The firm sees a solid future ahead for itself, too, but one with many challenges in today's economic climate. "The lack of funding from Washington, D.C., has caused a lot of problems for states, because they can't develop long-term budgets without direction and commitment from the federal government," says Wenning. "Most of their budgets are based on out-of-date taxing bases, so we have to do more with less all the time."

Those challenges will push the designers to look for more innovations and improved design techniques. "The states and consultants have risen to the challenge, but there's only so much that can be done without more commitments," Day says. "That means we have to continue to do our own materials research and look at using higher-strength concrete all the time. That may lead us to using 10,000 or 15,000 psi concrete and developing new sections. There are always changes and things we can do to improve." ▲

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



The four-span Jefferson Boulevard Bridge over the St. Joseph River in South Bend, Ind., was rehabilitated by American Structurepoint to retain its original earth-filled concrete Melan-arch design.

PERSPECTIVE

Financing Public-Private Partnerships

Innovative Solutions to Deliver Transportation Products

by Lowell R. Clary, Clary Consulting LLC



There has been much discussion in the transportation industry over the past 15 years on public-private partnerships (P3s). Those early conversations progressed from conceptual to actual, and are now being implemented across the nation. This article focuses on greenfield P3 projects. Greenfield is the term used for a project that lacks any constraints imposed by prior work. It also describes a new company or

relationship that forms to take part in a new activity without assets or capital, and involves sizable financial risk.

Revenue risk and government-backed are two major funding structures for greenfield P3 projects. Revenue risk applies when the private sector assumes the risk of revenue sources managed by the private team. Tolls are an example of this funding stream, which are collected

over time to repay funds borrowed for project. Government-backed applies when a public owner agrees to repay resources, over a period of time, borrowed by the private team to build the project.

The main government-backed approach in the United States is the availability payment structure. This structure is when the public owner pays the private team a set periodic amount (may be adjusted for inflation) and the payment is reduced if the facility is not available for use under the terms of the P3 agreement.

While serving as the Assistant Secretary for Finance and Administration at the Florida Department of Transportation, I was fortunate enough to participate in the development of the Port of Miami Tunnel and I-595 Expressway availability payment structure. It is believed to be the first use of this methodology in the United States.

Since the meltdown of the financial markets in 2008, developing new revenue-risk P3s, such as new alignment toll roads, has been extremely challenging. The financial community is currently unwilling to risk investing in P3 projects unless the repayment is backed by the public owner or the revenue stream is based on actual traffic counts.

The Transportation Infrastructure Finance and Innovation Act (TIFIA) provides federal financial assistance and is a key tool for moving P3 projects forward. TIFIA can include flexible repayment terms and the interest rate

The Port of Miami Tunnel Project is currently being built by MAT Concessionaires LLC, in partnership with the Florida Department of Transportation, Miami-Dade County, and the City of Miami. Photo: Port of Miami Tunnel.





This truck hauls precast concrete tunnel-liner components. Photo: Florida Department of Transportation.



Another view of the Port of Miami Tunnel Project. Photo: Florida Department of Transportation.

is indexed to a low rate for taxable debt. TIFIA can also be subordinate to the repayment of senior debt, such as bonds or bank loans in all cases except in bankruptcy of the P3.

All major P3 projects, since 2008, included TIFIA as a key component of the finance plan. A number of states have programs like TIFIA titled state infrastructure banks (SIB) that may be available for smaller scale projects. TIFIA and SIB loans, in combination with senior debt, can be essential to maintaining a P3 project schedule and delivery.

Senior debt relates to other project funding instruments typically, bonds, bank loans, or equity participation from the P3 team members. The importance of the TIFIA and SIB programs to the transportation industry cannot be overstated. Efforts to sustain these programs must be supported as Congress deliberates the new transportation bill.

An emerging project-funding strategy is garnering recognition as an innovative alternative. This creative approach,

called design-build-finance (DBF), allows the design-build team to provide gap financing to be repaid by the public owner over a period of time extending beyond the completion of the project. Florida has successfully implemented eight DBF projects.

The DBF methodology is not without risk. Examples of those associated risks include the contractor having to assume the gap finance amount on their balance sheet, and the lack of gap fund proceeds being available to the surety company.

I developed an innovative, cost-effective method for DBF projects to provide tax-exempt bond finance to the public owner through the design-build contractor. This creative method advances the gap funds to the contractor at no risk for the repayment of the bond principal and interest and also ensures the gap funds are available to the surety company in the case of a default by the contractor. The first project using this funding method is the I-95 DBF project on the Space Coast of

P3 Successes

In 2012, a number of states, including California, Colorado, Florida, Texas, and Virginia, successfully implemented P3 strategies to deliver the following greenfield projects:

- Presidio Parkway, San Francisco, Calif.
- Eagle P3, Denver, Colo.
- Port of Miami Tunnel, Miami, Fla.
- North Tarrant Express, Dallas, Tex.
- I-495 Capital Beltway Express Lanes, Va.

Florida, which should reach financial close in the summer of 2012.

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Industry Honors John Dick by Craig A. Shutt

Retiring executive editor of *ASPIRE* achieved many goals during long tenure in precast concrete structures industry



All photos: PCI.

As noted in last issue's Editorial, Executive Editor John S. Dick has retired from his duties with the magazine, as he earlier retired from his position as director of transportation systems at the Precast/Prestressed Concrete Institute (PCI). His long career in the precast concrete structures industry has had a big impact and left him with many colleagues who appreciate his contributions.

"John is the closest thing to a renaissance man that I've seen in my career," says James G. Toscas, president of PCI. "He truly knows how to do a tremendous variety of things and to do them very well. He also has a great work ethic. Who else would continue helping us for more than three years on *ASPIRE*™ after he had retired?"

Indeed, John retired from PCI in 2008 and moved from PCI's home base in Chicago to Monument, Colo., with his wife Nancy. There, he has enjoyed a more relaxed pace and a chance to spend more time with his daughters, Stephanie and Jennifer. Even so, he continued directing *ASPIRE* after conceptualizing the magazine in 2006.

"John has been a stalwart for *ASPIRE* since its inception," says William Nickas, who succeeded John as director of

Transportation Systems and is one of several PCI staffers to take on John's magazine duties. "He is extremely well organized, always on target, and loves concrete to the point that his blood must be gray. His quiet, calm demeanor invokes a fatherly, faithful man and always made me think he was a southern gentleman. Replacing John is a mission impossible, so we are going to take a team approach."

Early Days

ASPIRE is but one of many accomplishments that will continue after his retirement from PCI. They are the product of a career that began in the precast concrete industry in 1970 following his graduation from the University of Wyoming with a B.S. in Civil Engineering.

John spent 14 years in a variety of precasting companies before becoming owner/president/general manager at American Explosives Inc., which provided custom blasting services. In 1986, he joined PCI, and spent the remainder of his career with a singular goal, championing the use of precast concrete products.

He began as director of structural prestressed concrete services and soon added the duties of

director of plant certification. "John was instrumental in making plant certification a qualification for PCI membership," says Tom Battles, president of PCI as of 1987 and a predecessor to Toscas in the position. "It took an awful lot of effort by John, his committees, and staff to make it mandatory. Once it was, it really put the program on the map and gave PCI a significant marketing boost."

He also was responsible for expanding the erection-certification program. "John was the driving force behind that expansion," Battles says. "He did it by building an excellent plant certification committee and riding herd over it. He

Design, Fabrication and Erection of Uni Dome Stadium

David H. Geiger, PhD, PE
President
 Geiger Berger Associates, P. C.
 New York, New York

John S. Dick
Project Engineer
 C. W. Shirey Company
 Precast Prestressed Concrete Division
 Waterloo, Iowa



David H. Geiger



John S. Dick

Standard precast prestressed concrete elements provided a practical framing solution for the wall and ring systems of a 450-ft diameter covered football stadium with an air-supported roof in Cedar Falls, Iowa.

wouldn't disappoint anyone; he made everything happen."

Transportation services played a lesser role in the organization at the time, but John worked to expand PCI's services. "He built the transportation committees from scratch," Battles says. "He became PCI's bridge voice. He knew the subject and really pushed the membership to be more involved and created the technical committees to address specific issues."

Adds Toscas, "John has always been great with our members. When no one is around, people who work at associations like PCI will tell you that dealing with volunteers can be challenging. John never had a problem in this department, and is very highly regarded by the PCI membership."

Battles agrees that John not only worked well with members but also with PCI's staff, all of whom had their own perspectives and needs. "He was very devoted to his programs and fought for what he thought was needed. He was extremely focused on getting things done and worked the association politics to ensure that happened."

Code Vigilance

As he became more involved with transportation issues, the mutual trust and respect with such groups as American Association of State Highway and Transportation Officials (AASHTO) grew quickly. Members of the AASHTO Subcommittee on Bridges and Structures (SCOBS) saw his devotion to the industry and his knowledge, says Dr. Basile Rabbat, an independent consulting engineer and former manager of structural codes and transportation structures at the Portland Cement Association (PCA).

"John did an amazing job as an ambassador for precast concrete," he says. "He was well respected and very eloquent on behalf of his members. We participated in many seminars together, and he always knew the material and believed in it passionately."

Rabbat met John at AASHTO meetings in the late 1980s and helped him gain his footing, giving PCI its first strong

PCI Titles

After 14 years in the precast concrete manufacturing industry and two years running his own explosives business, John joined PCI in 1986 and took on various responsibilities during this career. His titles comprised:

1986-1987	Director of Structural Prestressed Concrete Services
1988	Director of Structural Prestressed Concrete Services and Director of Plant Certification
1989-1998	Member Services Director
1999-2005	Structures Director
2006-2008	Director of Transportation Services
2007-2012	Executive Editor, <i>ASPIRE</i> Magazine

representation. "He became very interested in committees dealing with code changes, because he understood that you have to mobilize your industry in such decisions or it becomes weaker." John was instrumental in creating the PCI LRFD Subcommittee to work with the AASHTO SCOBS T-10 Committee for Concrete Design. "That was no small job, as it took a lot of coordination and effort to make it happen."

During his time as a state bridge engineer, Nickas also met John through work on the T-10 Committee in 1998. "He always rallied the experts to help the T-10 Committee move through the most complex concrete issues," he says. Rabbat worked with John and others to create the National Concrete Bridge Council (NCBC), which was coordinated by PCA. "The precast industry was well represented by John." That was especially true at annual meetings with the Federal Highway Administration (FHWA), where issues about concrete construction were discussed and solutions created.

Cliff Freyermuth also met John on the AASHTO committee during his time with the Post-Tensioning Institute, ironically after Freyermuth had left PCI. "I worked continuously with him after that," says Freyermuth, who retired as manager of the American Segmental Bridge Institute (ASBI) in 2008. "He was very helpful to me in those meetings and in helping ASBI get coverage with PCI's publications," after that group's founding in 1988.

John helped Freyermuth organize the PCI-AASHTO-ASBI Segmental Box-Girder Standards that were approved in 1997, he says. "Those gave precast concrete

products the opportunity to more fully participate in the segmental bridge industry," he says.

His efforts at the state level also were appreciated, says M. Myint Lwin, director of the office of bridge technology for the FHWA. The state bridge engineer for the Washington DOT in the 1990s, Lwin met John during visits to the state by PCI staff for training and information sessions.

"I worked with John many times in Washington State, especially as we introduced our new, long-span girders and held seminars to promote precast concrete," says Lwin, who became a charter columnist for *ASPIRE*. "He was a great representative for the precast concrete industry. He gained the trust and confidence of many state DOTs by getting us information we needed and being responsive at all times."

Maher Tadros, emeritus professor of civil engineering at the University of Nebraska, also came to know John in the early 1990s, through his students. One of them received a PCI grant to study optimization of precast concrete bridge I-beams, in response to the government's push to convert to hard SI units.

"The result of that research was the birth of the NU I-girder," Tadros notes. "This girder shape marked the dawn of a new generation of girders throughout the country. John was visionary enough to support a fellowship that was resisted by other experts as rehashing old research. He contributed to creating millions of dollars of additional value for the precast concrete industry by promoting a serious competitor to high-performance structural-steel-plate girders."

Bridge Design Manual

Lwin also worked with John as he spearheaded PCI's *Bridge Design Manual*, which was issued in September 1997. The manual's initial request for proposal (RFP) was created by John in conjunction with Alex Aswad, Ed Wasserman, Reid Castrodale, Chuck Prussack, and several others.

In August of that year, a team comprising Tadros, Deb Derrick, Dick Imper, and Steve Zendegui presented a detailed report of market analysis and technical needs to the newly created Bridge Design Manual Task Group, led by John and consisting of Hank Bonstedt, Reid Castrodale, Roy Eriksson, Scott Olson, Chuck Prussack, and Joe Roche.

Following their recommendation, PCI's board authorized development of the manual, and a production team was assembled to work on the draft. Over the next two years, all initial chapters were balloted and the first edition was issued on September 15, 1997.

"John was gutsy enough to assign me the responsibility of preparing the planning report," says Tadros. "That led to one of the most important documents in PCI history being born in 1997. Even though I was the principal author and he let me have the title, he took the bulk of the responsibility of seeing that the various pieces of this giant project came together."

The second edition was updated in stages between 1999 and 2003, and the third edition was published in 2011. The manual has become a standard reference work for precast concrete bridges. "I received the first edition of the *Bridge Design Manual* as the state bridge engineer in Washington State, and I was very impressed with what had been accomplished," Lwin says.

Another way in which John was impressive, Lwin says, was his clear, articulate, modulated voice. "He could project and be eloquent very easily without a microphone, which can be very helpful at meetings." Indeed, John was well known for his "radio-quality" voice, notes Battles. He often provided introductions at meetings, as well as voice-over narration for PCI's recorded presentations, DVDs, and recordings.

HPC Bridge Views

The *Bridge Design Manual* was one of several publications that John helped build. Another was *HPC Bridge Views*, sponsored by FHWA and NCBC. PCA instigated its creation in 1999 and John ensured precast concrete was well represented, says Rabbat. "He made sure precast concrete bridges were prominent in every issue by providing strong material."

He also was responsible for creating the "Bridges for Life™" program that spun out of FHWA's "Highways for Life" initiative in 2004, Rabbat notes. "John created a way to focus attention on bridges and created brochures and marketing programs to promote the value of precast concrete bridges as part of that program."

Those efforts led John to conceptualize the quarterly *ASPIRE* magazine, which grew out of PCI's successful architect-oriented *Ascent* magazine. Expanding its focus to include all concrete bridges, John gathered executives at PCI, ASBI, PCA, PTI, ACAA, ESCSI, NRMCA, SFA, and WRI, who sponsored the magazine in its formative years and helped create its content, with John's direction.

"John pulled together organizations and sponsors of competing interest and a lack of history of working together and created an outstanding publication," Tadros says. "It's a wonderful magazine."

Adds Freyermuth, "John came to Phoenix to explain the magazine to me, and I thought it was the most significant concrete bridge promotional concept there ever had been. It was a no-brainer for us to participate, and it has proven to be an outstanding addition to the industry."

"John has always been a big-picture thinker," says Toscas. "He knew what the industry needed and worked tirelessly to make it happen. PCI's *Bridge Design Manual* and *ASPIRE* are only two examples of John having a vision of something that had never been done and successfully realizing it."

Tadros agrees. "He has always been a big thinker, but more importantly, he has not only the vision but the determination to turn daunting dreams into realities. These traits were combined with gentleness and the power of persuasion, as well as a very high ethical standard and sheer hard work. I truly admired his ability to get state bridge engineers to feel at home with PCI and have a rich experience. No other organization, to my knowledge, had the success we had with *ASPIRE* in combining all parties involved in bridge design and construction into one coherent and highly collaborative group."

"Our industry, and PCI in particular, is losing a tremendous asset now that John is really retiring," says Toscas. "He will always be a respected friend of the precast concrete structures industry." 





A Message from the New Editor-in-Chief

William Nickas, *Editor-in-Chief*

Photo: PCI

The only constant in our lives is the movement of time. Try as we might, we can never seem to figure out how to slow its advancement. Often as the hands of the timepiece move forward, they bring with them change or signify the start of a significant event. One such significant event is the retirement of our respected colleague John Dick, *ASPIRE's*TM executive editor and co-creator. I'm sure much to John's disliking, we share a bit about what a truly great person he is in this edition.

I wanted to take this opportunity to personally thank John for his dedication to our industry, *ASPIRE*, all things precast concrete, and to me for being there when I needed him. Additionally, I wanted to share with you a bit about the team I've assembled to continue to deliver this magazine, upholding the standard that John established almost 6 years ago.

I have assumed the duties as editor-in-chief, and am currently the managing director of PCI's Transportation Systems. Prior to my arrival at PCI, I worked in both the public sector as the state bridge engineer for the Florida Department of Transportation, and in the private sector as a principal in a bridge-centric consulting firm.

My goal is to continue to provide you with the finest concrete bridge magazine available, and I have added several new members to the *ASPIRE* team to assist me in that effort.

