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THE CONCRETE BRIDGE MAGAZINE

SPRING 2007

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BRIDGE

San Diego County, California

CSX TRANSPORTATION
RAILROAD BRIDGE

Bay St. Louis, Mississippi

MILL STREET BRIDGE

Epping, New Hampshire



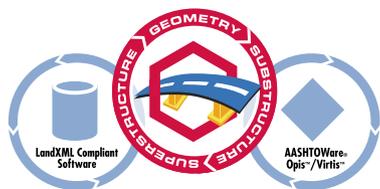


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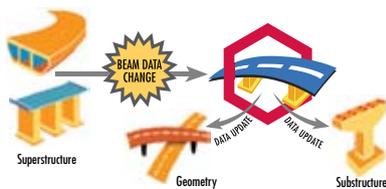
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Welcome Back to *ASPIRE*TM Magazine

John S. Dick, *Executive Editor*

Photo: Ted Lacey
Photography

Welcome back to *ASPIRE*TM Magazine! Your response to the inaugural issue was gratifying. We appreciate the comments and encouragement and have included some of your messages on page 4. Your questions and ideas are always welcomed.

It is obvious from the many messages; there is a strong demand for a magazine devoted to bridges—one written by bridge engineers for bridge engineers.

Concrete bridges play a predominant role in the nation's bridge inventory. Figures for 2003, the latest year available, show that concrete accounted for 74.4 percent of the bridges built that year, based on the surface area of their decks. This confirms the data from previous years. Concrete is clearly the material of choice of designers and the owner agencies.

Whether it is the creation of an aesthetic landmark or the use of high performance concrete to achieve higher performing bridges or the development of modular systems to facilitate very short construction periods, new applications for concrete are continually under development or implementation. The goal of this magazine is

to report the successes of practitioners, providing both inspirational and practical information about concrete bridge design and construction.

Articles in this issue report significant decisions to favor new and impressive concrete bridge solutions on the part of such owners as the Texas Department of Transportation, the New Hampshire Department of Transportation, the CSX Transportation, the Iowa Department of Transportation and the Pennsylvania Turnpike Authority. We believe you'll find these stories interesting and compelling.

I said it in the first issue and I think it's worth repeating again: according to the dictionary, the word *aspire* means to demonstrate "a strong desire for high achievement," to "strive toward an end," to "soar." That definition aptly describes both the ambition of a bridge designer and the mission of this new magazine.

If you have questions about any bridge featured in this issue or about information contained in the state, county, city or LRFD departments, send them to us via the "Contact Us" page of our website, www.aspirebridge.org.

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Cover: Veterans' Glass City Skyway
Toledo, Ohio
Photo: FIGG



Four Bears Bridge
Fort Berthold, North Dakota
North Dakota Department of Transportation
The Three Affiliated Tribes

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FOUR BEARS BRIDGE

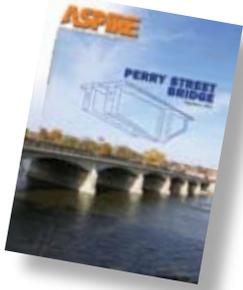
I-76, Susquehanna River Bridge
Near Harrisburg, Pennsylvania
Pennsylvania Turnpike Commission



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READER RESPONSE



"our Civil Engineering Chair [would like to] request 32 complimentary copies of your Winter 2007 magazine . . . There are many articles and information in this magazine that would be particularly relevant for his structures and concrete course students this semester."

University of Portland, Oregon

"I thought the inaugural issue of ASPIRE™ was outstanding! Good job . . .!"

Chuck Prussack PE, Vice-President and General Manager, Central Pre-Mix Prestress Co., Spokane, Wash.

"It is clear that a tremendous effort went into the magazine. It is very tastefully produced."

Dr. Maher Tadros, University of Nebraska, Omaha, Neb.

"I just finished reading the first edition of ASPIRE. [Your team has] put together a wonderful magazine. With the articles all centered [on] the concrete bridge world, it was impossible to put down the magazine until I had gone all the way through it. I can't say this about any other publication I receive. You have a real winner here. I noticed at least a couple of articles involving Wisconsin bridges. Thanks for including them. Overall, the articles covering design, construction and the AASHTO Spec. made for a well rounded presentation. Great work. I look forward to the next issue in a few months."

Finn Hubbard, Wisconsin DOT, Madison, Wisc.

"I just received and thumbed thru the first edition of ASPIRE—well done! Good articles, photos [and] content overall."

Ian M. Friedland, Federal Highway Administration, McLean, Va.

"We learned from a civil engineer about your exciting new magazine. I did submit a request for subscription . . . Thanks."

American Society of Civil Engineers, Reston, Va.

"Congratulations on a great first issue of ASPIRE. It just landed on my desk."

Kimberly Kayler, Constructive Communication, Inc., Dublin, Ohio

"I appreciated the great story on the Hays Kansas bridge. I learned of your website from KSDOT engineers last week and they had seen the story. I am the project manager for King Construction Company and was involved in both the removal of the damaged section and the repair of the structure. I really liked your article and it gave a very good overview of the situation. Thank you again."

Brice Goebel, Hesston, Kan.

"I enjoyed your inaugural issue of ASPIRE magazine. Last year I showed some of my students the damage to the Hall Street Bridge. Now I would like to show them the photos of the repair."

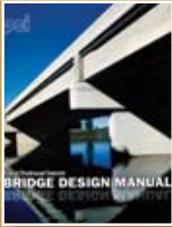
Donald A. Andersen, Civil Engineering Dept., North Dakota State University, Fargo, N. Dak.

"The new ASPIRE magazine is a great job and a welcome addition . . . Many thanks."

Carl S. Buchman, Rochester, N.Y.

The advertisement for Lehigh White Cement features a large, multi-level concrete bridge structure under a clear blue sky. The bridge has several support pillars and overpasses. The text is overlaid on the image. At the top, 'LEHIGH™' is written in a large, bold, white font with a blue outline. Below it, 'WHITE CEMENT' is written in a similar style. Underneath that, 'The White Line in the Sky' is written in a smaller, white font. Below the main text, 'Austin, TX - DOT' is written in a smaller, white font. At the bottom of the advertisement, there is a dark banner with white and yellow text. It says 'For Better Building' in yellow, followed by 'and added safety to your concrete bridges.' in white. Below that, 'LEHIGH WHITE CEMENT™' is written in white. Underneath, '"Increase Reflection Both DAY and NIGHT"' is written in white. At the very bottom, 'Lehigh Cement Company / White Cement Division' is written in white. Below that, the address and phone numbers are listed: '7660 IMPERIAL WAY • ALLENTOWN, PA 18195-1016 • 610-366-4600 • 800-523-5488'. At the bottom right, the website and email are listed: 'Fax 610-366-4638 • www.lehighwhitecement.com • email: info@lehighwhitecement.com'.

BUY BOTH AND SAVE!



Bridge Design Manual

This comprehensive, 1,600-page design manual contained in two loose-leaf binders provides everything you need for the design, fabrication, and construction of bridges using precast, and precast, prestressed concrete products and systems.

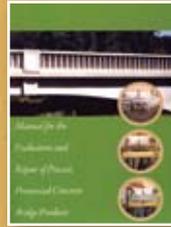
Created by more than 30 expert authors, the two-volume, 16-chapter manual from PCI covers both preliminary and

final design information, including:

- The advantages, durability, speed, and high performance of precast and prestressed concrete bridges
- Design theory, material properties, fabrication, and construction details
- Cost-efficient techniques used by experienced designers
- Complete design examples, including solutions using both the AASHTO Standard Specifications and the LRFD Specifications
- Continuity considerations, seismic requirements and spliced-beam innovations

Additional chapters cover aesthetics, bearings, curved and skewed bridges, seismic design, railroad bridges, load rating procedures, deck panels, and other bridge products. Periodic updates, revisions, and additions will be available.

Bridge Design Manual (PCI MNL-133-97) is available for \$490, with a 50 percent discount for PCI members.



Bridge Repair Manual

Damage or defects can occur during early stages in the plant, in transit or during erection of a beam, deck panels, or similar precast products. This manual was developed for the purpose of promoting a greater degree of uniformity among owners, engineers, and industry, with respect to the evaluation and repair procedures for precast, prestressed bridge-related concrete products.

Manual for the Evaluation and Repair of Precast, Prestressed Concrete Bridge Products (PCI MNL-137-06) (8½ x 11, softcover, 76pp) is available for \$50, with a 50 percent discount for PCI members.

Buy both books together and save! Now through Aug. 31, 2007, order both books together and pay only \$459 (just \$229 for PCI members!) That's a savings of 15% off the regular price!

To order, visit the PCI Bookstore at www.pci.org/publications/store. Or call (312) 786-0300 to place your order and ask about becoming a PCI member to save even more!



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Portland Cement Association

Seminar on LRFD Design

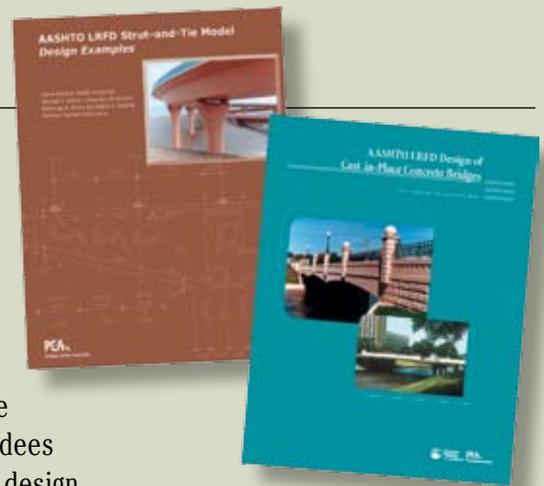
FHWA's deadline for the full implementation of LRFD is fast approaching. To help bridge engineers satisfy the FHWA requirement, PCA will conduct a one-day seminar on the design of concrete bridges by the AASHTO LRFD Bridge Design Specifications. The seminar will take place on Friday, May 25, 2007, at PCA's office in Skokie, Ill. Seminar attendees will be awarded 6.5 CEUs and will receive two PCA publications on LRFD design.

The seminar will cover the latest revisions to the AASHTO LRFD Bridge Design Specifications. Emphasis will be placed on the unified method of design for reinforced and prestressed concrete, shear design utilizing modified compression field theory and strut-and-tie modeling. Design examples for deck design; pier cap design; and precast, prestressed concrete girder design highlighting the key steps in LRFD will also be presented.

Registration Questions?

Contact: Caron Johnsen • (847) 972-9058 • cjohnsen@cement.org

To download the registration form, visit www.cement.org/bridges.



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



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



Mary Lou Ralls is Principal of Ralls Newman, LLC. She joined the Texas Department of Transportation in 1984 and was the State Bridge Engineer and Director of the Bridge Division from 1999 to 2004.

Stanley W. Woods worked for the Wisconsin Department of Transportation for 42 years and was the State Bridge Engineer before his retirement.

George D. Nasser is Editor Emeritus of the *PCI JOURNAL* where he has worked for 35 years.

MANAGING TECHNICAL EDITOR



Photo: Ted Lacey Photography

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

CONCRETE CALENDAR 2007

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

April 16-17

ASBI Grouting Certification Training
University of Texas at Austin,
JJ Pickle Research Center, Austin, Tex.

May 18

PCI Bridge Design Awards Entries due

May 6-8

PTI Annual Conference
Radisson Hotel Downtown, Miami, Fla.

May 7-11

World of Coal Ash
Covington, Ky.

May 7-11 Level I, Level II, and Level III

PCI Quality Control & Assurance Personnel Training & Certification Schools
Embassy Suites, Nashville, Tenn.

May 14-15

ASBI Seminar on "Design & Construction of Segmental & Cable-Supported Concrete Bridges"
Red Lion Hotel, Seattle International Airport, Seattle, Wash.

May 22-24

NRMCA Concrete Technology Forum—Focus on High Performance Concrete
Fairmont Hotel, Dallas, Tex.

June 4-6

International Bridge Conference (IBC) & Exhibition
Includes ASBI Seminar on "Construction Practices for Segmental Concrete Bridges"
Hilton Pittsburgh, Pittsburgh, Pa.

July 8-12

AASHTO Subcommittee on Bridges and Structures Meeting
Also ASBI Executive Committee Meeting, July 8; ASBI Board of Directors Meeting, July 8
ASBI-AASHTO 19th Annual Reception, July 9
Hotel DuPont, Wilmington, Del.

August 1

ASBI Bridge Award of Excellence Competition Entries due

August 6-11 Level I, Level II, and Level III

PCI Quality Control & Assurance Personnel Training & Certification Schools
Embassy Suites, Nashville, Tenn.

August 12-17

AASHTO Subcommittee on Materials Annual Meeting
Crowne Plaza Hotel, Denver, Colo.

September 23-26

Western Bridge Engineers' Seminar & Exhibition, Boise, Idaho

October 14-18

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

October 22-24

National Concrete Bridge Conference and PCI Annual Convention & Exhibition
Includes meeting of AASHTO Technical Committee on Concrete Design (T-10)
Hyatt Regency Phoenix/Phoenix Civic Plaza Convention Center, Phoenix, Ariz.
Abstracts for papers being accepted until April 6.