Taking over as managing editor is Wallace (Wally) Turner. I've known Wally for almost 30 years and we recently reconnected after a 25-year separation. Wally, a civil engineer, spent the majority of his career in the U.S. Army. Wally brings a unique perspective and is educated in the delivery of clear and concise communication.

We also added Emily Lorenz to the *ASPIRE* team. Many of you may know Emily from her years at PCI, where she is probably best remembered for her efforts as editor-in-chief of the *PCI Journal*. More recently, she assisted with the completion of the recently released, 3rd Edition, *PCI Bridge Design Manual*, by authoring the sustainability chapter. Emily will provide technical oversight to the production of the magazine and assist with the manuscript review process. I am really excited about reuniting with this talented engineer and gifted writer.

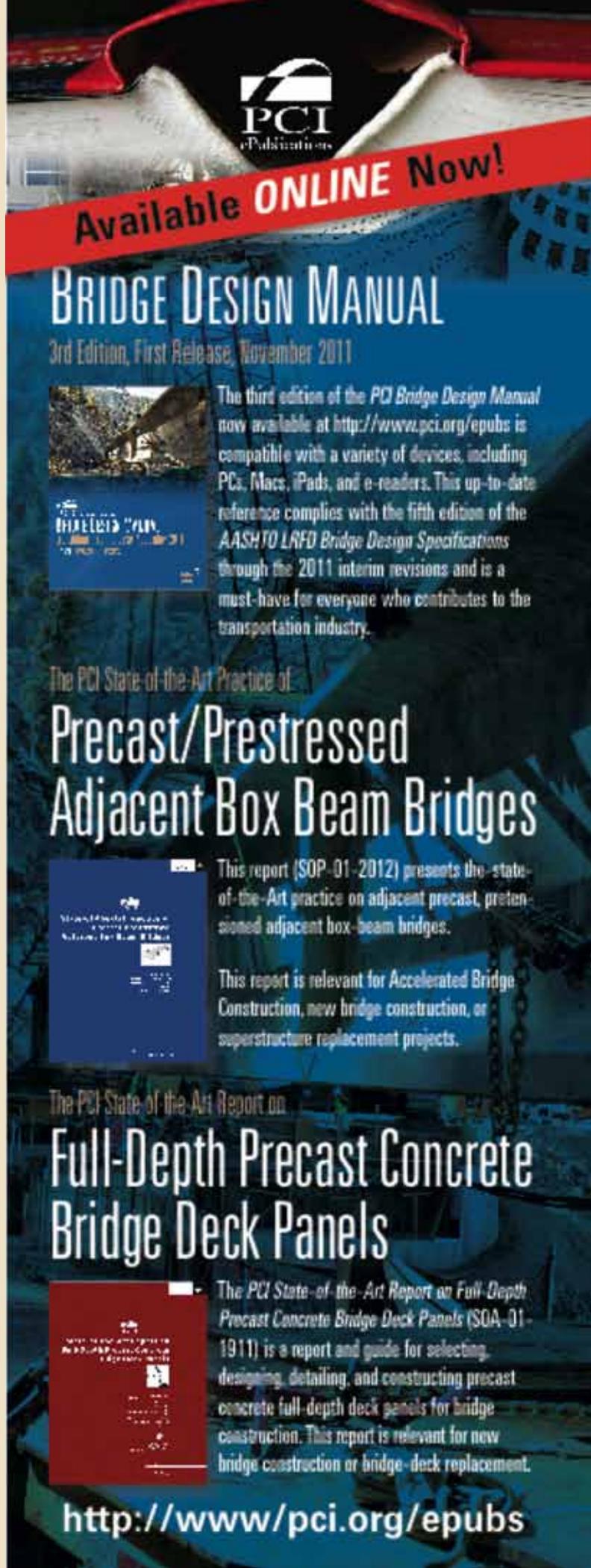
My vision for *ASPIRE* is to continue to highlight the use of concrete bridge products by showcasing their use, as we have in past issues. The message is clear: concrete is a versatile, robust, and sustainable material, with low life-cycle costs because it requires minimal maintenance and operational expenditures. Whenever possible, articles will highlight these characteristics ensuring *ASPIRE* continues to get the message to owners, designers, and engineers that concrete products create quality, sustainable, and long lasting transportation assets. Further, I believe there is a responsibility to inform our readership of peripheral actions, events, and programs that could affect our industry and I plan to focus my future editorials in that arena. Please continue to give the new team input. 



Wally Turner, *Managing Editor*



Emily B. Lorenz, *Associate Editor*



Available ONLINE Now!

BRIDGE DESIGN MANUAL

3rd Edition, First Release, November 2011

The third edition of the *PCI Bridge Design Manual* now available at <http://www.pci.org/epubs> is compatible with a variety of devices, including PCs, Macs, iPads, and e-readers. This up-to-date reference complies with the fifth edition of the *AASHTO LRFD Bridge Design Specifications* through the 2011 interim revisions and is a must-have for everyone who contributes to the transportation industry.

The PCI State-of-the-Art Practice of

Precast/Prestressed Adjacent Box Beam Bridges

This report (SOP-01-2012) presents the state-of-the-Art practice on adjacent precast, prestressed adjacent box-beam bridges.

This report is relevant for Accelerated Bridge Construction, new bridge construction, or superstructure replacement projects.

The PCI State-of-the-Art Report on

Full-Depth Precast Concrete Bridge Deck Panels

The *PCI State-of-the-Art Report on Full-Depth Precast Concrete Bridge Deck Panels* (SOA-01-1911) is a report and guide for selecting, designing, detailing, and constructing precast concrete full-depth deck panels for bridge construction. This report is relevant for new bridge construction or bridge-deck replacement.

<http://www.pci.org/epubs>

PROJECT

Welcome to Ocean City, Via Route 52 Visitors Center Bridge Curved, post-tensioned, spline bridge welcomes visitors

by Joseph J. Romano, Michael Baker Jr. Inc.; Joseph E. Salvadori, DYWIDAG-Systems International USA Inc.; and Daniel P. Zeller, Route 52 Constructors

A view of the new Route 52 Visitors Center Bridge. Photo: Route 52 Constructors.



The Route 52 Visitors Center Bridge (VCB) on Garrets Island had to provide an inviting and welcoming appearance to all stopping by the newly constructed Ocean City's Visitors Center. This bridge was part of a larger \$400 million project replacing the Route 52 Causeway bridges and the roadway section between Somers Point and Ocean City, N.J. Overall, this is one of the New Jersey Department of Transportation's (NJDOT's) largest projects and is a critical link because of its designation as the emergency evacuation route for Ocean City.

The VCB was designed to replace an existing bridge at the newly constructed

visitors center. Early in the bridge study, it was determined that aesthetics were going to play a significant role in the selection of the bridge type. In the end, two alternates were suggested for this bridge, a horizontally curved, steel plate girder and curved post-tensioned concrete spline bridge. After seeking input from the community, the curved, post-tensioned concrete spline bridge was selected. One of the more aesthetically pleasing details of the bridge are the large wings that extend over 20 ft from both sides of the bridge.

Superstructure Details

Measuring just under 400 ft in length, VCB consists of four spans (92, 107,

107, and 92 ft) constructed on a 449 ft radius with a 2% vertical grade in superelevation. The connection between the superstructure and three intermediate piers is integral with bearings and expansion joints used only at the two abutments. VCB's superstructure is 70 ft wide with a sidewalk on each side leaving a width of 50 ft for vehicular traffic. The superstructure is 4 ft 6 in. deep.

Considering the minimal depth and solid nature of this structure, post-tensioning was selected as the main reinforcing system for the superstructure. The VCB superstructure contains 17 longitudinal tendons, each with twenty-seven

profile

ROUTE 52 VISITORS CENTER BRIDGE / OCEAN CITY, NEW JERSEY

BRIDGE DESIGN ENGINEER: Michael Baker Jr. Inc., Hamilton, N.J.

PRIME CONTRACTOR: Route 52 Constructors: A Joint Venture of G.A. & F.C. Wagman Inc. and R.E. Pierson Construction Co. Inc., York, Pa.

CONCRETE SUPPLIER: Clayton Concrete, Block and Sand, Lakewood, N.J.

PRECASTER: Precast concrete piles by Bayshore Concrete Products Corp., Cape Charles, Va., a PCI-certified producer

POST-TENSIONING CONTRACTOR: DYWIDAG-Systems International USA Inc., Toughkenamon, Pa.

0.6-in.-diameter strands in the main section with an additional six tendons with nine 0.6-in.-diameter strands in the winged sections running the length of the structure. The path of the tendons is parabolic in the vertical plane and curved in the horizontal plane. In the transverse direction, the bridge contains 256 tendons, each with four 0.6-in.-diameter strands, which were spaced radially at approximately 1 ft 9 in. on center at the center line of the curve.

For strength and durability, a 5500 psi compressive strength normal weight concrete containing a corrosion inhibitor was utilized in the superstructure. The contractor was given three options for corrosion protection of the reinforcing steel: epoxy coating, stainless steel cladding, or galvanized reinforcement. The contractor chose epoxy coating. An additional design requirement that did not permit any tension in the superstructure, along with biaxial post-tensioning, a $\frac{3}{8}$ -in.-thick deck slurry overlay, and a $1\frac{1}{4}$ -in.-thick integral wearing surface ensures a durable structure that will easily meet the 75-year required service life.

Design

Design of the superstructure was based on the 4th edition *AASHTO LRFD Bridge Design Specifications* (2007) as modified by the *NJDOT Design Manual for Bridges and Structures*. The CEB-FIB 3rd Edition 1978 code was used to model the time-dependent behavior of concrete for creep and shrinkage.

Both two-dimensional and three-dimensional modeling were used. The first model involved the longitudinal analysis of the main solid box section. This time-dependent model constructed the VCB step-by-step and analyzed the structure for its entire design life to ensure that the superstructure remained in compression. Not only were dead and live load combinations considered in this design model, but also uniform-



Two pump trucks were used to fill the Route 52 Visitors Center Bridge cross section as quickly as possible to avoid any cold joints. Photo: Route 52 Constructors.

temperature and temperature-gradient load cases were analyzed. The model also accounted for the stiffness of the substructure and its impact on the superstructure design.

With the large overhanging wings, special design methods were utilized in the transverse analysis. A three-dimensional, finite-element model utilizing plate elements, to account for the plate bending and plane stresses (that is, membrane actions, in-plane action), was developed. The plates were considered planar elements in shape, and modeled with isotropic material properties. For simplicity, the VCB deck wing was modeled from the interface of the wing transition and assumed fixed at this location (outside of the taper where the wing was 2 ft thick). A linear-static analysis was run with this model, resulting in the design forces and stresses that were considered in the transverse post-tensioning design.

Earthquake design considerations were also incorporated into this structure. A multi-mode spectral analysis was performed in accordance with the latest AASHTO requirements. A site-specific response acceleration spectrum was



The path of the tendons in the Route 52 Visitors Center Bridge was parabolic in the vertical plane and curved in the horizontal plane. Photo: Route 52 Constructors.



The Route 52 Visitors Center Bridge superstructure was post-tensioned longitudinally and transversely. Photo: Route 52 Constructors.

NEW JERSEY DEPARTMENT OF TRANSPORTATION, OWNER

BRIDGE DESCRIPTION: Four-span (92, 107, 107, and 92 ft) cast-in-place, post-tensioned concrete spline structure 400 ft long and 70 ft wide

STRUCTURAL COMPONENTS: Precast, prestressed concrete piles and cast-in-place abutments, piers, and superstructure

BRIDGE CONSTRUCTION COST: \$6.6 million



Concrete for the midspan regions of the Route 52 Visitors Center Bridge was placed independently of that over the piers by using transverse bulkheads. Photo: Route 52 Constructors.

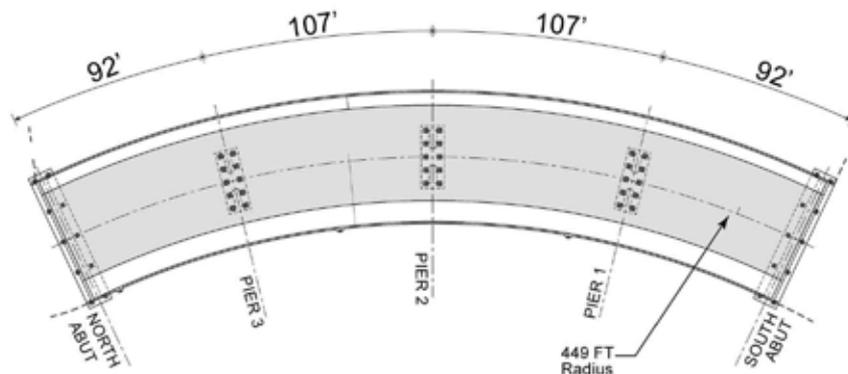
constructed and used for the evaluation of the bridge. VCB was classified as an essential bridge in Seismic Design Category B. The loads generated in this analysis were used in the connection design at the piers as well as in the design of the VCB substructure and foundation. Seismic restraint blocks with armoring were provided at the end abutments.

Foundations

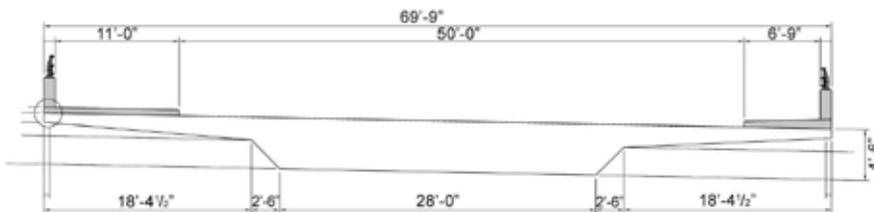
Square precast concrete piles were utilized in the foundations supporting the intermediate piers and end abutments. Twenty-four-inch square piles containing sixteen 0.5-in.-diameter, epoxy coated, 7-wire, 270 ksi prestressing strands were used at the abutments to a depth of approximately 80 ft. At the intermediate piers, 30-in. square piles containing thirty-six 0.5-in.-diameter, epoxy coated, 7-wire, 270 ksi prestressing strands were used to a depth of approximately 75 ft. The concrete utilized in the piles contained calcium nitrate corrosion inhibitor as required in NJDOT's standard specifications.

The piles at the abutments supported a 5-ft-thick, cast-in-place concrete footing and a 5-ft 9-in.-thick abutment wall, approximately 17 ft in height. Ground reinforcing strips were attached to the back wall to minimize the overturning tendency from the active soil loads.

Piles at the VCB piers support a 5-ft-thick, cast-in-place concrete footing and two non-rectilinear columns approximately 20 ft in height. Protruding reinforcement from the columns extends into the superstructure to accommodate the integral connection. All exposed surfaces of the piers and abutments were stained to provide continuity and consistency to the aesthetic theme and coated with an anti-graffiti treatment.



A plan-view drawing of the Route 52 Visitors Center Bridge. Drawings: Janssen & Spanns Engineering Inc.



A drawing of a typical section of the Route 52 Visitors Center Bridge. Drawings: Janssen & Spanns Engineering Inc.

Construction

The construction of VCB provided several challenges requiring innovative solutions. The soil conditions presented unique settlement concerns for both substructure and superstructure construction. A falsework system was erected to support the cast-in-place construction portion of the superstructure, but this too became a point of concern as the falsework reacted to differential settlement.

Inconsistent soil conditions, combined with vastly contrasting bridge cross sections, created some concern with the potential for structural cracking produced by differential settlement of the shoring foundation prior to post-tensioning.

To better distribute the weight of the structure over the entire footprint of the shoring, the shoring tower aluminum support beams were spliced together in the field to make continuous 80-ft-long beams under the formwork. Finally, the concrete placing sequence was separated into negative and positive moment sections of the bridge for added assurance even though the entire bridge was supported on falsework. These proactive measures proved successful.

In an effort to mitigate additional load on the falsework, the strand packs and specialized strand installation equipment for the transverse post tensioning tendons were installed from a flatbed positioned parallel to the east side of the bridge. 

Joseph J. Romano is the structures department manager for the Michael Baker Jr. Inc. office in Hamilton, N.J.; Joseph E. Salvadori is northeast regional manager for the post-tensioning business unit of DYWIDAG-Systems International USA Inc.; and Daniel P. Zeller is field engineer for Route 52 Constructors.

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

EDITOR'S NOTE

A more in-depth discussion of the proactive VCB construction methods used for this bridge is available at the ASPIRE™ website, www.aspirebridge.org. Click on Magazine.

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Dean Frank, PE, PCI director of quality programs,
at dfrank@pci.org or (312) 583-6770.

PROJECT

CHINCOTEAGUE ISLAND BRIDGE REPLACEMENT

Environmentally sensitive asset alleviates seasonal demands

by Henri Sinson, Hardesty & Hanover LLC

The Virginia Department of Transportation (VDOT) was in need of a new bridge to replace the existing 1940s era span in Accomack County, Va. The existing bridge, which carries Route 175 over the Black Narrows and the Chincoteague Channel, was deemed structurally deficient and functionally obsolete. In addition, the maintenance and repairs for the 60-year-old swing span were proving cost prohibitive. The location of the existing bridge also caused adverse impacts on the Town of Chincoteague, most notable was heavy traffic congestion on Main Street affecting residents, tourists, and emergency-response vehicles.