November 4-6

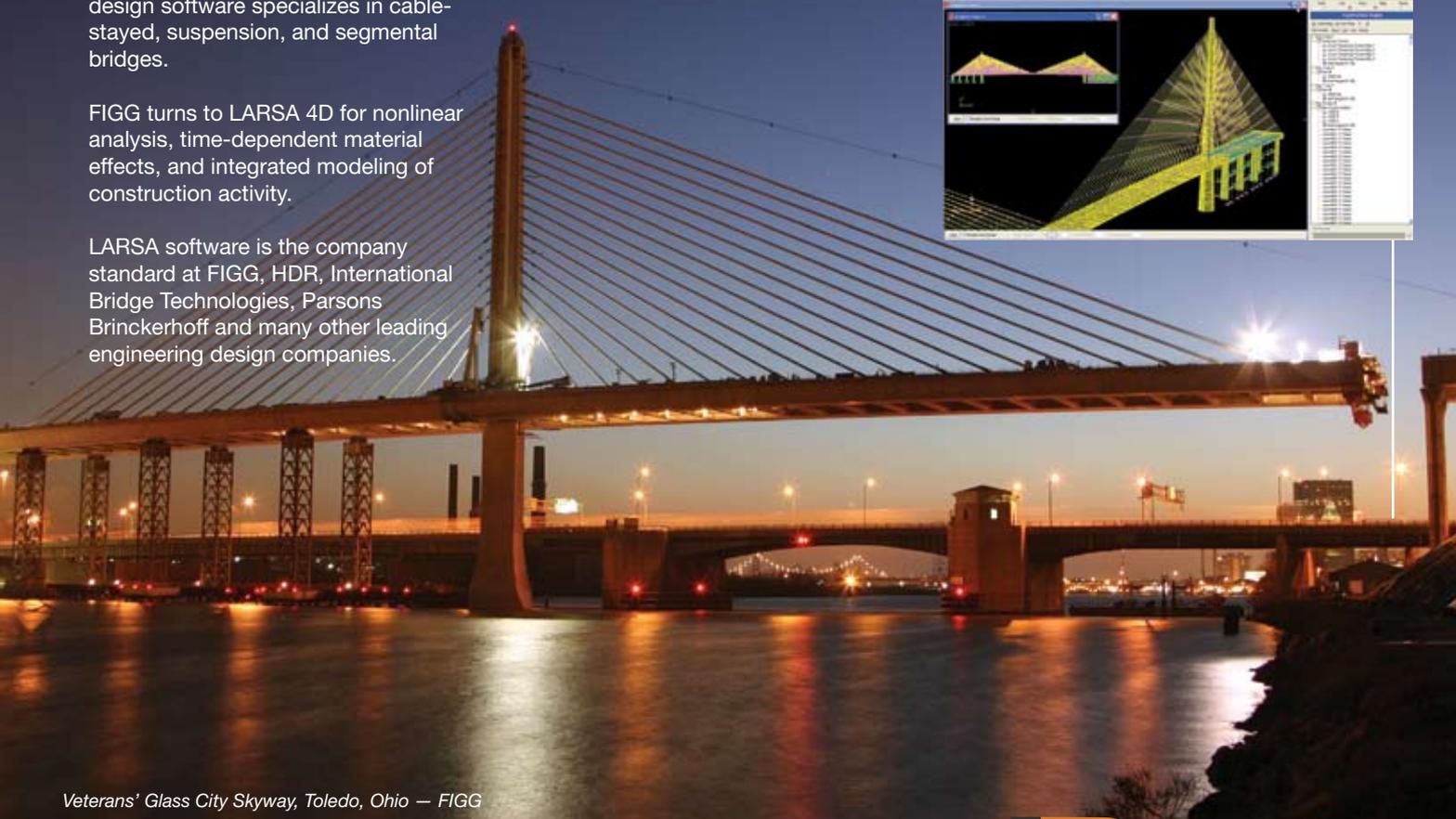
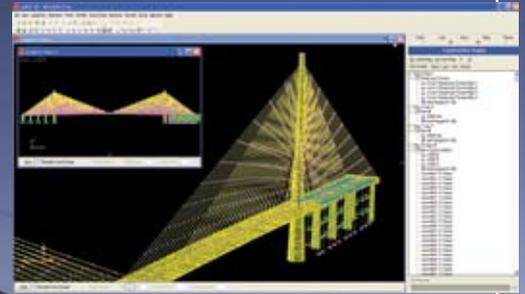
ASBI Annual Convention and Exhibition
Includes ASBI Board of Directors meeting, November 7
Includes meeting, AASHTO Technical Committee on Concrete Design (T-10)
The Orleans Hotel, Las Vegas, Nev.

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Veterans' Glass City Skyway, Toledo, Ohio — FIGG

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BRIDGES

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

ANALYSIS

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

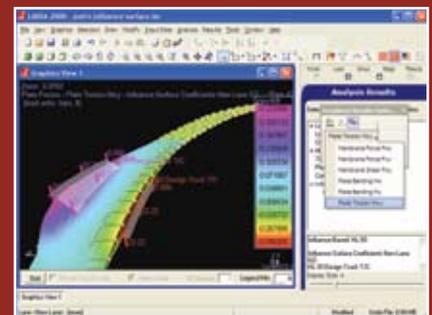
DESIGN

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

CONSTRUCTION

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

Susquehanna River Bridge, I-76, Pennsylvania — FIGG



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Blue Ridge Parkway
Viaduct around
Grandfather
Mountain,
North Carolina



FIGG Envisions

Concrete **FUTURE**

By Craig A. Shutt



FIGG has designed three of the five bridges to receive the Presidential Award for Design Excellence. One is the Sunshine Skyway Bridge across Tampa Bay, Florida.

Figg Engineering Group (FIGG) has become well known for its dramatic use of concrete to expand the material's capabilities and create distinctive structures. Its designs for a variety of concrete segmental bridges throughout America have shown that concrete's full capabilities are still being developed. The material's future, much like FIGG's own, is even brighter than its past has been, says the company's leader.

"The future of concrete segmental bridges is bright," says Linda Figg, President and CEO of the firm. "It provides the most cost-effective alternative for owners and offers great advantages in construction efficiency, durability, design innovation, and aesthetics." A majority of the company's bridge designs today feature concrete segmental components, she notes. "We are known as the leader in concrete segmental bridges and have designed more concrete cable-stayed bridges that have been built in the United States than any other firm."

The key to success since Gene Figg opened the firm's doors in 1978 has been to embrace concrete and fully use its capabilities. "The FIGG companies began with a vision and commitment to exclusively specialize in bridges," notes Figg. "Our vision continues, as we extend proven technology, especially in segmental and cable-supported bridges, to create better bridges for the future. We combine functionality

with distinction and constructability with aesthetic appeal, to create bridges that celebrate the connections between people and provide an uplifting visual experience."

The firm has grown right along with advances in concrete, she notes, and has helped spur those improvements as well. "When we opened, we began introducing concrete segmental bridges to the United States, particularly for medium- and long-span bridges, which prior to then had been constructed mostly with steel." That growth was aided by the Federal Highway Administration requiring competition of materials, she notes. "By creating the availability of alternative design concepts, they opened the door to better and more cost-efficient designs. That competition, in turn, drove the steel industry to be more economical, too, benefiting everyone."

The demand has grown since then, she adds. "Over the last 15 years, interest in signature bridges has greatly increased. The pleasing aesthetics of our designs and the public-design charette process we developed have allowed us to help many communities achieve their vision for a world-class structure. Concrete is the preferred material for creating bridges that express themes with various shapes and aesthetic features."

Linda Figg has been a strong participant in the company's growth, joining

Bridge specialty firm creates dramatic concrete landmarks and expects 'revolutionary' nature of material to bring even more advances



The Natchez Trace Parkway Arches, Tennessee. All photos in this article courtesy of FIGG

her father's firm just four years after it opened, following her graduation from Auburn University with a civil engineering degree. Figg worked with her father for 20 years before being named President/CEO in March 2002. She was responsible for operating the company for the previous 10 years, helping their team of bridge specialists create many bridge firsts and industry records.

Timeless Works of Art

"FIGG's designs are a decisive demonstration of the constructability, efficiency, and economy of precast concrete segmental construction," she says. Our engineers pride themselves on the fact that they are "as focused on aesthetic achievement as they are on cost- and time-saving innovations." Throughout the years, she notes, "our vision has been to create bridges as timeless works of art that reflect the natural environment and the spirit of the community they serve."

Use of concrete continues to increase, she adds. "Owners are very focused on economy and long-term value today. They want structures that will last 150-plus years. Life-cycle costs are very important. As a result, concrete is a very attractive material for owners." Concrete segmental bridges in particular offer a number of benefits to owners

in addition to initial economy and life-cycle costs, she stresses. "The majority of the bridges we design are concrete, because our customers recognize the many benefits of the material."

Among the key benefits is the ease and economy of long-term maintenance, particularly in coastal environments and restrictive sites. Concrete's durability and low-maintenance features make it an attractive choice for many owners. "Concrete segmental bridges have repeatedly proven their strength and endurance when tested by extreme natural forces," she says.

A number of the company's bridges built in sensitive locations around the Gulf Coast and East Coast have been the proof. They include the Dauphin Island Bridge near Mobile, Alabama, which won a Precast/Prestressed Concrete Institute (PCI) Design Award in 1983, and the Varina Enon Bridge over the James River in Richmond, Virginia, which was named one of the "12 Most Spectacular Bridges in America in 1995" by the American Council of Engineering Companies. Both have survived extreme weather events, as have all FIGG designed bridges along the southeastern U.S. and Gulf coasts during the recent severe hurricane seasons, Figg notes.

A History of Awards

With numerous "signature" bridges to its credit throughout America, FIGG focuses as much attention on aesthetic achievement as on cost- and time-saving innovations. "Our vision is to create bridges as timeless works of art that reflect the natural environment and the spirit of the communities they serve," says President/CEO Linda Figg.

In testament to that approach, FIGG's bridges have earned more than 250 awards, including three of the five bridges that have been honored with the Presidential Award for Design Excellence through the National Endowment for the Arts: The Sunshine Skyway Bridge across Tampa Bay, Florida; the Blue Ridge Parkway Viaduct around Grandfather Mountain, North Carolina; and the Natchez Trace Parkway Arches in Tennessee. All three are precast concrete segmental bridges.

In 2006, *Roads & Bridges* magazine named their top 25 bridges of all time, which included six designed by FIGG. Only 14 of the projects named were designed since 1978, when FIGG opened its doors.



Tex Hall, Chairman of the Mandan, Hidatsa and Arikara Nation, at the Four Bears Bridge dedication.

Two members of the Three Affiliated Tribes pose with a Four Bears Bridge sidewalk monument (Below Right).



The Four Bears Bridge in North Dakota, a 15-span precast concrete segmental bridge in North Dakota, celebrates the culture of the local Three Affiliated Tribes. The project was the first in the state to use post-tensioned precast concrete segmental construction (Main Photo).

Four Bears Bridge symbol at pier (Inset Photo).



'Over the last 15 years, interest in signature bridges has greatly increased.'

Four Bears Bridge

A recent example of a design that combines functionality with strong aesthetics is the Four Bears Bridge at Fort Berthold Indian Reservation in North Dakota. The 4500-ft-long bridge was designed to celebrate the culture and history of the Three Affiliated Tribes, while meeting highly functional needs as the primary crossing point of Lake Sakakawea. The bridge serves as a replacement structure for a historically significant bridge, and the new design had to reflect the local culture and be in context with the site.

The variable depth, precast concrete, segmental bridge features 15 spans, typically 316 ft long. The bridge was constructed using the balanced cantilever method. Cranes mounted

on barges lifted the pier segments. Two beam and winch travelers lifted the other segments. The abutments connect to the superstructure via an expansion joint on each end, the only such joints in the bridge. The structure was aesthetically connected to the local area through symbols along the bridge's pedestrian walkways. Cultural symbols are showcased on the exterior sides of the spans above the piers, and these were highlighted with accent lighting to create nighttime aesthetics.

The bridge, the largest ever in North Dakota, was the first in the state to use post-tensioned, precast concrete segmental construction. It opened to traffic in September 2005, and in its first year of operation, received nine awards from state and national groups.

Span Lengths Increase

As materials and construction technologies have advanced, so have the lengths that precast concrete segmental main spans can achieve using the balanced cantilever method, Figg notes. The company continues to expand its use of this design through projects such as the Sagadahoc Bridge in Maine. Finished in 2000, it features a main span of 420 ft consisting of two-cell precast box girder segments. Its length surpassed the 400-ft U.S. record previously set by the Dauphin Island Bridge, and that record was broken again in 2004 with the Victory Bridge in New Jersey.

The Victory Bridge, a 3971-ft-long, \$109-million structure, features a fully match-cast precast concrete main span of 440 ft with side spans of 330 ft each. The bridge carries traffic 110 ft above the Raritan River between Perth Amboy and Sayreville, replacing a 1927 steel-swing bridge. To expedite construction, the approach spans were erected using the span-by-span method simultaneously with the balanced cantilever main span. Precast piers up to 100 ft in height were erected in one day. The first of the twin structures was opened to traffic in only 15 months, with the second structure erected in just nine months. The project has received 13 awards for innovation, quality, and aesthetics.

Concrete Offers Environmental Sensitivity

Environmentally sensitive areas are easily addressed by concrete segmental bridges, Figg says. This capability has become more prized in recent years, as communities focus on maintaining the beauty of their areas, as they realize how long it can take for the natural environment to bounce back if damaged during construction.

An example of this type of environmentally sensitive construction can be seen in the I-70 Hanging Lake Viaduct completed in Glenwood Canyon, Colorado. The viaduct carries the highway across the Colorado River through a narrow portion of the canyon. FIGG's design, developed for efficient construction to meet the challenging site conditions, resulted in the \$34-million bridge being completed 5 months ahead of schedule.

Concrete segmental bridges have repeatedly proven their versatility during construction in environmentally sensitive areas.

The design focused on preserving the sensitive environment of the canyon, Figg explains. An overhead gantry was used to construct 8429 linear feet of precast concrete segmental bridges in balanced cantilever, with typical 200-ft-long spans that extended to 300 ft over the Colorado River. The firm's use of temporary straddle bents allowed work to continue over active traffic on U.S. Route 6, which flowed a few dozen feet beneath the construction. Once all traffic moved to the new elevated structure, permanent piers were centered under it, and the temporary bents were removed to create consistency of appearance for the bridges.

Design for the I-70 Hanging Lake Viaduct in Glenwood Canyon, Colorado, minimized its impact on the environment by using an overhead gantry to erect the precast concrete segments. Traffic continued beneath the construction until the project was completed.



More on FIGG

FIGG's design of the Pennsylvania Turnpike's bridge over the Susquehanna River is featured on page 34 of this issue of *ASPIRE*.™

The firm's design for the Penobscot Narrows Bridge & Observatory in Maine was featured in the Winter 2007 issue. FIGG also designed the concrete cable-stayed spans of the Leonard P. Zakim Bunker Hill Bridge, over the Charles River in Boston that was featured in the HNTB profile in the Winter 2007 issue. Both articles can be viewed at www.aspirebridge.org.

To learn more about other bridges FIGG has completed, visit www.figgbridge.com.



The design for the Lee Roy Selmon Crosstown Expressway in Tampa, Florida, shows the capabilities for concrete designs in tight urban spaces. Three reversible lanes were erected span by span in the highway's median using single piers only 6 ft wide at the base.

Photo: FIGG

Concrete bridges can be adapted to meet the community's vision.

Urban Designs Proliferate

The urban environment also can be handled easily with precast concrete segmental designs, Figg notes. "Precast concrete offers a significant and growing competitive advantage through its ability to be constructed in congested urban corridors, with erection next to and over traffic, while keeping traffic moving," she says.

One of the most dramatic examples of what can be achieved even with highly restrictive access is the recent work on the Lee Roy Selmon Crosstown Expressway in Tampa, Florida. Three reversible lanes were erected span-by-span within the median of the highway on single piers only 6 ft wide at the base. The 5.13-mile-long bridge, which opened this past July, more than doubled the tollway's capacity within the existing right of way, while maintaining essential traffic.

"Aesthetics on the new bridge were planned to provide drivers on the existing lanes with a pleasing visual experience," Figg notes. During the planning phases, the Tampa Hillsborough Expressway Authority stressed to the public that aesthetics would be a key criterion. "The

project received overwhelming support, largely based on the commitment that the project would be attractive," she says.

The result was a bridge with curved superstructure box girders, curved tapering piers, and typical open spans of 142 ft that were erected in as little as 2½ days. A concrete sealer was used to add a uniform color in keeping with the site. "As a 'sculpture in the sky,' the colors reflect soft hues of the sky," Figg explains.