The selected option was an off-line 4035-ft-long trestle Mainline Bridge, including a single leaf bascule, spanning environmentally sensitive wetlands and a navigable channel. A 729-ft-long connector bridge provides the necessary link from the new Route 175 Mainline Bridge to Marsh Island. Superstructure units for the approach spans consist of VDOT bulb-tee precast, prestressed concrete beams with custom variable-depth precast, prestressed concrete fascia beams on curved alignments. The beams support an 8.5-in.-thick reinforced concrete deck slab containing epoxy-coated reinforcing steel. The bridge elements were chosen to minimize the visual clutter and impacts to the scenic vista.

Construction commenced in December 2006 and was completed in December 2010.

Challenges and Solutions

Geometry

The determination of the preferred alignment required the collection of considerable information, community perspectives, and significant data from the numerous stakeholders. The selected alignment alleviated the summer congestion, reduced the number of openings at the movable span, and reduced the length of the movable span due to the narrower channel at that location. Commitments were made to minimize the amount of construction impacts to the environmentally sensitive wetlands and oyster beds whose harvests are primary income for many of the inhabitants.

Once the bathymetric survey data was received, the design team analyzed the water depths and draft requirements for the construction equipment. It was determined that the alignment be changed to make the best use of the natural channels in this predominantly shallow marshland. This shift increased the length of the connector bridge but significantly reduced the length of temporary trestle needed to perform the construction activities, minimizing impacts to the channel bottom, and considerably reducing the overall cost of the project.



Aerial view of the new Chincoteague Island Bridge site. Photo: Patrick J. Hendrickson.

profile

CHINCOTEAGUE ISLAND BRIDGE REPLACEMENT / CHINCOTEAGUE ISLAND, VIRGINIA

BRIDGE DESIGN ENGINEER: Hardesty & Hanover LLC, New York, N.Y.

CIVIL DESIGN ENGINEER: MMM Design Group, Norfolk, Va.

GEOTECHNICAL ENGINEER: Schnabel Engineering, Glen Allen, Va.

HYDRAULIC DESIGN ENGINEER: Ayres & Associates, Atlanta, Ga.

TRAFFIC DESIGN ENGINEER: JMW Engineering Inc., Fairfax, Va.

PRIME CONTRACTOR: American Bridge Company, Coraopolis, Pa.

CAST-IN-PLACE CONCRETE SUPPLIER: Branscome Concrete, Nassawadox, Va.

PRECASTER: Bayshore Concrete Products Corp. (subsidiary of Skanska USA Civil), Cape Charles, Va., a PCI-certified producer



The substructure consisted of 36-in.-diameter cylinder piles. Photo: Hardesty & Hanover.

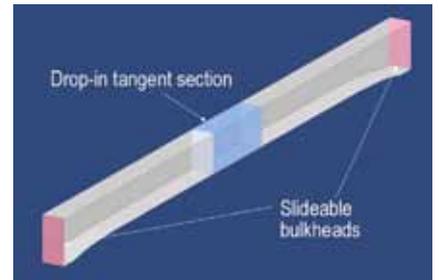
Substructure

The soils below the marshy Chincoteague Channel are so poor, for the first 30 ft, that just the weight of the hammer, resting on top of the pile, is enough to cause the pile to move downward. In response to the need to minimize the visual clutter of the new bridge and satisfy the settlement and load requirements, 36-in.-diameter precast, prestressed concrete hollow cylinder piles with 6.5-in.-thick walls were the chosen foundation elements. The piles varied from 84 to 108 ft in length. One fifth of the approximately 300 piles driven had to have tip elevations extended beyond the typical -85 to -129 ft elevation by using a 30-ft-long follower. This installation is the first instance of a hollow cylinder pile being driven 25 ft underwater.

Superstructure

An aesthetic study was performed with stakeholder input and guidance from the design team yielding a bridge facade with arched fascia beam elements and cheekwalls. This selection helped to minimize the vertical elements and match the quaint architecture of the town and environs. The spans were optimized to yield a typical 80-ft span length for the majority of the project.

Forty-five-inch-deep precast, prestressed VDOT bulb-tee beams were used for the interior beams. The custom arched load bearing beams on the fascia had a depth ranging from 54 to 45 in. To minimize the cost of the custom forms and decrease costs through production repetition, the design team added drop-in form sections at the midspan and slideable bulkhead sections at the form ends. The drop-in sections, with a constant depth, form tangent soffit geometries that allowed the



Rendering showing variable length tangent section and fixed length arched sections of the fascia beams. Rendering: Hardesty & Hanover.



Fascia beam being erected for the new Chincoteague Island Bridge. Photo: Hardesty & Hanover.

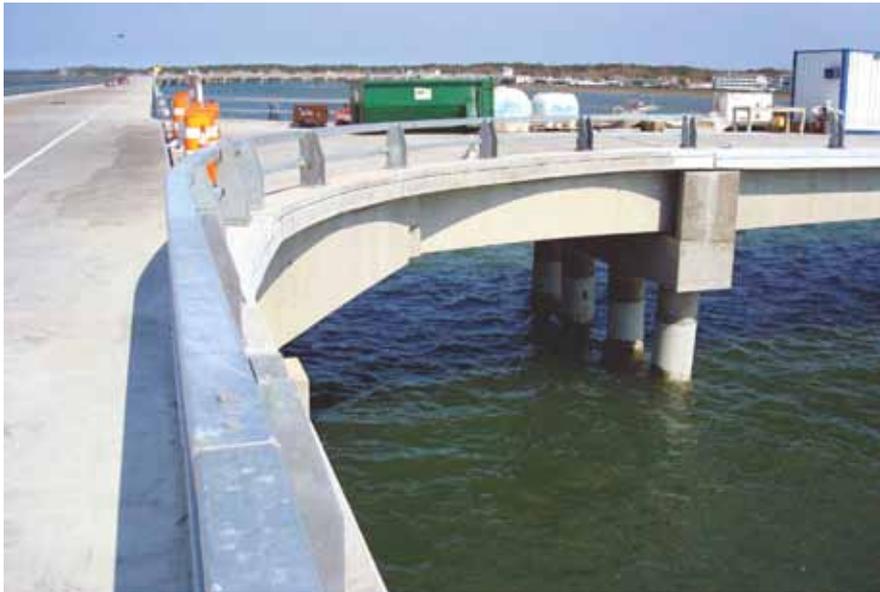
VIRGINIA DEPARTMENT OF TRANSPORTATION, OWNER

BRIDGE DESCRIPTION: A 4035-ft-long trestle structure spanning environmentally sensitive wetlands and a navigable channel. Intersecting it is the 729-ft-long Connector Bridge linking the new Route 175 Mainline Bridge to Marsh Island.

STRUCTURAL COMPONENTS: 173 VDOT Type PCBT 45 prestressed concrete bulb-tee beams, 120 load carrying prestressed concrete arched fascia beams, and 300 36-in.-diameter prestressed concrete hollow cylinder piles

BRIDGE CONSTRUCTION COST: \$68.7 million

AWARDS: 2012 Engineering Excellence Award in Category H: Transportation for the Replacement of the Chincoteague Bridge



The diagonal dapped beam spans between the mainline pier and a bracket on the fascia beam of the connector bridge. Photo: Virginia Department of Transportation.

curved forms to be reused without compromising the aesthetic effects and still accommodate all the different beam lengths needed for the curved horizontal alignment. The bridge width is 43 ft 4 in. in the mainline and 32 ft 4 in. at the connector with girder spacing of 9 ft 5 in. (mainline) and 8 ft 9 in. (connector). The spans were designed as simple spans for live and dead load and the deck continuous for live load. The bent caps are 4 ft 6 in. wide and 4 ft 2 in. deep. Specified concrete compressive strengths for the girders and piles were 8000 and 7000 psi, respectively, for design and 5600 and 4000 psi, respectively, at prestress transfer. Specified concrete compressive strength of the deck concrete was 4000 psi.

The intersection between the mainline and connector bridges presented a geometric challenge. Typically these types of intersections utilize steel or

cast-in-place concrete superstructure elements that can be formed to match the tight radii of the flare. The intersection geometry was achieved by framing a short dapped-end beam supported at the pier adjacent to the mainline bridge at one end and on a bracket on the fascia beam along the connector bridge at the other end.

The identical formwork used for the typical fascia beams was utilized with small modifications to the bulkhead to create the dapped end. The fascia beam supporting the dapped beam had an arch shape on one side only. The short supported beam and the fascia beam together were able to satisfy the tight flare radii and at the same time maintain the same aesthetic arch fascia. Additionally, prestressed concrete elements were used in lieu of cast-in-place concrete or steel elements, which would have greatly increased the

Sustainability

The Town of Chincoteague Island encompasses a scenic historic town nestled in pristine wetlands. Residents tend the small shops and harvest the oyster beds. Commitments were made during the design phase to construct the new bridge with minimal damage to the environment. The bridge alignment was changed in order to utilize the natural channels for barge construction without dredging.

Temporary construction trestles were used near the bridge abutments in order to not impact the wetlands in the vicinity.

maintenance burden of the intersection superstructure.

Conclusion

The new Chincoteague Bridge provides the community with the only access to the historic Town of Chincoteague. The project succeeded in providing a durable, structurally sound, and functionally modern facility alleviating severe seasonal congestion. This was achieved without disturbing the environmentally sensitive area and maintaining the scenic vistas for residents and travelers. This project is a shining example of finding the balance between development and sustainability: both environmental and human. 

Henri Sinson is an associate and Tampa Branch manager for Hardesty & Hanover LLC.

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



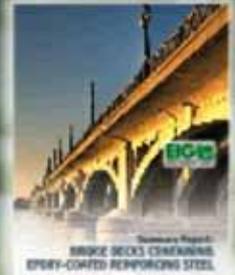
The new Chincoteague Island Bridge elevation. Photo: Virginia Department of Transportation.

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© Photos courtesy of EIG, photographer Tim Davis.

Expanded Shale, Clay and Slate Institute Releases Internal Curing Resources



The Expanded Shale, Clay and Slate Institute (ESCSI) announces the release of several Internal Curing resources that have been developed over the last year.

Internal curing is achieved by incorporating prewetted expanded shale, clay and slate (ESCS) aggregate into the concrete mixture to deliver moisture to the hydrating cementitious materials from within the concrete. The absorbed moisture in the ESCS is not a part of the concrete mixing water and therefore does not increase the effective w/cm .

ESCSI has released an online guide for calculating the quantity of prewetted ESCS lightweight aggregates for internal curing. Users can input their mixture requirements into the guide which will calculate the minimum quantity of prewetted ESCS lightweight aggregate needed to provide the moisture for internal curing of cementitious materials in a concrete mixture. This calculator is located in the Internal Curing section of the ESCSI website: www.ESCSI.org.

"Internal Curing: Helping Concrete Realize its Maximum Potential," an ESCSI brochure that was just released, explains the benefits of internal curing and how internal curing is the common sense addition to improve the sustainability of concrete. ESCSI also published a guide specification for internally cured concrete that can be used to modify a conventional normal weight concrete mixture to provide internal curing of the concrete by replacing a portion of the normal weight fine aggregate with prewetted fine or intermediate ESCS lightweight aggregate.

For more information about internal curing and ESCS aggregate, visit www.ESCSI.org.



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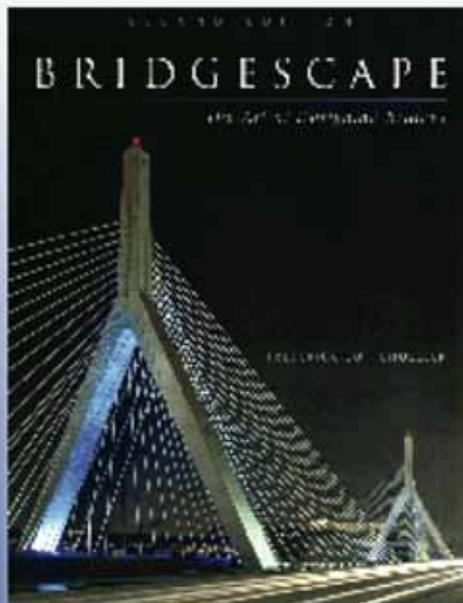
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Author, Frederick Gottmouller, P.E., P.A., is a world-recognized expert and consultant on the aesthetics of bridge design. His celebrated bridges include the new Washington Wilson Bridge in Washington, D.C. and the Clearwater Memorial Causeway in Clearwater, Fla.

Available from www.amazon.com or direct from the author at www.bridgescape.net.

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Precast Concrete Solutions

by Craig A. Shutt

Accelerated bridge construction (ABC) has become a watchword for many design teams, as owners look to shorten the design and construction process. Not only does faster construction reduce user costs and enhance community relations, but it increases safety by minimizing the time workers are exposed to hazardous conditions. A variety of methods can accelerate bridge construction based on the types of materials, conditions, and program goals.

Bridges that feature precast concrete components have found success using several new techniques. Design-build delivery methods, casting techniques, and design concepts in combination with precast concrete components can shorten construction times. Here are some examples.

Eight-Day Schedule

With the Mill Street Bridge over the Lamprey River in Epping, the New Hampshire Department of Transportation (NHDOT) officials used precast concrete components to finish erection of the 115-ft-long bridge in only eight days.

Seven precast, prestressed adjacent box beams were used, with five abutment and wingwall pieces on one end and six on the other, plus ten footing pieces. The precaster also supplied four precast concrete pilasters to add a decorative

touch. This superstructure is supported by an all-precast concrete substructure, composed of full-height cantilevered abutments founded on spread footings.

The project was let using an approach somewhere between the traditional design-bid-build and the design-build process. Design control remained with NHDOT engineers but the specific method of bridge assembly was left to the contractor and precaster. They determined where joints within the substructure would be introduced and how the precast concrete bridge elements would be assembled.

Horizontal joints in the stems and between the stems and footings feature full moment connections with grouted splice sleeves. The splice sleeves were cast into the front and back faces of the stem elements to accept reinforcement extending from the bottom footing element.

The precast concrete components could be cast in advance and delivered for assembly when the site was ready. Savings realized on items such as the reduced rental time for a temporary bridge and elimination of the labor needed to mobilize around available construction windows compensated for the costs associated with the fabrication and delivery of the precast concrete.

Mill Street Bridge over the Lamprey River in Epping, N.H. Photo: New Hampshire Department of Transportation.





The new Route 70 Bridge over Manasquan River in New Jersey.
Photo: Aurora & Associates.

Memorial Bridge

In replacing the Route 70 bridge over Manasquan River, the New Jersey Department of Transportation officials chose a method that reduced construction time by 25 months over more-typical designs.

Each 724-ft-long structure has two, three-span continuous superstructure units comprising precast concrete bulb-tee beams. The superstructures are supported on two abutments and five architecturally treated, in-water piers with pile foundations.

To minimize the duration of in-water construction, architectural piers were supported at the waterline on a simulated masonry-faced plinth. The piers have a pair of prismatic vertical columns near the bridge's centerline, as well as inclined tapered columns sloping outward towards the bridge fascias.

The pier structural system consists of precast concrete cofferdam shells, hollow precast concrete columns, and hollow precast, prestressed concrete cap beams connected with post-tensioning.

In Phase 1, the girders for the eastbound structure were set using the existing bridge as a working platform. Then the completed eastbound portion was used to set the westbound structure. The contractor operated on a six-day workweek and employed multiple crews, which moved from one pier location to the next, performing the same tasks for each pier in sequence. This allowed a production rate of 19 working days per pier on each half of the bridge. As a result, the project was substantially completed more than two years ahead of schedule.

This example shows that by providing flexibility and alternate provisions and allowing reasonable substitutions, engineers and owners empower (and challenge) contractors and fabricators to construct high-quality projects at a lower cost and faster pace. As engineers and contractors gain experience with precast concrete substructure construction, these techniques will be adopted for more conventional spans, realizing even greater efficiencies with lower costs and timely deliveries.

The South Maple Street Bridge in Enfield, Conn. Photo: Hoyle, Tanner & Associates Inc.





The State Highway 86 Bridge over Mitchell Gulch in Colorado.

South Maple Street Bridge

To complete the first, totally precast concrete bridge in the town of Enfield, Conn., town officials used ABC concepts to reduce user costs. As a result, the structure was erected in just 17 days.

The South Maple Street Bridge, which spans the Scantic River, was assembled from 71 precast concrete components. The concept used precast concrete adjacent box beams, with a continuous-length lip extending in front of the abutment panels to hide the horizontal joint. Additional components comprised footing blocks with threaded jacks to level them to grade after setting, 10 abutment walls, 12 wingwall pieces cast in decorative patterns, 4 cheek walls, and 12 pavement approach slabs.

The contractor cast an unreinforced “mud slab” at the abutment sites and set the footing blocks on them. The abutment walls and wingwalls then were set over the reinforcing bars and the dowel bar splice sleeves were grouted. The precast concrete abutment bridge seat was set onto the projecting reinforcing bars from the abutment walls, allowing the abutment pieces to act as one unit. Then the box beams were set on elastomeric bearing pads on the precast bridge seat. Following erection of the box beams, the precast concrete cheek walls and precast concrete approach slabs were erected.