Transit Projects Expand

Transit projects of all types are proliferating, she notes. FIGG designed the first precast concrete segmental bridge for use in mass transit for MARTA in Atlanta, Georgia, in the early 1980s. One of the most recent prominent projects is Airtrain JFK, the shuttle train to and around JFK International Airport in Jamaica, New York. The 9-mile-long bridge included constructing 12,144 linear ft of bridge in the median of the Van Wyck Expressway in just 11 months. Construction took place while 160,000 vehicles passed by each day.

Span-by-span construction was used for



Precast concrete offers a significant advantage through its ability to be constructed in congested urban corridors.

90 percent of the project, with balanced cantilever construction used for tight horizontal curves or where span lengths were longer. The project comprised 5409 precast concrete segments, the most for any segmental bridge in the United States. Span lengths ranged from 51 to 150 ft, with a typical length of 125 ft. The entire 9-mile superstructure was erected in 20 months—and was completed two months ahead of schedule. The project later won the prestigious Dr. W. W. Hay Award for Excellence from the American Railway Engineering & Maintenance of Way Association, along with a dozen other honors and awards.

Cable-Stayed Designs

Concrete bridges continue to offer innovative applications that stretch the material in new directions, and that can be seen in the growth of cable-stayed bridges, Figg says. The I-280 Veterans' Glass City Skyway being constructed in Toledo, Ohio, she notes, "offers an outstanding illustration of innovation in precast concrete segmental bridges."

The unique cable-stayed structure carries I-280 over the Maumee River. The top 196 ft of the 404-ft-tall pylon features four sides of specially engineered glass with concrete, which will be illuminated by internal LED lights to produce a spectrum of vivid colors. The aesthetic feature was selected by community participants in design workshops as a tribute to the area's glass manufacturing history.



To create the slender concrete pylon shape and use a single plane of stays as desired by the community representatives, designers created and patented a cradle system that carries the stays through the pylon, eliminating the need for anchorages in the pylon. The cradle simplified construction while providing the opportunity for selective removal, inspection, and replacement of stays throughout the life of the bridge, even as the bridge carries traffic. The cradle also allows for stays to be larger than previously used on cable-stayed bridges. The largest stays on the project are an increase of 70 percent and use 156 strands—the largest in the world.

The bridge design also relies on precast delta frames, weighing up to 87.5 tons. They are placed in the box girders to transfer the weight of the superstructure to the single plane of stays. The bridge features a single pylon, with twin 612-ft-long, cable-stayed spans on either side.

A 9-mile-long bridge was erected in the median of an expressway for Airtrain JFK in just 20 months. The bridge features the most precast concrete segments (5409) of any segmental bridge in the United States.



The new Veterans' Glass City Skyway in Toledo, Ohio, is a cable-stayed structure that features an illuminated pylon and an innovative cradle system that carries the stays through the pylon, eliminating the need for anchorages in the pylon.

Community involvement, as seen in a number of these projects, has been enhanced by the creation of FIGG's Bridge Design Charette™ process, which engages owners and the public in selecting features. Between 20 and 100 community participants meet for a day to cover possible solutions, and then vote their preferences. Various key topics are presented by the designers, with multiple options offered. The participants score their preferences, and FIGG's designers use these for inspiration in capturing the local vision for the aesthetics.

Such local involvement is only one of the growing needs that owners have for ensuring they create functional, economical, and community-pleasing projects. "Bridge owners have always needed, and will continue to need, bridges that are economical and quickly constructed with minimal traffic disruption and sustainability for a 150-year-plus service life," says Figg. "Concrete bridges offer all those benefits, plus each bridge can be adapted to meet the community's vision."

Owner's needs have definitely expanded, she adds. "The biggest challenge today is the current construction market, which is characterized by a shortage of contractors that want to build large bridge projects, along with higher

material prices." The ability of precast concrete to create repetitive shapes in an economic fashion meets the need for constructible details.

"When those designs are used, more local contractors with the knowledge of regional labor and materials markets can participate in major bridge projects," she says. "This increases competition and reduces construction costs." A recent example is the cable-stayed Penobscot Narrows Bridge & Observatory in Maine, which was highlighted in the Winter 2007 issue of *ASPIRE*.™ "Even though neither contractor in the joint venture previously had built a cable-stayed bridge, they successfully completed the concrete segmental bridge, with a 1161-ft-long main span on time."

Figg expects to see such an expansion of the market continue, with FIGG being an industry leader. "More than any other construction type, concrete segmental bridges provide an unequalled opportunity to marry engineering and art, the utilitarian and ethereal, and the intellect with the human spirit," she says. "The fruit of such unions are elegant, functional sculptures that inspire universal feelings of awe and pride."

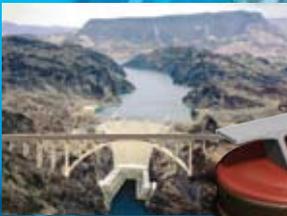
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HIGHLIGHTS:

TOUR HOOVER DAM BRIDGE BYPASS AND THE 2007 BRIDGE AWARDS OF EXCELLENCE



A FULL CONVENTION BROCHURE MAY BE OBTAINED ON THE ASBI WEBSITE WWW.ASBI-ASSOC.ORG.



PTI's Bridge Activities

Established in 1976, the Post-Tensioning Institute (PTI) is recognized as the worldwide authority on post-tensioning and is dedicated to expanding post-tensioning applications through marketing, education, research, teamwork, and code development while advancing the quality, safety, efficiency, profitability, and use of post-tensioning systems.

PTI's bridge activities include:

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

The *PT Journal* is published semiannually and often includes papers on durability and bridge design. PTI also sponsors an annual technical conference to showcase the latest in post-tensioning technology. The next conference will be held in Miami, Florida, on May 6-8, 2007.

For more information on PTI, please visit www.post-tensioning.org.



Accelerated Bridge CONSTRUCTION

by Mary Lou Ralls

Accelerated bridge construction includes both the replacement of existing bridges and the construction of new bridges. Innovative design and construction methods and high performance materials are used to reduce the typical bridge construction timeline without sacrificing bridge quality. The goal of accelerated bridge construction is to open a cost-effective, long-lasting bridge to traffic with increased safety and reduced traffic disruption in a shortened construction period.

Delivering projects quickly to improve safety and reduce congestion is now the priority on many of today's bridge construction projects across the country. This trend is increasing. Improved safety is needed to avoid injury to construction crews in the work zone and to motorists as they move through the growing number of work zones. Reduced congestion is needed to provide reliable travel times for motorists and emergency response teams and to avoid negative economic impact to surrounding businesses. Rapid delivery of both emergency and planned bridge construction projects ensures that people and goods continue to be efficiently and effectively moved across cities, counties, regions, states, and bordering countries.