Mitchell Gulch Bridge

Precast concrete abutments and pier caps offer a strong option for accelerated construction schedules. State Highway 86 Bridge over Mitchell Gulch in Colorado is another example of those benefits. The use of precast concrete abutments allowed the bridge to be constructed over the weekend and open only 46 hours after closure.

The original timber bridge was replaced with a 40-ft-long, 43-ft-wide, single-span precast concrete slab superstructure and precast, reinforced concrete abutments. The precast concrete abutments and wingwalls with embedded steel plates were erected by crane and welded to the steel H-piles and to each other, finishing in less than two days.

These projects present several innovative ways precast concrete components are being used to accelerate bridge construction while meeting a variety of needs for economy, aesthetics, and durability. By using easily designed techniques, the projects achieve their goals while also ensuring bridges are brought into service quickly. 

This is the first in a series of articles examining different approaches to Accelerated Bridge Construction and examples featuring those techniques. Details of these projects can be found in the issue archive at www.aspirebridge.org. They originally appeared in the Spring 2007 issue (Mill Street Bridge and Mitchell Gulch Bridge), Fall 2009 issue (Route 70 Bridge), and Summer 2011 issue (South Maple Street Bridge).

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

PROJECT

West Mesquite Interchange AT I-15

NDOT's First Bridge Slide Using Accelerated Bridge Construction

by Adam Searcy, Nevada Department of Transportation; Mike Dobry, Horrocks Engineers; and Laycee Kolkman, HDR Engineering Inc.

In early January 2012, the Nevada Department of Transportation (NDOT) lifted a new bridge on Interstate 15 (I-15) and slid it 60 ft into its permanent location in a matter of hours.

The West Mesquite Interchange was NDOT's first use of accelerated bridge construction (ABC) technology. With ABC, crews were able to build the 159.5-ft-long bridge (including approach slabs) in six months less time than with traditional methods and for millions of dollars less than the cost of a typical rebuild.

The I-15 interchange was part of a \$15 million project to widen Falcon

Ridge Parkway in Mesquite, Nev., and to increase capacity for projected future traffic in the city (the original project estimate was approximately \$25 million). The improvements, which were completed in April 2012, widened the parkway, increased the bridge length, added roundabouts at interchange ramps, replaced 1200 ft of existing mainline pavement, and included new landscaping and lighting that creates a welcoming entrance to this popular tourist destination.

ABC Conditions

The interchange was in a prime location to accommodate Nevada's first bridge slide and fulfill the goal to reduce construction impacts on I-15. The

following factors led to the decision to use ABC:

- Ample land was available adjacent to the final location for building the bridges on temporary foundations.
- There were no viable alternate routes.
- Precast concrete components were available.
- High traffic and freight volumes.
- The location of the bridge at an interchange allowed interstate traffic to be routed down the ramps during the demolition of the existing bridges and the slide, avoiding any closures on I-15.
- Traditional methods would have required significant I-15 traffic restrictions to construct the bridges.



Aerial photo of West Mesquite Interchange following the I-15 southbound bridge slide. Photo: NDOT.

profile

WEST MESQUITE INTERCHANGE AT I-15/ MESQUITE, NEVADA

PROGRAM MANAGER: HDR Engineering, Omaha, Neb.

BRIDGE DESIGN ENGINEER: Horrocks Engineers, Pleasant Grove, Utah

GEOTECHNICAL ENGINEER: Intermountain GeoEnvironmental Services Inc., Salt Lake City, Utah

SURVEYOR: Forsgren, Mesquite, Nev.

PRIME CONTRACTOR: W.W. Clyde, Springville, Utah

CONCRETE SUPPLIER: Sunroc Corporation, St. George, Utah

PRECASTER: Hanson Structural Precast Eagle, Salt Lake City, Utah, a PCI-certified producer

Construction and Materials

Bridge construction began in mid-November 2011 adjacent to the freeway. Crews expedited the work by using precast concrete components.

The actual construction of the single-span bridge followed the same steps as traditional, build-in-place construction with the exception of the foundations. Temporary hollow-bar soil nails were used to support the existing structure while the permanent foundations for the new bridge were constructed underneath the existing bridge. The design specified a temporary steel substructure to support the new, 10,000 ft² superstructures. The shotcrete for the soil-nails had a specified compressive strength of 4000 psi, while the grout for the hollow-bar nails was specified to be 3000 psi.

Precast concrete components were used to significantly reduce construction time. These included 9-ft 9-in.-spaced precast, prestressed concrete Utah bulb-tee beams (UBT58). Nonprestressed, 3.5-in.-thick, partial-depth, precast concrete deck panels were used to eliminate deck formwork, allowing faster placement and improving safety for the public and construction workers. The overall thickness of the bridge deck is 8 in., including a 4.5-in.-thick, cast-in-place concrete topping.

Workers set bridge girders in preparation for sliding a 1000-ton bridge into place on the superstructure. Photo: Alan Preston.



Specified compressive strength for the cast-in-place concrete and deck panels was 4000 psi, while the precast concrete girders used 9000 psi compressive-strength concrete. As a time-saving strategy for ABC, flowable fill with a compressive strength of 200 to 500 psi was used to backfill behind the abutments and under the approach slabs after the bridges were slid into their permanent locations.

Bridge longevity was an important focus, given the project investment. Prestressed concrete girders increased durability and lowered maintenance requirements. Although not required in Clark County, Nev., epoxy-coated reinforcing bars were used in the precast concrete girders to reduce the probability of corrosion and extend the life of the girders. The structures were designed and detailed for a 75-year service life.

The final bridge dimensions measure 111 ft 6 in from center-line between each abutment, with an additional 24 ft to account for the approach slabs at each end and an overall width of 45 ft 11 in.

Bridge Move

The bridge slides were done in two separate moves (I-15 southbound on January 10 and I-15 northbound on January 24) over two 56-hour periods. For each slide, the existing I-15 structure was demolished at the interchange and the new 1000-ton superstructure was slid transversely 60 ft into its final position using two 64-ton capacity hydraulic jacks with a stroke of 3 ft. The approach slabs were slid with the rest of the superstructure.

First, crews rerouted traffic on I-15 through the interchange on- and off-ramps that were temporarily widened to two lanes for the closure. Next, the existing bridge was demolished, which took about 12 hours. Crews then lifted



Construction of the southbound I-15 bridge deck happened directly adjacent to live I-15 traffic. Photo: Alan Preston.

the new bridge 3 in. into the air from its temporary foundations to clean and lubricate the bearings below. In final preparation for the move, crews applied gallons of lubricating dish soap to Teflon-coated elastomeric bearing pads.

The bridge alignment followed a vertical and horizontal curve with a cross slope of 4.6% on the southbound side and 4.7% on the northbound side. The bridge has a 31-degree skew.

Two specialized hydraulic jacks, each controlled by a single joystick, locked into slide rails and pushed the bridge 38 in. every 2 minutes until it was in place. The initial push required 800 to 900 tons with 8 to 9% friction, and approximately 600 to 700 tons and 4 to 5% friction to continue moving the bridge. A steel rail was cast into the temporary support system of the bridge; this rail included steel plates, or "ears." During the move, the ears slid into notches, forcing the bridge to move in only one direction. The jack stayed within this frame, moving the bridge from notch to notch. Once in its final location, crews used jacks to raise the bridge and install the bearings. The actual slide on the southbound bridge took 1 hour and 15 minutes, and the northbound bridge, which did not proceed smoothly and began to come in askew, took 5 hours.

NEVADA DEPARTMENT OF TRANSPORTATION, OWNER

BRIDGE DESCRIPTION: Two single-span bridges, 111-ft 6-in.-long, plus 24-ft-long approach slabs, with widths of 45 ft 11 in. Built 60 ft away from and parallel with their final location and moved in a transverse slide using accelerated bridge construction

STRUCTURAL COMPONENTS: UBT58 precast, prestressed girders (Utah bulb tee) and conventionally reinforced 3.5-in.-thick precast concrete partial depth deck panels

BRIDGE CONSTRUCTION COST: Approximately \$2 million (\$200/ft²) for construction only costs. Another \$900,000 for demolition, removal, and slide costs

AWARDS: 2011 Transportation Project of the Year – Institute of Transportation Engineers, Nevada Chapter



Top down view of the hydraulic jack pushing the bridge. Photo: Jackie Borman, HDR.



Side view of the hydraulic jack pushing the bridge. Photo: Jackie Borman, HDR.



Teflon pads on rails assisted the sliding of the approach slab and bridge into place. Photo: Jackie Borman, HDR.

Safety

The bridge construction and slide required detailed planning. From design, scheduling, surveying, and construction, every step took additional time to prepare for the move.

Safety provisions were put into place to ensure workers and the public were able

to negotiate the detour. Constructing the bridge using ABC eliminated the need to divert traffic as required for most traditional projects. This kept the construction area safer for motorists, pedestrians, and the workers. Crews installed temporary concrete barriers on either side of I-15 to prevent live I-15 traffic from entering the construction areas and to prevent construction equipment from crossing over into I-15 traffic during the move.

Challenges

As-built dimensions are essential in ABC bridges. Unlike building in place, dimensions must be built to absolute precision to ensure the substructure and superstructure fit together during the slide. Adding to the challenge was the high skew angle on the West Mesquite bridges. The design team performed a thorough analysis to demonstrate bridge performance in this particular skewed geometry.

To expedite the move and avoid costly alternatives, the design team decided

Recycling

The crushed concrete from the old West Mesquite Interchange bridges was hauled to a local golf course and used to construct a new flood control system. The asphalt surfaces were also recycled. The material was rotomilled and used in the aggregate base on new sections of the roadway.

to move the approach slabs with the bridge. The approach slabs were built on temporary falsework and shoring along with the rest of the superstructure. All three pieces were elevated together, tied with reinforced cables and reinforcement and coordinated with the jacking system. Approach slabs were slid onto horizontal steel grade beams.

National Attention

The NDOT bridge slide provided more than 150 representatives from 23 different DOTs, the Federal Highway Administration (FHWA), and industry the opportunity to witness ABC techniques and innovation firsthand. The group watched, on site, before attending an FHWA-sponsored workshop highlighting the design and engineering aspects associated with this achievement. More than 100 residents also came out to view the move.

Using ABC techniques, NDOT ultimately saved taxpayers nearly \$13 million by eliminating or minimizing closures, detours, and lowering speeds. Based on the successes of the West Mesquite Interchange project, NDOT is now reviewing the applicability of using ABC innovations on other projects in the state. 

Adam Searcy is a senior project manager at the Nevada Department of Transportation; Mike Dobry is a structures design manager at Horrocks Engineers in Pleasant Grove, Utah; and Laycee Kolkman is a senior project manager at HDR Engineering Inc. in the Las Vegas, Nev., office.

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PROJECT

VETERANS MEMORIAL BRIDGE

THE VITAL LINK FOR TWO CITIES

Segmental bridge makes statement in Maine

by Christopher P. Taylor, T.Y. Lin International

The original Veterans Memorial Bridge (VMB), which was built in 1954, is an important link connecting the cities of Portland and South Portland, Maine, and spans the Fore River. While the existing bridge is still safe for use, the Maine Department of Transportation recognized that the old structure had met its life expectancy and made replacing the bridge a top priority.

An alternative technical concept for a new bridge alignment was developed by the team of Reed & Reed and bridge designer T.Y. Lin International. The new bridge is being built upstream and at a slightly different angle from the older structure. This offers several significant advantages:

- Overlap with the existing bridge was eliminated, greatly reducing impact to the 22,000 vehicles using the bridge each day.

- Work over and adjacent to the active railroad was minimized.
- The overall bridge length was reduced by nearly 800 ft.
- The level of service of the intersections at the north end of the bridge will be improved.
- The new location and alignment will result in a more popular and efficient entry point to the city.

Superstructure

The new segmental precast concrete bridge has a required 100-year service life and is a more visibly compelling structure for the cities it connects. It is designed to enhance the aesthetic experience and reduce the number of spans needed while providing Portland and South Portland with a signature bridge for this important transportation link. The VMB superstructure consists of twin seven-span continuous,

variable-depth, single cell, trapezoidal box girders built using the balanced cantilever method. Typical span lengths are 250 ft each and end spans are 185 and 175 ft. The 1610-ft-long bridge is continuous from abutment to abutment; expansion joints are only required at each end. The superstructure is post-tensioned in both the longitudinal and transverse directions.

The roadway is designed for two lanes of traffic in each direction with an additional 12-ft-wide, multi-use pathway. The superstructure is made up of two parallel precast concrete boxes built using the balanced cantilever method of construction and joined by a cast-in-place (CIP) concrete longitudinal closure strip. The 361 segments vary in depth from 8 ft 1 in. at midspan typical to 11 ft 1 in. at the piers. Segment length is 8 ft to 10 ft, with pier segments of 5 ft. The bridge is on a constant 1.33% longitudinal grade.

Most of the alignment is straight with the north end having a 680-ft radius curve. The width of the north end also widens to accommodate a left turn lane. Here the width of each box top flange increases from 39 ft 9 in. to 45 ft 9 in.

The new bridge is being built on new alignment upstream at a slight angle to the existing bridge. Photo: T.Y. Lin International.



profile

VETERANS MEMORIAL BRIDGE / PORTLAND-SOUTH PORTLAND, MAINE

BRIDGE DESIGN ENGINEER: T.Y. Lin International, Falmouth, Maine

GEOTECHNICAL ENGINEER: GZA Geoenvironmental Inc., Portland, Maine

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

PRECASTER: Unistress Corporation, Pittsfield, Mass., a PCI-certified producer

POST-TENSIONING CONTRACTOR: DYWIDAG-Systems International USA Inc., Bolingbrook, Ill.

CAST-IN-PLACE CONCRETE SUPPLIER: Dragon Products Company, Portland, Maine



Three overlooks are provided along the multi-use pathway. Photo: Unistress Corporation.

At three points along the bridge, the 12-ft-wide pedestrian and bicycle path widens into scenic outlooks over the Fore River, providing excellent views toward Casco Bay and Portland Harbor.

The curved concrete walls that divide the path from the motorway will be topped with curved metal poles that appear to wave in a sinuous pattern. The overlooks are accomplished by extending the box girder overhang by 8 ft on one side to 16 ft 3 in.

Substructure

Independent piers support each box girder. The piers are rectangular, single-shaft, cast-in-place columns. The tops of the columns flare out to meet and blend into the superstructure. The columns are pile supported with buried pile caps. Only the shafts of the columns project above the river bottom, creating an elegant appearance with minimal permanent impact to the aquatic resource. The 22-in.-diameter steel pipe piles were driven through approximately 100 ft of marine clay to bedrock.

Construction

During the bidding phase of this design-build project, the team determined that the segmental precast concrete option would provide the best value based on aesthetic and durability aspects. On this relatively small project, segmental precast concrete construction was made competitive by basing the design on reusing existing formwork, saving both time and money. The segments were precast and the four-strand transverse tendons were stressed and grouted prior to being trucked 240 miles to the project site. The transverse tendons consisted of 0.6-in.-diameter strands and were spaced at 2 ft centers. At the bridge site, the segments were loaded onto a barge for delivery to the cantilever tips where they were erected by barge-mounted cranes.

The pier segments, weighing up to 76 tons, were supported on disk bearings, temporarily fixed during erection. Temporary shoring towers were installed below the second pair of typical segments to resist the overturning

moments. Top slab cantilever post-tensioning tendons are typically nineteen 0.6-in.-diameter strands and the bottom slab continuity tendons are fourteen 0.6-in.-diameter strands.

Community Involvement

Because the bridge is a signature structure, significant public involvement was included throughout the project. A series of public workshops was held in the spring of 2010 for the community to provide input on elements of the bridge that were important to the various stakeholder groups, including pedestrians, bicyclists, veterans groups, and area residents. The bicycle and pedestrian paths connect to an existing parkway trail system. Memorials will also be placed on both sides to honor Maine's U.S. Service and Merchant Marine veterans.



Segments cantilever out from Pier 6 at the north end of the bridge. Photo: Reed & Reed Inc.



In the yard, segments were shuttled with a straddle lift. Photo: Reed & Reed Inc.

MAINE DEPARTMENT OF TRANSPORTATION, OWNER

BEARING SUPPLIER: The D.S. Brown Company, North Baltimore, Ohio

PRECAST SEGMENT FORMWORK: EFCO Corporation, Marlboro, N.J.

BRIDGE DESCRIPTION: Twin 1610-ft-long post-tensioned, precast segmental box girder superstructures supported on cast-in-place (CIP) piers, founded on 100-ft-long, 22-in.-diameter steel pipe piles. Segments vary in depth from 8 ft 1 in. to 11 ft 1 in. Twin structures are joined with a CIP closure strip for an overall bridge width varying between 82 ft 6 in. and 94 ft 6 in.

BRIDGE CONSTRUCTION COST: Bridge cost \$44.2 million (\$325/ft²); total project cost \$63.1 million

The new segmental precast concrete bridge has a required 100-year service life.