In addition to delivering bridge projects more quickly, the need exists to deliver bridges that last longer. Almost a quarter of the nation's 595,000 publicly owned vehicular bridges are currently structurally deficient or functionally obsolete¹ at a time when the average age of the bridge inventory is approaching its design life. This state of the nation's bridges requires bridge professionals to pursue design and construction materials and methods that extend the service life of bridges to 100 years and that reduce maintenance requirements during this extended life.² To obtain longer life with improved performance, bridge owners increasingly specify the use of high performance

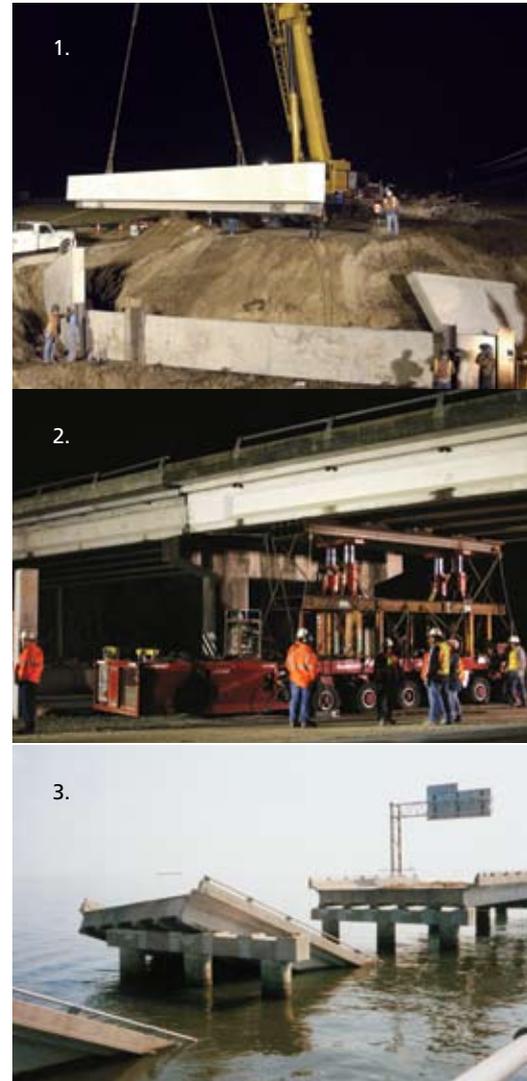
materials, including conventional strength and high strength, high performance concrete, as the standard for accelerated bridge construction projects.

Accelerated bridge construction encompasses the entire process from planning through construction. Planning and preconstruction activities may include:

- early meetings between the owner, contractors not bidding on the project, and suppliers to discuss possible innovations;
- right-of-way acquisition and utility relocations before advertisement of the project;
- early environmental clearance and permitting;
- innovative contracting strategies such as A+B bidding, lane rental, and incentive/disincentive clauses in the contract documents;
- electronic shop drawing submittal and approval process;
- procurement of prefabricated products, such as prestressed concrete girders before advertisement of the project;
- stockpiling of standardized components.

Design activities may include prefabrication of bridge components or the entire bridge. In addition, geotechnical engineering enhancements, such as mechanically stabilized earth walls instead of conventional cantilever retaining walls, may be included. Reinforced or lightweight backfills may also be used.

Construction activities may include allowing contractors to adopt innovative ideas, use innovative equipment, and perform concurrent on-site engineering operations. Innovative equipment includes self-propelled modular transporters (SPMTs) to move the entire bridge into place. Concurrent operations can include building abutments and intermediate supports simultaneously.



Bridge prefabrication is an accelerated bridge construction method in which the bridge components or the entire bridge are built in an off-site or nearby controlled environment. This helps achieve quality construction. The components or entire bridge are then moved to the final bridge location for rapid installation. A decision-making framework to assist owners in determining whether prefabricated bridges will provide benefits for their specific project is available on the Federal Highway Administration (FHWA) website.³

Because of the success of accelerated bridge construction projects to date, the FHWA has increased its support efforts and resources to further advance the development of these systems into more conventional practice nationwide. Aspects of accelerated construction may be included in any concrete



New Jersey's first concrete segmental bridge, the Victory Bridge, has precast segments in both superstructure and piers to accelerate construction.

bridge project, whether cast-in-place, reinforced concrete; cast-in-place, post-tensioned concrete; precast, reinforced concrete; precast, pretensioned concrete; or precast, post-tensioned concrete. Most bridge projects have components of more than one concrete bridge technology. The determination of the most appropriate technologies depends on project time requirements, site constraints, and availability of the technology and the related expertise. Examples of accelerated bridge construction projects in each concrete technology are described below. Both emergency replacement projects and planned rapid construction projects are included.

Cast-in-Place, Reinforced Concrete Bridges

Cast-in-place, reinforced concrete may be the most expedient technology for some emergency construction projects. An example is the Hall Street Bridge over I-70 emergency replacement project near Hays, Kansas, described in the Winter 2007 issue of *ASPIRE*.⁴ In this project, the 45-ft-long section of the 76-ft-long bridge span that was damaged by an over-height load was replaced with the same cast-in-place box section design as the original structure, allowing the bridge to be reopened in less than six months.

Photos Far Left

1. Colorado's totally precast single-span bridge, the State Highway 86 Bridge over Mitchell Gulch, was installed over a weekend in 46 hours.

2. Each span of Florida's Graves Avenue Bridge over I-4 was installed in a few hours using self-propelled modular transporters.

3. Collapsed spans on the I-10 bridge. Photo courtesy of HPC Bridge Views, No. 44.

Cast-in-Place, Post-Tensioned Concrete Bridges

Cast-in-place, post-tensioned concrete is used in the substructures of some bridge projects that are accelerated in other ways as described in the introduction. This concrete bridge technology is not typically used for bridge superstructures on accelerated construction projects because of the extended time in traffic required for the sequential on-site construction processes of erecting formwork for the superstructure, placing steel cages and post-tensioning ducts, placing the concrete, curing the concrete before post-tensioning, and removing formwork.

Approximately 85 percent of California's bridge inventory currently consists of cast-in-place, post-tensioned, concrete box girder bridges. California uses incentive/disincentive clauses developed from lane mile rental rates and other factors, as well as A+B bidding on selected projects. These acceleration techniques were first used shortly after the 1994 Northridge Earthquake for cast-in-place, post-tensioned concrete bridges. A+B bidding has been successful in accelerating construction projects for both precast and cast-in-place, post-tensioned projects.

Precast, Reinforced Concrete Bridges

Precast, reinforced concrete is used for abutments and pier caps on an increasing number of bridges that require an accelerated construction schedule.

A deck girder with railing attached at the precast plant is lowered into position on State Highway 86 Bridge over Mitchell Gulch.



An example with precast abutments is the Colorado Department of Transportation's State Highway 86 Bridge over Mitchell Gulch replacement project.⁵ In 2002, the original 40-ft-long, 26-ft-wide, two-span deteriorated timber bridge was replaced with a 40-ft-long, 43-ft-wide single-span precast, pretensioned concrete slab superstructure and totally precast reinforced concrete abutments. Prior to the bridge closure, steel H piles were driven just outside the existing roadway width. The 44-ft-wide precast abutments and 23-ft-long precast wingwalls with embedded steel plates were erected by crane and welded to the steel H piles and to each other. This was followed by placement of flowable backfill. The

contractor initiated the field change to precast concrete construction to shorten the on-site construction time and to reduce the construction crew's exposure to traffic in the work zone. The use of precast abutments allowed the bridge to be constructed over a weekend, and opened 46 hours after closure.

A bent cap example is the Texas Department of Transportation's State Highway 66 Bridge over Lake Ray Hubbard replacement project.⁶ In 2003, the narrow two-lane bridge was replaced with a pair of bridges. The 4360-ft-long, 40-ft-wide eastbound bridge includes 43 identical precast, reinforced concrete caps on cast-in-place columns. The contractor initiated the field change

from the planned cast-in-place caps to improve the construction crew's safety while working over water and adjacent to high-voltage transmission lines. The change to precast caps also saved nine months on the construction schedule.

Precast, Pretensioned Concrete Bridges

Examples abound for rapidly constructed precast, pretensioned concrete bridges. For example, since the Northridge earthquake, Caltrans has moved more toward employing precast, pretensioned concrete girder superstructures in emergency situations to reduce potential jobsite delays and allow concurrent construction activities. Two recent Caltrans' examples are the emergency replacement of the Russian River Bridge on State Route 128 in Sonoma County and 12 bridges on I-40 in the Mojave Desert. Current research related to seismic concerns will likely further advance the use of precast members for accelerated bridge construction in California.