100-Year Service Life

The Veterans Memorial Bridge is located over salt water in a harsh, cold-weather environment. This made life-cycle cost and longevity important considerations in the project request for proposal. A number of features were incorporated to ensure long-term durability and corrosion protection and to minimize maintenance costs.

The specified compressive strength for the superstructure concrete was 7000 psi. The concrete contains 20% fly ash by weight of cementitious materials to decrease permeability to below 1000 coulombs at 120 days per AASHTO T 277 and contains 5.5 gal/yd³ of calcium nitrite corrosion inhibitor.

The superstructure is post-tensioned in both the longitudinal and transverse directions. The deck is designed for a minimum of 250 psi longitudinal compression under permanent loads and zero longitudinal tension under live load. These strict criteria exceed the AASHTO LRFD Bridge Design Specification requirements and reduce the likelihood of cracking. The post-tensioning tendons are protected within grout-filled, polyethylene ducts, virtually eliminating the possibility of chloride attack. All substructure elements exposed to salt water also utilize calcium nitrite corrosion inhibitor at 5.5 gal/yd³ and have 4 in. of concrete cover to the main reinforcement.

Corrosion resistant ASTM A1035 reinforcement is used in cast-in-place concrete portions of the superstructure. The deck is further protected by a high-performance waterproofing membrane and a 3-in.-thick bituminous wearing surface consisting of modified asphalt. No intermediate deck joints are used.



Segments were carried to temporary docks and loaded on barges to be delivered to the cantilever tips. Photo: Reed & Reed Inc.



Once the two structures were erected, a cast-in-place closure strip joined the two halves, creating a continuous deck surface. Photo: Reed & Reed Inc.

The project was awarded in February 2010 with design starting immediately and segment shop drawing production, in close coordination, starting shortly thereafter. Casting of the segments began in August 2010, and erection was completed in November 2011. The contractor is currently working on paving, barriers, and other finishing touches. The new landmark bridge is scheduled to open to traffic this July. Demolition of the old bridge is scheduled for completion by December 2012. 

Christopher P. Taylor is a senior bridge engineer at T.Y. Lin International.

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

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1. 4th Street Bridge, CO Photo Courtesy of FHWA
2. I-84 Kanawha River Bridge, WV Photo Courtesy of FHWA/Armedstrong
3. I-95/I-295 North Interchange, FL Photo Courtesy of FHWA/FL
4. DCR Access Road Bridge Over Rte 24, MA Photo Courtesy of MassDOT
5. US 191 Colorado River Bridge, UT Photo Courtesy of FHWA
6. SW Line Bridge, Nalley Valley Interchange, WA Photo Courtesy of Jay F. Johnson/ConcreteConstruction.com
7. Bridge of Honor, OH and WV Photo Courtesy of FHWA/Ohio's Turnpike
8. Hoover Dam Bypass Bridge, NV & AZ Photo Courtesy of FHWA
9. Jixius Bridge, China Photo Courtesy of FHWA/International

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PROJECT

I-5 Willamette River Bridges

Longest concrete arch spans in Oregon

by Jim Bollman, OBEC Consulting Engineers

In late 2009, construction of new twin arch bridges commenced in Eugene, Ore. The bridges carry Interstate 5 (I-5) southbound (SB) and northbound (NB) over the Willamette River, a local highway, railroad tracks, an off-ramp, and two multi-use paths. To span the complex project area, the bridge lengths are 1759 and 1984.7 ft for SB and NB, respectively. The bridges replace the original structure built in the early 1960s, which was closed in 2004 due to structural deficiencies. Since 2004, traffic had been using a detour bridge near the alignment of the NB replacement structure.

The Willamette River Bridges (WRBs) are exceptional in many respects:

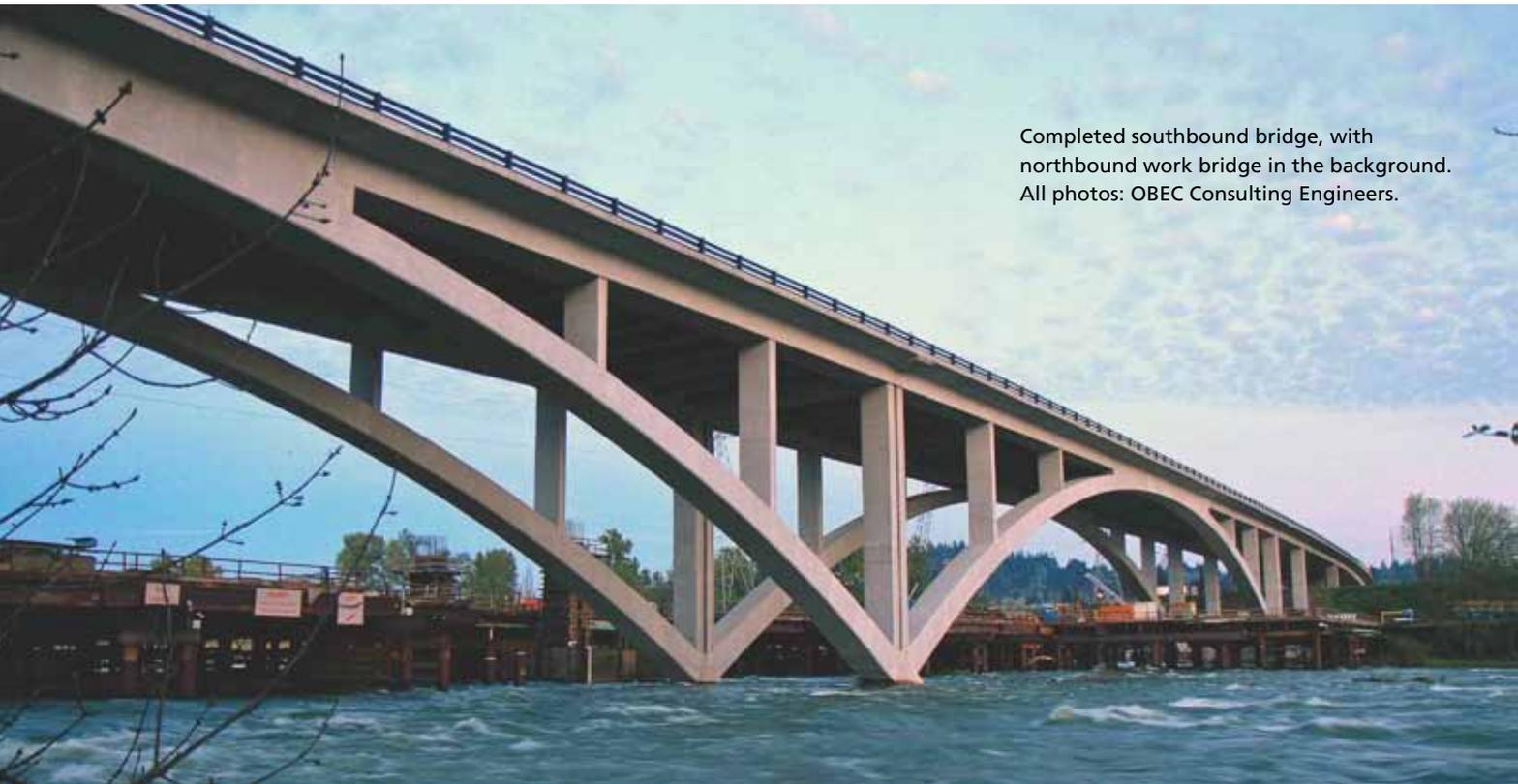
- The spans over the river are the longest concrete arch spans in Oregon.
- The project is the last and largest of the \$1.3 billion, multi-year Oregon Transportation Investment Act (OTIA III) program.
- It is the largest bridge replacement project ever undertaken by the Oregon Department of Transportation (ODOT).

Structural Arrangement

Oregon has an impressive inventory of historic concrete arch bridges, providing

aesthetic and functional crossings of estuaries and rivers throughout the state. More than 20 of the structures completed in the 1920s and 1930s are credited to Conde McCullough, a highly influential engineer who worked for ODOT into the 1940s. The WRBs fit nicely with these older bridges that are well known for their aesthetic mix of Romanesque, Gothic, and art-deco architectural styles.

However, the WRBs also represent two of the few contemporary concrete arch bridges in Oregon. The basic form of the WRBs builds on the Maple Avenue Bridge, a 2005 award winning OBEC



Completed southbound bridge, with northbound work bridge in the background. All photos: OBEC Consulting Engineers.

profile

I-5 WILLAMETTE RIVER BRIDGES / EUGENE, OREGON

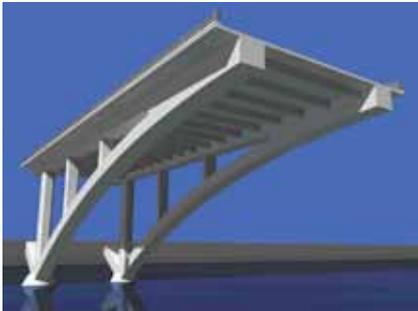
BRIDGE DESIGN ENGINEER: OBEC Consulting Engineers, Eugene, Ore.

CONSTRUCTION ENGINEER: Jiri Strasky, Consulting Engineer, Greenbrae, Calif.

PRIME CONTRACTOR: Hamilton Construction Company, Springfield, Ore.

CONCRETE SUPPLIER: Knife River, Harrisburg, Ore.

Consulting Engineers-design spanning Dry Canyon in the City of Redmond, Ore. The WRBs similarities to the 2005 design include slender un-strutted ribs, composite crowns for lateral stability, compact supports at rib intersections, double columns for bearing-free thermal joints, and sleek clean lines with an open, uncluttered appearance. The WRBs are unique in their scale, spandrel column arrangement, floor system, and span-rise ratio of 7.09.



Rendering of structural arrangement for the southbound Willamette River Bridge in Eugene, Ore.



Finished view of bent 3 shaft cap/arch rib/column joint in foreground, with floor system visible above. At far end of rib, a solid soffit of post-tensioned box girder spans adjoins arch span.

The main spans of each bridge consist of two arch spans with lengths of 390 ft (span 2) and 416 ft (span 3) cast with 6000 psi compressive strength concrete. A girder-floor-beam-slab system comprises the superstructure with one girder in the vertical plane of the two arch ribs. Ribs are composite with the longitudinal girder for 124 ft over the rib crowns.

The arches for each bridge consist of two parallel ribs without transverse bracing. The arches are supported by 8-ft-diameter drilled shafts in bedrock. Two shafts spaced at 20 ft, support each rib at bents 2 and 4 with one shaft per rib line at a midstream rock outcrop (bent 3). The north approach span uses post-tensioned girders with the same superstructure form as the arch spans. The south approach spans are cast-in-place, variable depth, multi-cell box girders, which match the width and depth of the outside faces of the arch span girders where they adjoin at bent 4 on the south riverbank.

Two spandrel columns at equal spacing are used in each open spandrel for each rib half. The short column is hinged top and bottom to limit flexure with thermal movements, while the tall spandrel columns and bent columns are fixed, thin, and of sufficient height to be flexible along the length of the bridge. Columns at bents are arranged in pairs with one on each side of the deck joint between arch spans and adjacent spans to provide for thermal movements without bearings.

The floor system consists of a tapered thickness cantilever deck outside the girders and a 10-in.-thick longitudinal deck between girders and supported on custom-designed, rectangular, precast, prestressed (PCPS) concrete transverse floor beams spanning between girders. The PCPS concrete stem section was designed to provide falsework support for deck casting. Floor-beam spacing is coordinated with the column spacings

Recycling Concrete

Recycling of demolished concrete is an important factor in concrete's life-cycle environmental impact, so for the Willamette River Bridges project the architect and engineer partnered with the concrete supplier and owner to develop a mix design using recycled-concrete aggregate (RCA) in such proportions to be suitable for selected components of the new northbound bridge. Testing of both the crushed material and the class 4500 mix produced with 30% RCA demonstrated equivalent performance in many respects to the class 4500 mix with virgin aggregate. Strength, shrinkage, and permeability were included in the testing program, which concluded with use of an RCA low-heat mixture used in the mass concrete shaft caps for bents 2 and 4, where freezing and thawing, and slightly lower modulus of elasticity are not issues. Using the demolished concrete of the detour bridge in the foundations for the new bridge will help keep concrete waste out of landfills.

so columns frame into the girders at mid-spacing of floor-beams, avoiding conflicts between column and floor-beam reinforcement. Both the girders and floor-beams become composite T-beams with the deck for resistance to live load.

Special-Purpose Concrete

The bent 2 and 4 shaft caps are mass concrete incorporating the development length of the bundled No. 18 shaft bars from the two shafts, and the development length of the No. 14 rib bars midway between the shafts. Thermal cracking from differential temperature between the cap core and surface was a risk, mitigated by a low heat of hydration mix design. Specific limits are a maximum water-cementitious materials ratio (w/cm) of 0.45, maximum 660 lb/yd³ of cementitious materials with 60% ground-

THE OREGON DEPARTMENT OF TRANSPORTATION, OWNER

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

REINFORCEMENT FABRICATOR: Farwest Reinforcing Division, Eugene, Ore.

BRIDGE DESCRIPTION: Twin southbound (SB) and northbound (NB) structures consisting of one cast-in-place post-tensioned concrete girder span; two concrete deck arch spans over the Willamette River; three spans of cast-in-place, constant-depth, post-tensioned box girders over Franklin Boulevard; and three spans (SB) or four spans (NB) of cast-in-place, haunched, post-tensioned box girders over UPRR and I-5 exit ramp

granulated, blast-furnace slag, minimum coarse aggregate solids/total volume of 0.46, and a maximum concrete placing temperature of 70°F. Acceptance of 4500 psi design compressive strength was based on 56-day test results.

At bent 3, the ribs from spans 2 and 3 intersect with the single shaft per rib line and the double column from above. Complex reinforcing details were required for these five intersecting compression members with an approximate volume of a 7-ft cube, but with a complex shape from the different member cross sections and the small streamlined shaft cap. Each of these members was fixed to all the others in the joint to meet requirements of either the final design condition (fixed ribs and columns) or construction-stage loading. A monolithic rib/shaft connection for construction stage loading is related to rib crown jacking for arch pre-compression and camber adjustment.

After casting the arches on falsework, the transfer of their self-weight to axial thrust plus each load stage thereafter, produces both elastic and inelastic shortening. The horizontal thrust component at bents 2 and 4 deflect the shaft tops away from the ends of the



Placing rib cross-ties through bent 3 joint.



Placing column bars through rib reinforcement in bent 3 joint. Shaft cap skin reinforcement remains to be placed along with remainder of steel forms.



Casting of the reinforcement-congested bent 3 shaft cap/arch rib/column joint with special high-slump 6.0 ksi concrete.



Drilled shaft to arch rib connection bars at bent 3.

arches, lengthening each span slightly. If the ribs were cast monolithically on falsework, rib shortening and span lengthening would yield a flatter curvature than initially constructed; flexure and shear would arise from imposed distortion to the as-cast shape. Rib crown jacking provided a temporary hinge and a means of lengthening and pre-compressing the rib to fill the load-lengthened span, while raising it to compensate for further compression from subsequent loads. Construction complexity was reduced by jacking span 2 and then span 3 sequentially. To control the jacked rib shape, a fixed rib to shaft connection was necessary at bent 3.

The joint including the rib to shaft connection was formed into a single placement. The 6000 psi compressive strength concrete for casting the reinforcement-congested space utilized $\frac{3}{8}$ -in. maximum size aggregate and had a 9-in. slump with performance similar to self-consolidating concrete. Both internal and external form vibration were used, and the results were top quality.

High-performance concrete with specified compressive strengths of



Shaft and rib reinforcement extending into partially-completed bent 2 shaft cap reinforcement cage. Column bars are not yet placed.



Span 2 ribs become self-supporting after crown jacking. Weight of each rib is carried by eight, 2.5-in. diameter, 150 ksi post-tensioning rods, two of which are visible at the side of the jacking frame.

4000 psi for the arch spans and 5000 psi for the other spans was used in the deck.

In addition to standard specification requirements to control deck cracking (fog nozzles until curing is applied, 20 minutes maximum from placement to wet curing and 14 days wet curing, and saw-cut grooving), polypropylene fibers were included in the deck mix to provide early tensile strength for shrinkage-cracking resistance.

The SB bridge was completed in September 2011 and is now carrying four lanes of I-5 traffic. The NB bridge is expected to be completed by fall 2013. **A**

Jim Bollman is a bridge engineer with OBEC Consulting Engineers in Eugene, Ore.

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

AESTHETICS COMMENTARY

by Frederick Gottemoeller



Normally, an even number of spans is not the best solution for a major bridge. This bridge is a great exception, because an island in the middle of the river provides an obvious and practical location for a center pier. The pier lands in the center of the river and the side piers land on the bank, out of sight in the trees. There is very little impact on the water itself. The arches frame its entire flow, through the rapids and into the distance, leaving just a peek of the far horizon.