The conventional precast, prestressed concrete bridge consists of superstructures with pretensioned concrete beams and cast-in-place decks, a technology that has been used extensively in the United States since the 1950s. At the other extreme is an accelerated bridge construction technology that cuts on-site construction



Completed section of Graves Avenue Bridge over I-4.



time to a small fraction of conventional construction time: the use of SPMTs to quickly remove or install entire bridges.

In early 2006, the Florida Department of Transportation demonstrated the use of SPMTs to remove two 71-ft-long, 30-ft-wide spans of the Graves Avenue Bridge that crossed I-4 northeast of Orlando, Florida. Each removal required less than one half hour.⁷ Six months later, following the widening of I-4 and the construction of two 143-ft-long, 59-ft-wide spans in a nearby staging area, the SPMTs were again used to install the new spans. Each new span consisted of eight 78-in.-deep Florida pretensioned concrete bulb-tee beams with an 8-in.-thick reinforced concrete deck, and weighed 1300 tons. The interstate was closed for only a few hours for the installation of each span. Use of the SPMTs reduced the Graves Avenue closure from 12 months to eight months and reduced the I-4 lane closures from 32 nights to four nights. Total delay-related user cost savings was estimated to be \$2.2 million.

Emergency construction can also be streamlined with the use of conventional precast, pretensioned concrete girder bridge spans in combination with

innovative contracting strategies and innovative construction equipment. This was demonstrated in both the rehabilitation of the I-10 bridges across Escambia Bay in Florida following Hurricane Ivan in 2004⁸ and the rehabilitation of the I-10 bridges across Lake Pontchartrain in Louisiana following Hurricane Katrina in 2005.⁹ Significant incentives/disincentives encouraged innovation. Modular transporters, cranes, and barges were used on both projects to quickly re-open the bridges to traffic.

This issue of *ASPIRE* includes three articles on precast, pretensioned concrete projects: the Mill Street Bridge over the Lamprey River in Epping, New Hampshire; the CSX Transportation heavy freight railway bridge across Bay St. Louis in Mississippi; and an Iowa precast concrete approach slab project.

Precast, Post-Tensioned Concrete Bridges

Full-depth bridge decks, girders, segmental superstructures, and sub-structures may be constructed of precast, post-tensioned concrete to accelerate construction. Several examples are described below.

Following Hurricane Katrina, self-propelled modular transporters and barges were used to realign I-10 spans on Lake Pontchartrain in record time. Photo courtesy of Mammoet.

In 1998, the National Park Service's bridges over Dead Run and Turkey Run on the George Washington Memorial Parkway were rehabilitated with new full-depth precast post-tensioned concrete deck panels.¹⁰ The decks were replaced at the rate of one span per weekend, with no weekday impact to commuters traveling between the states of Virginia and Maryland and Washington, D.C. The bridge was closed on Friday evening. The existing deck was saw cut into transverse sections that included the barriers. The old sections were removed and the new panels placed. Longitudinal post-tensioning strands were stressed after all panels in the span were in place. The areas beneath the panels above the



Completed Victory Bridge.
Photo courtesy of FIGG

steel girders were then grouted, and the bridge was re-opened to traffic by early Monday morning.

Precast concrete segmental construction originated in France in the early 1960s and was introduced in the United States in the late 1970s. It is now a well-established bridge technology that offers aesthetic long-span concrete bridges on an accelerated construction timeline relative to conventional construction.

The New Jersey Department of Transportation's Victory Bridge on State Route 35 is New Jersey's first segmental concrete box girder bridge. The twin parallel superstructures are constructed of match-cast segments and have a main span of 440 ft. The piers are precast concrete box segments that were each assembled in one day. In June 2004, the first 3971-ft-long structure was opened to traffic 15 months after the notice to proceed; the second structure was completed nine months later.¹¹

In 2005, Florida's 5-mile-long Lee Roy Selmon Crosstown Expressway expansion, owned by the Tampa Hillsborough Expressway Authority, was completed. The 60-ft-wide precast concrete, segmental bridge includes over 3000 segments and was constructed within a 40-ft-wide median on an active expressway in two years.¹²

This issue of *ASPIRE* includes an article on the new Susquehanna River Bridge, Pennsylvania's first vehicular concrete segmental bridge.

More Projects Planned

Numerous accelerated concrete bridge construction projects have been completed to date, saving motorists countless hours of travel time that would otherwise have been spent in construction-related traffic jams. These

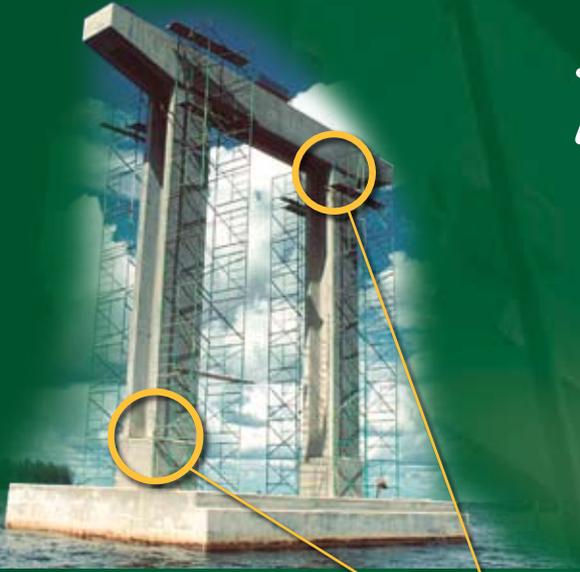
projects consist of both cast-in-place bridges and precast bridges, with both reinforced concrete and prestressed concrete. Many more such projects are planned as bridge owners deliver projects more quickly to improve safety and reduce congestion.

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How to do it in Precast...

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



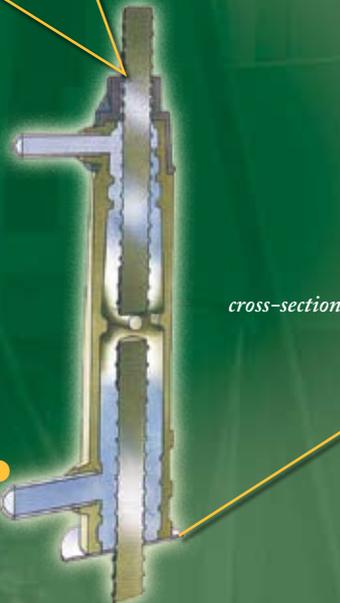
Edison Bridge, Fort Myers, Florida

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Q How do you connect the rebar?

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by Peter E. Stamnas and Mark D. Whittemore. New Hampshire Department of Transportation



Minimizing construction-related traffic delays and improving work-zone safety are key drivers for New Hampshire DOT to create fast construction plan

The New Hampshire Department of Transportation (NHDOT) has taken a lead role in promoting the benefits of high performance concrete (HPC) in bridges because of its ability to improve the quality of the material and extend bridge life. Recently, the department took that focus a step further by using HPC and precast, prestressed concrete components to erect a 115-ft-long bridge in only eight days.

The program's goal was to create a prototype system that could be followed for other projects as the need arose. Such rapid speed of construction provides a number of significant benefits. They include mitigating traffic delays and improving worker safety in construction zones, which are critical issues today. The initial plan was to

design the bridge and prepare for the construction, so the actual assembly and disruption to traffic would be completed in two weeks. Ultimately, the contractor exceeded expectations by easily beating that schedule.

Precast Box Beams Used

The new single-span concrete bridge replaced two existing spans carrying Mill Street over the Lamprey River in Epping, New Hampshire. The bridge features a precast concrete, adjacent box beam superstructure and a precast concrete substructure. One of the reasons that this site was chosen to test this procedure was that its location minimized the overall risk of using a newly developed and untested substructure system. NHDOT wanted to

profile

MILL STREET BRIDGE / EPPING, NEW HAMPSHIRE

ENGINEER: New Hampshire Department of Transportation, Concord, N.H.