And it is easy to see all of this through the bridge. All of the structural members appear to be as thin as calculations will allow and the joints are simple intersections, without thickening or fillets. The edge of the deck is barely thicker than the deck itself, and the railing is easy to see through in both directions. There is no extraneous material here.

“Keep it simple _____” is usually the best rule. Let me count the ways this bridge does that:

- Two arch ribs
- Deck girder and arch rib the same width and shape
- No bracing in the plane of the ribs
- Floor beams regularly spaced with no diagonal bracing
- Spandrel columns all of the same shape
- Spandrel columns at expansion joints simply doubled standard columns
- Approach girder overhang and depth the same as arch deck girder overhang and depth
- Approach piers same shape as arch spandrel columns

The curvilinear shapes of the center pier bases, one for each rib, are just enough of a departure from the ruling simplicity to draw the eye and make clear their function to divide and direct the river’s flow. They make the bridge look like it’s riding the river, supported by the waves.

Historic arch bridges made an impact by imposing mass and elaborate shapes on a site, with much-added ornament, often borrowed from traditional architectural styles. This bridge makes its impact by imposing very little on its site. It creates a memorable visual effect by contrasting its precise geometry and extreme transparency with its natural surroundings, and by inserting only those few physical elements required to do its job. It is a wonderful expression of what we now can do with the high-performance materials and advanced analytical techniques of the twenty-first century. Let’s hope it becomes a frequently imitated model in the future.

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Preservation of Concrete Bridges

by M. Myint Lwin and Anwar Ahmad, Federal Highway Administration



Highway bridges form major links in the national transportation network. Their structural health is important because these bridges allow the public to travel from Point A to Point B safely with little interruption and predictable arrival time. The role of bridge preservation is vital in meeting these expectations.

Definition

Bridge preservation is defined by both FHWA and AASHTO as “actions or strategies that prevent, delay, or reduce deterioration of bridges or bridge elements, restore the function of existing bridges in good condition, and extend their life. Preservation actions may be preventive or condition-driven.”

The goals of preservation are to:

- maintain bridges in good or fair condition by systematic, preventive, and regular maintenance, and
- not allow the bridge to deteriorate into poor condition, which would cause condition-driven preservation actions to be taken.

Preventive maintenance is a lot less demanding on resources than condition-driven preservation actions. States report that the cost-benefit ratio for preventive maintenance

is very high. Bridge preservation encompasses preventive maintenance, rehabilitation, and repair activities.

Lessons from History

In 1806, President Thomas Jefferson authorized the federal government to plan and build the famous and historic Cumberland Road. The President appointed a Board of Commissioners to decide on the route through which the road would run. The congressional specification for building the road was very simple. The road was to be 66 ft wide with a stone surface covered with gravel. The bridges were to be of stone. Grades were to be leveled after the manner of good road construction.

Cumberland Road was one of the first major improved highways in the United States that was built by the federal government. It was the first road in the United States to use the new Macadam road surfacing. Within a few years after the road was opened to traffic, Cumberland Road deteriorated as a result of heavy traffic and lack of funds for maintenance. Does this sound familiar?

In 1822, Congress passed a bill authorizing the federal government to collect tolls to be used for maintenance. This bill was vetoed by President James Monroe on the constitutional

grounds that it was an unwarranted extension of the power vested in Congress. President Monroe’s position has continued to be the federal position on highway matters to present day.

During the next nine years, Cumberland Road continued to deteriorate despite a few small federal appropriations for maintenance. It was finally recognized that the only solution was state-operation as a toll road. In 1831 and 1832, the state legislatures of Ohio, Pennsylvania, Maryland, and Virginia agreed to accept and maintain their sections of Cumberland Road. These states set the earliest example of meeting the challenges of maintaining roads and bridges in good condition.

Systematic Preservation

Systematic preventive maintenance is a key part of an effective preservation program. It is necessary for ensuring proper performance of the transportation infrastructure. Experience has shown that preventive maintenance is a very cost-effective way for extending the service life of highway bridges and structures.

Congress finds and declares that it is in the vital interest of the nation that a highway bridge program:

- enables states to improve the condition of highway bridges,
- rehabilitates bridges that are determined to be structurally deficient or functionally obsolete, and
- implements systematic preventive bridge maintenance.

This results in legislation that makes systematic preventive maintenance activities, such as crack sealing, expansion-joint repair, and controlling deterioration, eligible for Federal-Aid funds. A state may carry out systematic preventive maintenance for a highway bridge without regard to sufficiency rating or deficiency status. Systematic preventive maintenance implies the use of an effective maintenance strategy or a prioritization and optimization preservation program to gain the most benefit from the investment on preventive maintenance activities to keep bridges in a state of good repair.



Deck delamination repair before application of an overlay. All photos: Virginia Department of Transportation.



Expansion joint repair before further deterioration occurs.

Effective Maintenance through Good Design and Quality Construction

Effective maintenance starts with good design and detailing to ensure durability, inspection, and replacement. Bridge designers must be mindful of maintenance when they prepare the bridge drawings for construction. Certain bridge elements and components—such as metal elements, bearings, connections, expansion joints, and movable parts—require periodic inspection, maintenance, and eventual replacement. Bridge designers must provide access, platforms, lighting, ventilation, and attachment devices to simplify the work of maintenance personnel so they can perform their duties as efficiently as possible.

Effective maintenance also starts with quality construction. Construction defects left uncorrected will soon become a nightmare. Lack of quality invariably results in early maintenance requirements and frequent repairs. Quality control (QC) and quality assurance (QA) play an important role in ensuring the quality of the constructed project and minimizing maintenance needs. The final acceptance inspection of the finished project is the last chance for QA of the completed project. The maintenance personnel are encouraged to join the owner's construction personnel in performing the final acceptance inspection. All unacceptable defects should be documented and corrected before final acceptance of the project.

The maintenance personnel should be involved in the design to convey their needs to the designers. The opportunity for building a cost-effective, maintenance-sensitive structure is during the design phase. Cost for maintainability is minimal when proper consideration is given in the design phase. There is opportunity in the construction phase, but at this time any change to the contract can be costly.

State Practices

Several exemplary practices are shown in the photographs. States are willing to share work plans to highlight good practices and lessons learned. The FHWA Division Bridge Engineers



Modular joint replacement in progress.



Treatments to restore pier condition.

may be contacted for information on bridge maintenance and preservation.

FHWA Preservation Guide

FHWA publishes the *Bridge Preservation Guide: Maintaining a State of Good Repair Using Cost-Effective Investment Strategies*. The guide provides bridge related definitions, commentaries, and examples that can assist bridge owners in developing and implementing a systematic preventive maintenance delivery plan, which is a major component of a bridge preservation program. The guide walks through step-by-step in the development of the delivery plan. It is available at <http://www.fhwa.dot.gov/bridge/preservation/guide/guide.pdf>.

FHWA also has a website that provides a toolbox containing bridge-related links

organized in four sections titled Legislation & Policies, Bridge Management, Bridge Preservation Treatments, and Research & Development. The address for the website is: <http://www.fhwa.dot.gov/bridge/preservation>.

Closing Remarks

The importance of systematic preventive maintenance and effective preservation program is recognized nationwide. Many states are developing and implementing bridge preservation programs with performance measures to track their progress. Learning and sharing nationally will lead to integration of good practices in effectively reducing the number of bridges in poor condition, and increasing the number of bridges in good condition in the National Bridge Inventory. 

PIONEERS IN CONCRETE BRIDGES

Nebraska bridges evolve from 1900s to 2000s...and beyond

by Fouad Jaber, Nebraska Department of Roads



Nebraska is not a stranger to concrete bridges. State inventory figures reveal that there are approximately 5000 cast-in-place concrete (mostly slab) bridges and 1500 precast, prestressed concrete girder bridges. A look at some of these bridges demonstrates how rapidly Nebraska's bridge technology has evolved over the years and why the state is among the pioneers in concrete bridge technology.

The earliest concrete bridges in Nebraska date to the early 1900s; these modest concrete bridges, including concrete arch and box culverts, appear throughout the state. By the second decade of the twentieth century, concrete gained favor as a material for a bridge's superstructure. Concrete plans were standardized and concrete slab bridges and concrete arch bridges became increasingly common into the 1920s and beyond.

In 1911, state legislation created the State Aid Bridge Fund, which led to increased funding and building of bridges. A shortage of funds during the Depression forced Nebraska to phase out the popular program, with the last appropriation occurring in 1933.

During the fund's existence, a total of 97 bridges at 80 locations were built or purchased. These bridges included designs popular during the period, including steel trusses, stringers and transverse-joist girders, concrete arches, and girders. A surprising number of well-preserved concrete bridges survive from this period.

Jointless Bridges Emerge

In the 1930s and 1940s, concrete bridges continued to become more economically feasible and increased in number. In the 1950s, Nebraska was among the first to build precast, prestressed concrete bridges, with four of these bridges located along the Sherman Reservoir in central Nebraska. These were simple-span girder designs without diaphragms at the interior supports. This design evolved in the following decades to simple span for dead load and continuous for live load by adding diaphragms at the interior supports starting in the 1970s. Thus, the concept of "jointless bridges" was born.

The jointless bridge system eliminates all expansion joints over the entire length of the bridge superstructure, and limits joints to locations at the junction between the bridge approach slab and the pavement. With this system, the opportunity for joint leakage over the abutments and pier bearing areas is eliminated. This is not only an important durability issue, but also a very significant aesthetic issue. Having expansion or separation joints through the deck over the supports creates the potential for stains, cracking due to freezing and thawing, and spalling.

Performance of bridges designed using the Nebraska system have stood the test of time. A number of structurally sound, 40-year-old bridges are being replaced due to Interstate realignment. The girders being removed appear to be as good as new, despite Nebraska's harsh

weather and use of deicing salts. This validates the Nebraska Department of Roads' (NDOR's) design philosophy, which results in significant savings in prestressing levels and better control of cambers.

University Influence

Nebraska is the birthplace of the NU (Nebraska University) hard SI I-girder series, developed in 1992. The NU girder series, NU900 to NU2000, vary in depth from 900 to 2000 mm (36 to 79 in.). These new shapes, despite the national retreat from the SI system, proved to have significant advantages compared to the previously used AASHTO girders. They:

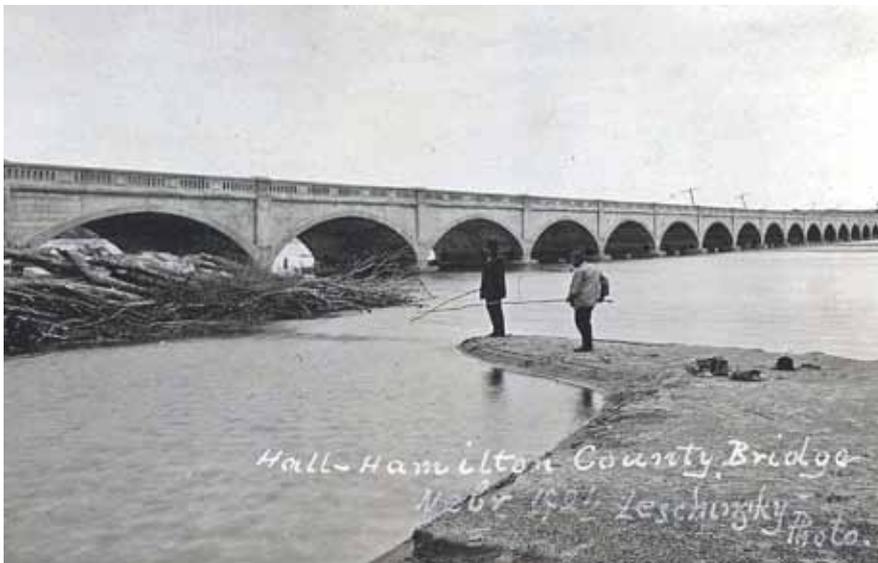
- are more stable during handling and erection,
- house more strands, resulting in longer span capacities for the same depth, and
- take advantage of the improvements in concrete technology such as high-strength, self-consolidating concrete that allows for thin, cross-section geometry.

This new series of girders was selected as the standard girder I-shape by NDOR, providing a clear direction for consultants, suppliers, and contractors. The ability of the 38-in.-wide bottom flange to hold up to sixty 0.6-in.-diameter strands creates the potential for a relatively shallow structural depth. A 5.9-in.-thick web allows ample shear capacity while keeping the girder weight to a minimum. A 48-in.-wide thin top flange reduces the cost of deck forming, improves buckling stability, and minimizes the girder weight.

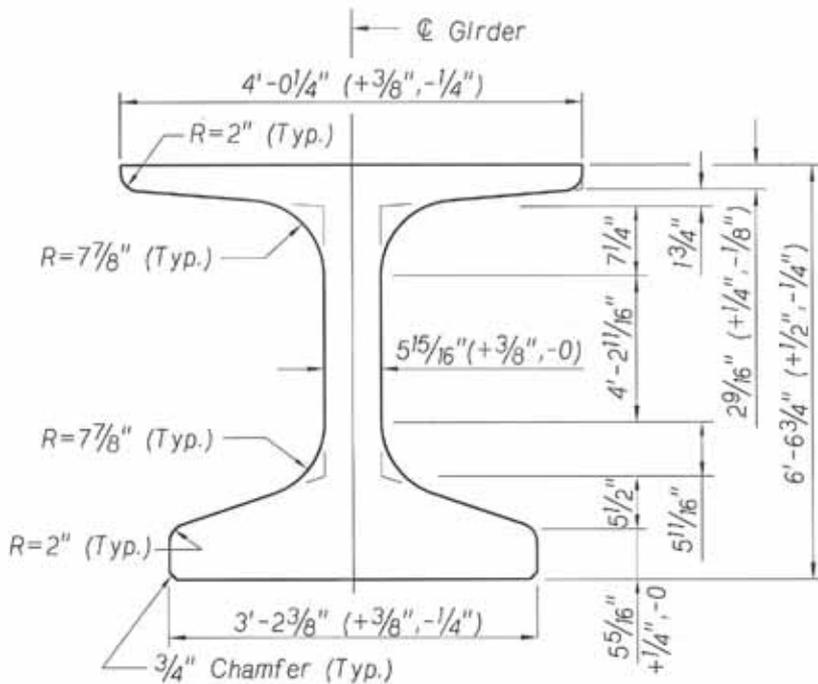
Since its introduction, the NU girder series has been exclusively used in Nebraska for spans up to 206 ft. The 204th Street Skyline Bridge in Omaha, completed in 2004, was the first bridge to achieve this span length. It used NU2000 79-in.-deep girders at 9 ft spacing.

This highly efficient design was possible through the use of a combination of pretensioning and post-tensioning of three segments with lengths of 28, 150, and 28 ft. The prestressing consisted of 46 pretensioning strands and 45 post-tensioning strands. Self-consolidating, 10,000 psi compressive strength concrete was used for the girders.

The bridge's main 206-ft-long span featured three girder segments per girder line with two cast-in-place concrete splice joints. This is thought to be the longest simple span with the greatest girder span-to-depth ratio of any bridge



The photo shows the historic Hall-Hamilton County Bridge in 1926. All photos: Nebraska Department of Roads.



This drawing shows the typical dimensions of a NU2000 girder.

in the country. The bridge is a strong example extending the adaptability of precast, prestressed concrete girders to longer spans to compete with other materials.

A number of bridge overpasses were constructed between Omaha and Lincoln in the past 15 years as part of the I-80 widening to three lanes in each direction. The I-80 widening effort required the replacement of many older, four-span steel and concrete structures. The replacement bridges were typically two-span concrete structures, which were selected to take advantage of performance characteristics that allow the superstructure depth to essentially remain unchanged. This reduced the number of

issues related to meeting existing business access and road crossing grades. Most of these bridges are precast, prestressed concrete structures with span-to-depth ratios near 30. These bridges are often mistaken for slab bridges because of their shallow depth and elegant appearance.

Teamwork

The state of Nebraska prides itself in creating effective partnerships. The team environment established with the Federal Highway Administration; the NDOR; the University of Nebraska (UNL); the precast concrete suppliers, represented by the Prestressed Concrete Association of Nebraska

(PCAN); and the contractors, represented by the Associated General Contractors of Nebraska has been extremely beneficial. In the past several decades, much of the innovation and progress in Nebraska is directly attributed to this partnership. The introduction of the NU I-girder is one of the early examples.

Other innovations include the use of high-strength concrete and self-consolidating concrete (SCC) in all bridge girders, which has been a standard practice in the state for all precast, prestressed concrete bridge products since the early 2000s. SCC was used in the Dodge Street Bridge in Omaha.

Nebraska was the selected site for the first high-performance concrete demonstration bridge project. Opened to traffic in 1997, the 120th Street and Giles Avenue Bridge, in Sarpy County, incorporated 12,000 psi precast, prestressed concrete girders and an 8000 psi cast-in-place concrete deck, and is another example of successful teamwork.



Dodge Street Bridge is an example of an elevated highway bridge in Omaha, Neb.

Innovation Continues

Another recently introduced innovation pioneered by Nebraska is the use of 0.7-in.-diameter strands. This strand size is available in the United States but had been limited to the mining industry and cable-stayed bridge applications. The 0.7-in.-diameter size has a cross-sectional area of 0.294 in.² and thus allows for nearly twice the prestressing force over that provided by 0.5-in.-diameter strands.

The Pacific Street Bridge over I-680 in Omaha was completed in 2008 and was the culmination of ongoing research on the impact of using 0.7-in.-diameter strands in NU I-girders; it was the first bridge in the United States to utilize this unique strand size. A standard high-performance concrete design was used to deliver the specified concrete compressive strengths of 10,000 psi. Indications are that labor savings, combined with the ability to introduce almost twice the prestressing force, will lead to a significant future increase in the span capability of the current NDOR NU I-girder, without having to modify the sections or acquire new forms.



A typical NU girder bridge overpass over I-80.

Nebraska continues to refine and advance NU I-girder design and construction. Recent developments include use of high-strength rods to create continuity for deck weight and the creation of a new, cost-effective, 15,000 psi compressive strength precast concrete mixture.

The Grand Island Bridge over I-80, built in 2003, was the first bridge designed continuous for dead load and live load and is a prime example of the use of threaded rod continuity over the pier. This structure has two 145-ft-long spans using NU1100 girders. This innovative solution allowed bridge girders to be extended in their span range.

The Arbor Road Bridge put into use another innovative system. The structure is the first for Nebraska, and one of the first in the United States, utilizing precast concrete curved girders. The curved girders, which are approximately 4 ft tall, spanned about 140 ft over the Interstate near Lincoln, Neb. The tub-shaped girders consist of straight 40-ft-long segments that are kinked at the joints. Commuters on the interstate cannot tell if the bridge girders are truly curved or just made of chorded 40 ft straight lines.

Creative Deck Design

Nebraska has developed an innovative full-depth, full-width precast concrete deck system (NUDECK 1st Generation). The panels were first used on a bridge in the Skyline development, near the 204th Street Skyline Bridge. The system, developed in collaboration with UNL and PCAN, extends service life and accelerates bridge construction.

The precast, transversely pretensioned, longitudinally post-tensioned concrete panels, ensure a crack-free, two-way prestressed concrete deck system. This innovative deck system was designed for long-term durability and low maintenance requirements. Currently Nebraska engineers are in the process of designing the 2nd generation NUDECK scheduled to be constructed in 2013.

During the past decade, the trend toward longer, stronger and lighter concrete bridges has continued. Shortly, Nebraska will combine, for the first time, 15,000 psi compressive strength concrete girders, with 0.7-in.-diameter strands, and threaded rod continuity, in a single application. ▲

Fouad Jaber is assistant state bridge engineer with the Nebraska Department of Roads in Lincoln, Neb.

For more information about Nebraska's bridges visit www.roads.ne.gov/design/bridge/



Grand Island Bridge over I-80 utilizes threaded 150 ksi reinforcing-bar connections for full continuity of dead load and live load over the support.



Arbor Road Bridge over I-80 in Lincoln, Neb., used curved precast concrete box girders.



NUDECK being installed over the Skyline Bridge near Omaha, Neb.



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Concrete Bridges for the Expressway Authority

by Joe Berenis, Orlando-Orange County Expressway Authority and Scott Kamien, Atkins North American, Inc.

The Orlando-Orange County Expressway Authority (OOCEA) was established as an agency of the state under Chapter 348, Part IV, of the Florida Statutes in 1963. The current system consists of 105 centerline miles of limited access expressway (over 500 lane miles), 57 interchanges, 13 mainline toll plazas, as well as a non-system 2-mile-long tolled roadway (Goldenrod Road), 58 ramp toll plazas, and 286 bridges covering SR 408 (Spessard Lindsay Holland East-West Expressway), SR 417 (Central Florida GreeneWay), SR 528 (Martin Andersen Beachline Expressway), SR 429 (Daniel Webster Western Beltway), and SR 414 (John Land Apopka Expressway).

Approximately 85% of the OOCEA's bridges are concrete, utilizing many structure types. Concrete slab bridges are common for short spans and low-profile structures, AASHTO beams for the older medium span structures, and more recently, Florida bulb-tee beams, concrete U-beams, and Florida I-beams for the newer, larger structures.

OOCEA plans and constructs its expressways to bring value to the community through economical new designs and aesthetic appeal. The Goldenrod Road project was the first in Florida to include the design and construction of 72-in.-deep concrete Florida U-beams for use over vehicular traffic. Two spans totaling 265 ft 10 in. in length (the largest being 145 ft long and 8 ft wide) were set over SR 528. The U-beams were chosen for their appearance, improved maintenance of traffic, and lower maintenance costs. The Expressway Authority also utilized the U-beams as an economical alternative to steel box girders on structures for SR 429, SR 408, the I-4/SR 408 interchange, and the SR 414/SR 429 interchange.

When developing concepts for the widening of SR 408 through downtown Orlando, a non-traditional design approach to increase traffic capacity was needed to satisfy the diverse communities it spans. OOCEA added a degree of architectural creativity to its always-sound highway engineering. The resulting design incorporated decorative concrete architectural precast concrete panels, typically used for buildings, to create a facade concealing the sloped pavement and bridge piers. The precast concrete panel facade used native Florida stone in two shades of earth tones to blend into native landscaping and improve the overall look of the bridges. The signature component at each bridge was precast concrete pylons that matched many of the craftsman-style homes along the frontage.



Close-up photos of decorative concrete pylons. All photos: Orlando-Orange County Expressway Authority.



Decorative architectural precast concrete panels were used on the expressway widening through downtown Orlando.

The concrete industry is robust in central Florida; concrete is typically the material of choice for short- and medium-span bridges. It has also provided options and competed well with steel in the long-span bridges through segmental structures. The use of Class VI, 8500 psi compressive strength concrete and the new Florida I-beam shapes have helped extend the range of concrete shapes now available.

This past year, a value-engineering redesign replaced a two-span steel plate girder on CR 437 over SR 429 with a new Florida I-84 beam, providing a six-figure cost savings to the

OOCEA. With the added benefit of cost savings, combined with the increased durability and reduced maintenance, concrete continues to be a viable option for use in the OOCEA system. **A**

Joe Berenis is the deputy executive director, Orlando-Orange County Expressway Authority and Scott Kamien is Orlando-Orange County Expressway Authority general engineering consultant project manager, Atkins North American Inc., Orlando, Fla.

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ABC Tool Weighs Alternatives

Matrix compares preferences two at a time to create ultimate priority listing for bridge designs

by Benjamin Tang, Oregon Department of Transportation and Toni L. Doolen, Oregon State University

The factors involved in deciding how and when to replace substandard and functionally obsolete bridges can be more complex than the decision to build a new structure. These factors also impact whether accelerated bridge construction (ABC) methods can be used to complete construction quickly to improve safety and minimize costs. A new software analysis tool can help decision makers assess alternatives with more confidence that their choices will be the safest, fastest, and most cost effective.

The tool was developed in an Oregon Department of Transportation (ODOT) pooled-fund study, TPF 5(221). Based on the analytical hierarchy process (AHP), it determines the best alternative using specific weighted criteria (Saaty & Vargas 2001). The various criteria are compared two at a time to develop ranked priorities and a final decision.

The process compares criteria and sets priorities and weights for each criteria based on the relative importance of one criterion to another. Matrices of weighted priorities are used to create utility values for specific bridge replacement alternatives. The weighted numerical results are compared for each alternative and used to identify a preferred alternative.

The process can also be used to help designers decide among material as well as design choices. By comparing various cast-in-place concrete designs, precast concrete designs, or steel designs, the user of the tool can identify the best alternative, based on the criteria included in the hierarchy for a particular bridge replacement or rehabilitation project.

A simple example of how the matrices and weighting can be applied to a decision can be seen at <http://www.fhwa.dot.gov/publications/publicroads/11novdec/02.cfm>.

Application to Bridges

ODOT's technical advisory committee developed a two-level hierarchy of criteria relevant to determining the best construction methods to apply to bridge replacement and rehabilitation projects. The highest level consists of five criteria, each of which is specified by two to nine sub-criteria (Figure 1).

One of the projects used to test the tool was the U.S. 52 Bridge over the Mississippi River

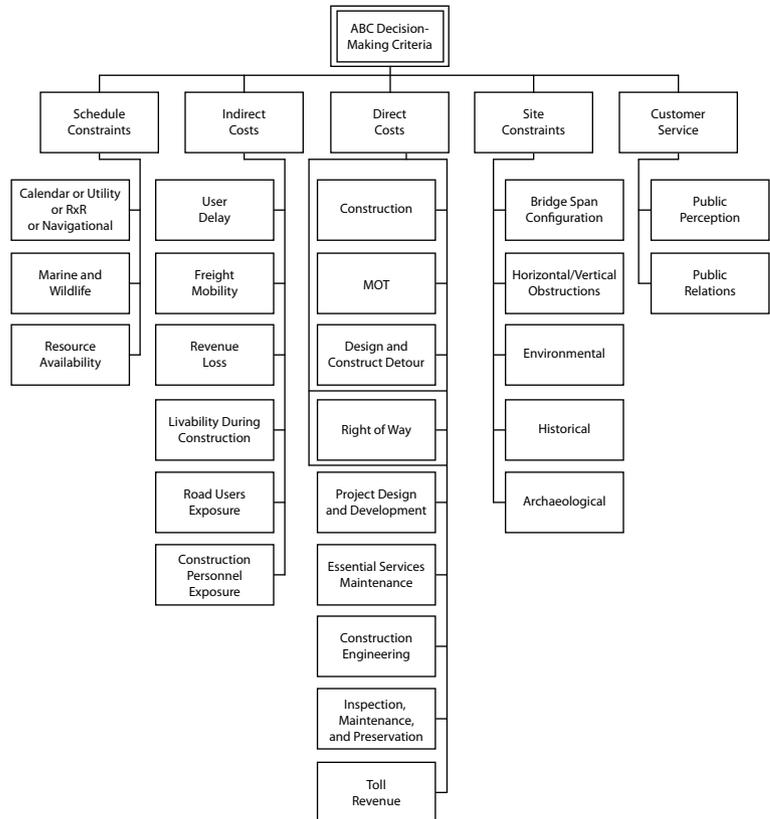


Figure 1: Decision criteria for bridge replacement or rehabilitation projects.

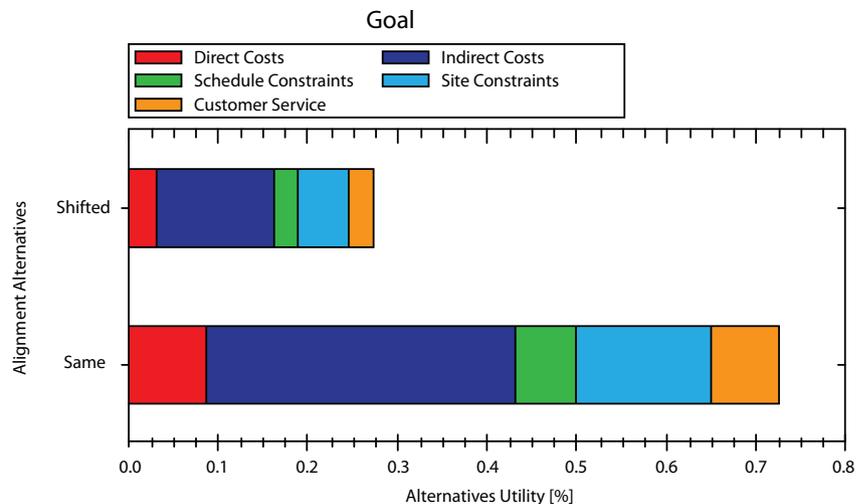


Figure 2: Overall priority for two replacement alternatives for Sabula Bridge.

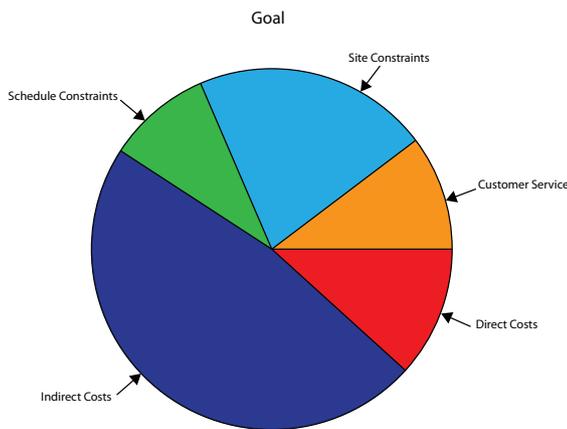


Figure 3: High-level criteria weights for Sabula Bridge.

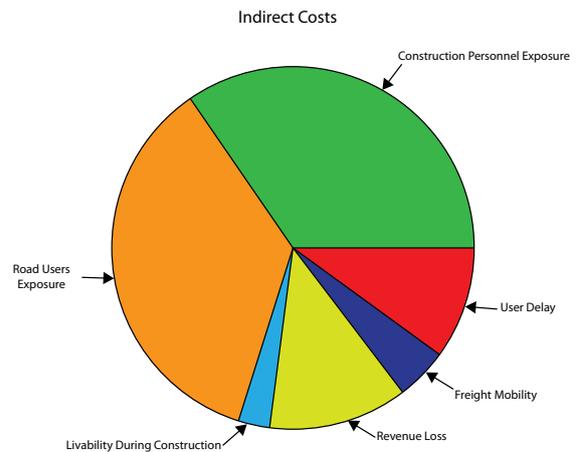


Figure 4: Sub-criteria weights for indirect costs for Sabula Bridge.

Overflow in Sabula, Iowa, which is functionally obsolete due to inadequate roadway width and clearance problems. The existing bridge is a 342-ft by 20-ft steel high-truss structure, for which the approach spans' deck was replaced in 1985.

There was no rehabilitation option available, so the bridge is being replaced. The required data for this analysis was provided by the Iowa Department of Transportation. Two construction alternatives were compared: same alignment with detour (ABC) and shifted alignment (conventional).

The AHP process was applied using the criteria shown in Figure 1 for these two alternatives. After completing the evaluation, the ABC alternative was preferred. The calculated overall priorities for the same and shifted-alignment alternatives were 0.727 and 0.274, respectively. Figure 2 summarizes the relative weighting of the five high-level criteria for this particular project. The size of each bar segment is based on the criteria weights resulting from the AHP analysis.

Figure 3 presents a top-level summary of criteria weights for the project. The results indicate that Indirect Costs and Site Constraints criteria have the greatest impact on the decision to select the same alignment alternative as the best alternative. Additional detail is also available, as a result of the analysis, which indicates the relative weighting of the second level criteria within each criterion, as shown in Figure 4 for indirect costs.

To date, the approach has been tested on projects in seven states (California, Iowa, Montana, Oregon, Texas, Utah, and Washington). It has proven to help decision makers clearly articulate the rationale for choosing an alternative by evaluating multiple criteria and diverse (sometimes opposing) perspectives. Using such a tool in a project's early stages can promote dialog and ultimately foster effective solutions.

Reference

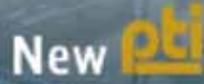
Saaty, L. and Vargas, L. (2001). "How to Make a Decision," *International Series in Operation Research and Management Science*, vol 34, 1-25. 

Benjamin Tang, P.E., is manager of bridge preservation for the Oregon Department of Transportation in Salem, Ore.

Toni L. Doolen, Ph.D, Oregon State University, is the principal investigator of TPF 5(221) Pooled Fund Study for the AHP Decision Tool.

EDITOR'S NOTE

For more information on the pooled fund study, visit www.pooledfund.org/Details/Study/449.

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Lightweight Concrete Facilitates Deck Replacement

by Catherine Higgins, Utah
Department of Transportation

Lightweight concrete is not commonly used for constructing bridge decks according to Joshua Sletten, structures design manager at the Utah Department of Transportation (UDOT). However, lightweight concrete was the right choice for the Taggart Bridge, which is comprised of twin structures that carry I-84 over the Union Pacific Railroad. Originally built in 1967, the deck replacement was a priority. Lightweight concrete allowed the bridge deck to accommodate a thicker deck and asphalt overlay to meet the adjoining freeway profile, while not exceeding the load capacity of the older, precast, prestressed concrete girder bridges.

The bridge geometry, along with the requirement to keep the freeway open during construction, presented the initial challenges to UDOT, Hanson Structural Precast, and Granite Construction Company Inc.

Both bridges are three-span structures on a curved alignment. Sixty individual deck panels were designed, and “no two panels were the same,” according to UDOT design engineer Robert Nash. He kept dimensions the same where possible but “the location of shear blockouts and leveling devices were different for every panel.” Each panel was connected to the beams using reinforcing bars grouted into the top flanges of the concrete beams.

Hanson created precise shop drawings for each precast concrete panel. An indoor precasting yard made production immune to weather delays, and a rigorous internal quality-control process eliminated fit issues at the construction site. Panels used concrete with expanded shale lightweight aggregates from Utelite Corporation, a local supplier.

Granite Construction achieved UDOT’s aggressive construction schedule requirements while keeping traffic moving during construction. The precast concrete panels and detailed construction sequence allowed workers to keep pace even during snow flurries and low temperatures.

The project won recognition from UDOT as the Rural Project of the Year for 2011. 

Catherine Higgins is an interactive specialist with the Utah Department of Transportation Communications Office.



Lightweight concrete panels allowed the use of a thicker deck and overlay while not exceeding the capacity of the older beams. Photo: Utelite Corporation.



The panels were connected to the beams through reinforcing bars grouted into the top flanges of the beams. Photo: Utelite Corporation.

Rainbow Bridge

The Positive Impact of Concrete Bridge Preservation

by Chris Ball, Vector Corrosion Technologies

The Rainbow Bridge, completed in 1933 at a cost of \$74,000, is the longest (410-ft) single-span concrete arch bridge in Idaho and a landmark structure on the Payette River National Scenic Byway. The bridge is listed in the National Register of Historic Places and designated for rehabilitation rather than replacement.

Decades of exposure to freezing and thawing cycles and deicing chemicals began to affect the integrity of the structure. A consultant's 2004 study assessed the structure and evaluated alternatives to preserve the bridge. This evaluation identified the most destructive corrosion as that which was located in the substructure near the joints and deck drains.

The repair scope included partial and full replacement of railings and curbs, replacement of expansion joints, concrete patching, and corrosion mitigation of the arches. After evaluating a series of alternatives, the consultant and the Idaho Department of Transportation (IDOT) specified two systems to protect distinctly different sections of the structure: electrochemical chloride extraction (ECE) to passivate corrosion in the concrete arch substructure and alkali-activated embedded galvanic anodes in sections that did not receive electrochemical treatment.

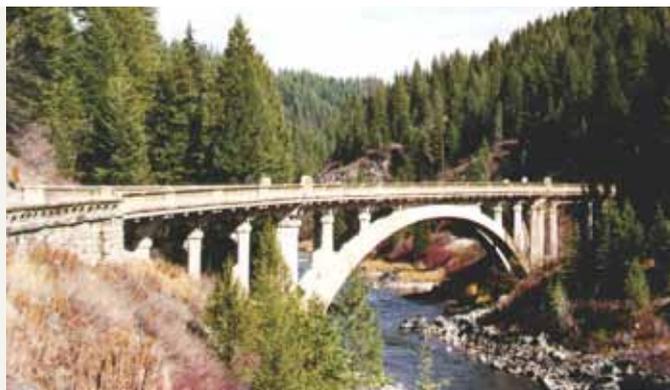
The implementation of the concrete repair and corrosion mitigation plan provided several important benefits:

- Minimal impact on the aesthetics of the historic structure
- Shorter construction schedule and reduced traffic impact
- Sustainable, long-life bridge preservation solution

The Rainbow Bridge, selected "2007 Project of the Year" by the International Concrete Repair Institute, is an example of modern techniques used to preserve a unique historic structure. This signature bridge identifies a local community, serves as a reminder of past successes, and continues to provide an important gateway for the area.

Bridge preservation techniques and strategies are playing an increasing role in mitigating performance concerns as more than 30% of the nation's 600,000 bridges are near their theoretical 50-year service life. 

Chris Ball is vice president of Vector Corrosion Technologies.



The historic Rainbow Bridge, Valley County, Idaho. Photo: Vector Corrosion Technologies.

Extending Performance

Since 2008, the U.S. Highway Bridge Program provides flexibility for state transportation departments to use federal funds for bridge replacement, rehabilitation, or systematic preventive maintenance. In 2011, the Federal Highway Administration (FHWA) published the *Bridge Preservation Guide: Maintaining a State of Good Repair Using Cost Effective Investment Strategies*.

This guide provides many examples of cost-effective interventions to extend bridge performance through preventive maintenance. Two techniques detailed in this guide are cathodic protection and electrochemical chloride extraction (ECE). Evaluations of existing bridges determine if these preventative maintenance approaches will achieve bridge service life requirements.

Cathodic Protection

Cathodic protection systems can be galvanic or impressed current (ICCP). Galvanic systems use low maintenance sacrificial anodes. These surface-installed systems include: metalized galvanic anodes, galvanic jackets/encasements, and embedded anodes in concrete repairs.

ICCP systems use transformer/rectifiers to deliver protection via inert anodes. The anodes are placed on the surface, placed in sawcuts, encased in overlays and jackets, or grouted into drilled holes.

ECE

Electrochemical treatments passivate active corrosion by providing temporary current that changes the environment around the reinforcing steel. ECE reduces the level of chlorides and increases the pH in chloride-contaminated concrete. This re-alkalization also increases the pH in carbonated concrete

Widening Hazel Avenue Bridge Over American River

by Ali Seyedmadani, Parsons
Brinckerhoff

In 2000, the Sacramento County Department of Transportation (SACDOT) began planning improvements to 2.5 miles of Hazel Avenue from U.S. Highway 50 to Madison Avenue to relieve congestion and improve multi-modal mobility. As part of the Phase I project, the Hazel Avenue Bridge over the American River was widened, multi-use path connectivity was improved, and sound walls and retaining walls were constructed.

The existing bridge over the American River was a 570-ft-long, four-span (127, 157, 157, and 129 ft) reinforced concrete box girder, carrying four lanes of traffic. The project widened the bridge by 37 ft, adding two lanes of traffic and widening the pedestrian sidewalk on both sides of the bridge. The bridge is located 500 ft upstream of the Nimbus Fish Hatchery and 1500 ft downstream of Nimbus Dam on Bureau of Reclamation right-of-way in an environmentally sensitive area. The project was funded with local, state, and federal resources, which required California Environmental Quality Act (CEQA) and National Environmental Policy Act (NEPA) approval.

Project Constraints and Bridge Type

The existing Hazel Avenue Bridge foundations consisted of a spread footing and driven steel pile system. The seismic analysis of the existing bridge indicated deficiencies with the performance of the bridge during a seismic event. The design of the widened structure had to account for the environmental restrictions, limited in-water construction window from June 1st to October 1st, limited access to the site, and the seismic performance deficiencies.

The addition to the existing bridge consisted of 34-ft-long cast-in-place (CIP) concrete pier sections supporting 120-ft-long, 7-ft-deep precast, prestressed concrete bulb-tee beams. The length and stiffness of the CIP pier section was adjusted to minimize the live load differential deflection at the closure between the existing bridge section and the widened section.

The proposed bridge substructure consisted of a single, 15-ft-long, 5-ft-wide oval column supported on a 3-ft-diameter

drilled shaft pile group. The size of oval column was adjusted to create the required stiffness and reduce the seismic displacement demand of the combined structure. This structure type allowed a top-down construction method, met all the environmental constraints, minimized environmental impacts, and limited interaction with the river during construction.

Construction

To meet the environmental constraints and the in-water construction work window, a steel trestle work platform system was used for accessing the site. In addition, sheet pile cofferdams were installed during the in-water work window to segregate the work space from the water. The cofferdams allowed the contractor to work within the constraints of the environmental permit and minimize impacts to the river.

As part of the superstructure construction, 70-ton precast concrete girders were erected using two cranes positioned on the existing bridge. The girder erection operation started on Saturday morning and was completed by Sunday afternoon, requiring only a single weekend road closure. For the aesthetic treatment, wave patterns were cast into the girders using formliners. Similar patterns were utilized in the bridge railing system for the pedestrian and multi-use paths along the bridge, thereby carrying this theme throughout the structure.

Other outstanding project elements included the soil-nail wall systems for reducing project impacts and multi-use pedestrian and bike facilities that improve connectivity to the American River Parkway. This includes a multi-use bridge crossing and emergency vehicle access. This project is an outstanding example of a context-sensitive approach to design that results in a cost-effective, aesthetically pleasing, and environmentally sensitive project. 

Ali Seyedmadani is the senior engineering manager and a bridge engineer with Parsons Brinckerhoff in Sacramento, Calif.



Hazel Avenue Bridge, a context sensitive solution, meeting public expectation and site constraints.

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.willametteriverbridge.blogspot.com

This Oregon Department of Transportation (DOT) blog contains photographs taken during construction of the Willamette River Bridges described on page 36. There is also a link to two webcams.

<http://cce.oregonstate.edu/about/history/mac/index.htm>

The article about the Willamette River Bridges mentions Conde B. McCullough, a former Oregon state bridge engineer. More information about Conde McCullough and his bridges is available at this website.

www.veteransmemorialbridge.org

More information about the Veterans Memorial Bridge in Maine and described on page 32 is available at this Maine DOT website.

www.state.nj.us/transportation/commuter/roads/route52/

Visit this website for more information about the new Route 52 Visitors Center Bridge in New Jersey mentioned in the article on page 16.

http://www.nevadadot.com/projects_and_programs/road_projects/west_mesquite_interchange_design-build_project.aspx

This Nevada DOT website contains information about the West Mesquite Interchange at I-15 design-build project described on page 28.

www.fhwa.dot.gov/bridge/preservation/guide/guide.pdf

The Bridge Preservation Guide mentioned on pages 40 (FHWA article) and 53 (CBP article by Ball) may be downloaded from this website.

www.fhwa.dot.gov/bridge/preservation/

This website provides a toolbox containing bridge-related links on bridge preservation.

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.

Bridge Technology

www.aspirebridge.org

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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.hpcbridgeviews.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.

NEW www.dot.state.fl.us/structures/Innovation/Ubeam.shtm

This Florida DOT website contains information about curved precast spliced U-girder bridges. Links are provided to concept drawings and presentations about Colorado precast girders, development of precast spliced U-beam construction, and PCI Zone 6 standards.

www.fhwa.dot.gov/bridge/abc/docs/abcmanual.pdf

The FHWA report titled *Accelerated Bridge Construction: Experience in Design, Fabrication, and Erection of Prefabricated Bridge Elements and Systems* may be downloaded from this website.

Bridge Research

www.fhwa.dot.gov/research/publications/technical

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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 available from this National Cooperative Highway Research Program website.

NEW www.trb.org/publications/Blurbs/165909.aspx

NCHRP Report 698 titled *Applications of Accelerated Bridge Construction Connections in Moderate-to-High Seismic Regions* evaluates the performance of connection details for bridge members in accelerated bridge construction in medium-to-high seismic regions.

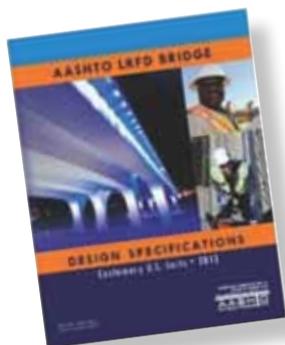
NEW www.trb.org/publications/Blurbs/164866.aspx

NCHRP Report 681 titled *Development of a Precast Bent Cap System for Seismic Regions* explores the development and validation of precast concrete bent cap systems for use throughout the nation's seismic regions.

2012 Interim Changes Related to Concrete Structures



by Dr. Dennis R. Mertz



At the annual meeting of the American Association of State Highway and Transportation Officials (AASHTO) Subcommittee on Bridges and Structures (SCOBs), hosted in May 2011 by the Virginia Department of Transportation (VDOT) in Richmond, Va., the subcommittee considered and adopted four agenda items specifically related to concrete structures. Technical Committee T-10, Concrete Design, developed Agenda Items 51 through 54 over the past several years and moved them to the subcommittee ballot for consideration in Richmond. The agenda items represent revisions and additions to the *AASHTO LRFD Bridge Design Specifications*. This column reviews the 2011 concrete-structures agenda items, which are integrated into the 6th Edition of the *AASHTO LRFD Bridge Design Specifications* published earlier this year.

Agenda Item 51 revises Article 5.5.4.2.1, which specifies resistance factors for conventional construction (as opposed to segmental construction) at the strength limit states. The shear resistance factor for lightweight concrete is increased from 0.70 to 0.80. The original shear resistance factor for lightweight concrete of 0.70, a reduction from the value of 0.90 for normal weight concrete, was introduced during the initial development of the *AASHTO LRFD Bridge Design Specifications* because of a lack of available data to evaluate the statistical variability of lightweight concrete. Research by professor Andy Nowak of the University of Nebraska, Lincoln, based upon statistical evaluation of 8889 lightweight concrete cylinder compression test results from projects across the United States and the comparison of shear test results to shear capacities computed using the General Method of the *AASHTO LRFD*

Bridge Design Specifications, concluded that the resistance factor for shear for lightweight concrete could be increased from its current value of 0.7 to the new value of 0.8.

Through **Agenda Item 52**, provisions and commentary in Articles 5.4.2.6 and 5.7.3.3.2, are revised. The revision in Article 5.4.2.6, modulus of rupture, basically removes the specific modulus of rupture equation for Article 5.7.3.3.2 reverting to the basic equation. The revisions to Article 5.7.3.3.2 replace $1.2M_{cr}$ with a varying coefficient multiplied by M_{cr} . This coefficient is a function of the component's effect on modulus of rupture, the effective prestress, and the ratio of yield to ultimate strength in the prestressing steel. This revision results in a less severe minimum reinforcement requirement for continuous concrete box girder bridges with parabolic post-tensioning, and segmentally constructed concrete box girders because f_{pe} becomes less significant. The agenda item also exempts compression-controlled members from the minimum reinforcement requirement.

Agenda Item 53 adds detailed provisions specific to curved post-tensioned box girder bridges in a new article, Article 5.8.1.5, webs of curved post-tensioned, box girder bridges, and revises other articles to accommodate this addition. These revisions are based upon California's demonstrated success with hundreds of curved post-tensioned, box girder bridges.

The concept of partial prestressing and all the provisions in the *AASHTO LRFD Bridge Design Specifications* relative to it are removed through **Agenda Item 54**. The term "partial prestressing"

has gradually lost its significance since the publication of the *AASHTO LRFD Bridge Design Specifications*, first edition in 1994. Due to the lack of adoption of this concept, the presence of articles about partial prestressing in the specifications is an unnecessary complication.

The AASHTO SCOBs will be meeting this year in Austin, Tex., July 8 to 12, and will be considering proposed revisions for publication in 2013. **A**

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.

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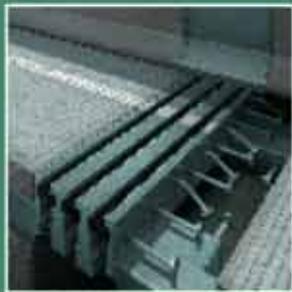


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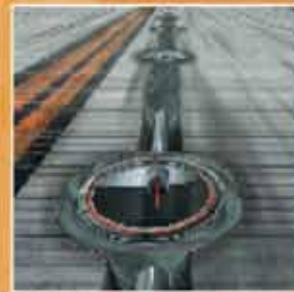
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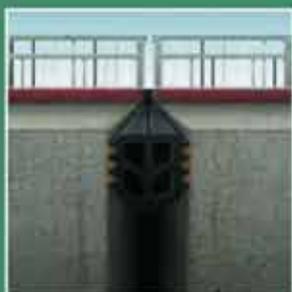
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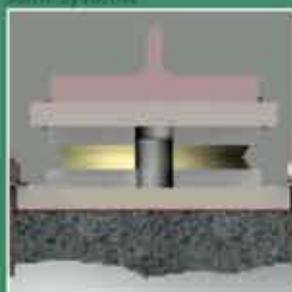
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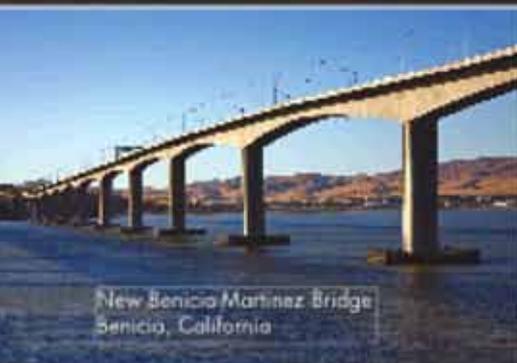
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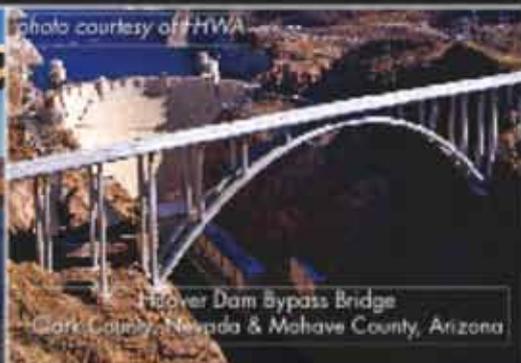
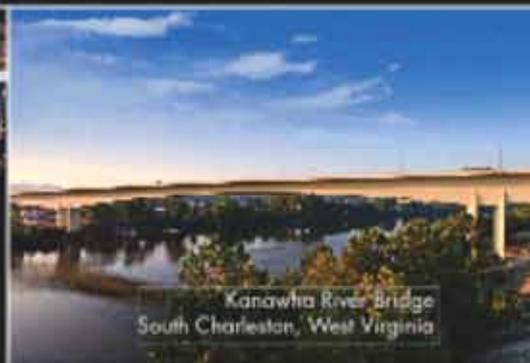


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Hoover Dam Bypass Bridge
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