DESIGN/CONSTRUCTION/INSPECTION TEAM: NHDOT, Bureaus of Bridge Design & Construction

PRIME CONTRACTOR: R.M. Piper Construction, Plymouth, N.H.

PRECASTER: J.P. Carrara & Sons Inc., Middlebury, Vt., a PCI-Certified Producer



The Epping, New Hampshire, bridge features a precast concrete, adjacent box-beam superstructure and a precast concrete substructure.

The design format allowed the contractor and precaster to determine the specific method of bridge assembly.

precast concrete abutments founded on precast concrete spread footings using 5000 psi compressive strength concrete.

The project was let using an approach somewhere between a traditional design-bid-build delivery and a design-build delivery project. The approach kept design control with NHDOT engineers but turned over the specific method of bridge assembly to the contractor and precaster. The contractor and precaster determined where joints within the substructure would be introduced and how the precast bridge elements would be assembled.

ensure the system would work before incorporating it into a high-traffic situation where failure would not be an option.

A significant portion of the project's funding was provided through the Federal Highway Administration's Innovative Bridge Research and Construction program. To create the final design, NHDOT worked with engineers at the University of New Hampshire, local contractors, and the technical committee of the Precast/Prestressed Concrete Institute's Northeast Region.

The bridge features 3-ft-deep adjacent box beams cast with 8000 psi compressive strength HPC and 0.6-in.-diameter prestressing strands. Full-depth grouted shear keys were used. Two rows of 1/2-in.-diameter strand were used to transversely post-tension the deck at six locations along the box beams. The riding surface features a waterproofing membrane and a bituminous pavement overlay. The superstructure is supported by an all-precast concrete substructure, composed of full-height cantilevered

NHDOT typically constructs abutments using cast-in-place concrete, but on this project, that approach would have required six separate concrete placements and approximately one month for construction. Using precast components, the abutment construction could be completed in less than two days. The footings were divided into individual sections to facilitate shipping and handling. These pieces were standardized to reduce fabrication costs, and precasters used a template to ensure a proper fit between the stem and footing elements.

The precast footings were set to proper grade using leveling screws installed near the corners of the footing elements. This proved to be a simple and cost-effective detail. A flowable grout bed was placed below the footings through grout tubes spaced at 5-ft centers in the footings. The minimum 3-in. thickness for the bed provided a sound, unified, bearing surface that acts as the 'glue' between the bearing materials and the roughed bottom surface of the precast footing.



Precast concrete abutments were set onto the precast concrete footings using reinforcing bars grouted onto reinforcement extending from the footings.

PRECAST CONCRETE REPLACEMENT BRIDGE / NEW HAMPSHIRE DEPARTMENT OF TRANSPORTATION, OWNER

BRIDGE DESCRIPTION: A 115-ft-long, single-span bridge constructed in eight days

STRUCTURAL COMPONENTS: Seven 3-ft-deep precast concrete box beams, 11 abutments and wingwall pieces, 10 footing pieces, and four pilasters

CONSTRUCTION COST: Total: \$1.047 million; Bridge cost: \$806,000



Fitting the precast concrete wingwalls and abutments onto the footings required close tolerances and careful handling to ensure they fit together.

Careful attention was paid to ensure splice sleeves connected smoothly at the site.

The minimum compressive strength required to resist full design loading of 250 psi was easily achieved overnight.

Splice Sleeves Provide Connections

Standard details were provided in the plans to address various types of joints. Vertical joints in the stems and footings required grouted shear keys, while horizontal joints in stems and between the stems and footings were designed as 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. High-strength grout was pumped by hand into the splice ports to complete the connection.

Matching the splice sleeves in the footings and wingwalls proved to be the most challenging pieces for the precaster to produce. Careful attention had to be paid to how each piece was laid out to

ensure the splice sleeves would match and connect up smoothly at the site. It required a lot of coordination to make it work, but everything went smoothly. The contractor developed a detailed assembly plan to minimize the costs and time needed.

Seven box beams were used in the single-span bridge, with five abutment and wingwall pieces on one end and six on the other, plus 10 footing pieces. The precaster also supplied four precast concrete pilasters, which were set along the top of the abutment walls on each side of the outside box beams to add a decorative touch.

The project moved smoothly once erection began. Bad weather slowed the preparation work, but casting continued at the plant. This timetable ensured that the components were ready when the site was prepared, so construction would proceed as planned despite the weather complications.

Design Offers Potential

The precast concrete substructure system used on this project offers great promise for future construction. It emulates the favorable aspects of cast-in-place construction, such as:

- Using standard design concepts
- Incorporating elements produced locally with readily available materials
- Providing easy construction and assembly
- Creating a durable structure

At the same time, it improves on some aspects of cast-in-place construction by:

- Significantly reducing the time to construct the substructure
- Being constructed to tight tolerances
- Providing a high-quality solution using HPC

The reduction of construction time is a critical issue today in all work zones. Because not all projects can be planned in advance under these conditions, partial use of these techniques may be the right answer in many instances. Precast substructures, for instance, could be used on bridge projects that cross commute rail lines.

Pros and Cons to Consider

One of the key advantages offered by precast components is that they can be cast in advance so they are ready to be assembled in the available construction window. Savings realized on items such as the reduced rental time for a temporary bridge and wasted labor to mobilize the construction crew around these windows helps to compensate for the additional costs associated with the fabrication and delivery of the precast pieces.

Achieving the aggressive schedule used on this project may require the mobilization of two or more construction crews working in parallel. That may exclude some smaller contractors from being able to bid the project. At the same time, accelerated construction using precast components may expand those opportunities, increasing competition, and ultimately reducing costs.

The accelerated timetable also minimizes construction-related traffic delays on high-volume roads. This provides a significant advantage, particularly on

projects where construction may extend into a second construction season. Accelerated construction creates risks for the contractor that will increase his costs. The magnitude of those costs will vary between projects and will be site specific. As these risks are minimized, the cost will follow.

At the same time, the increased cost due to accelerated construction must be evaluated in comparison to the value gained in reduced user costs for shorter-term detours and less need for traffic-control items. The long life that precast concrete components can provide for the bridge also offers savings that should be factored into a life-cycle study.

One option offering potential is to substitute precast substructure

The precast concrete substructure system used on this project offers great promise for future construction.

components for cast-in-place elements. Typical cast-in-place elements could be designed for use on the contract drawings, with standard details for emulating these elements included as well. The contractor then could decide the means and methods to use in order to complete the project on time and within budget on his own. On the downside, the owner cannot take full advantages of the potential savings in engineering and plant-preparation costs. The substructure detailing on this

project, for instance, was reduced by half, from 10 plan sheets to five. For these reasons, NHDOT considers the Epping project not only a great success on its own, but we see it as a strong starting point for a promising concept. That was made even more apparent during this past spring, when the bridge was submerged after heavy rains caused the Lamprey River to surge well above its typical level. When the river subsided, the bridge was found to have sustained no damage (photos below).



Shortening the Learning Curve

Creating a bridge that can be constructed in eight days requires careful planning and design. These are some of the ideas we learned that are critical in creating a fast construction project:

- Limit angle changes between abutment and wingwalls to 30, 45, 60, and 90 degrees.
- Stem heights for abutments and wingwalls should be detailed in 6-in. increments, and site grading should be used to fine-tune the solution.
- Batters on abutment and wingwall stems should be eliminated. The overall thickness of the stems should be minimized to reduce weight.
- Footing widths should be detailed in 6-in. increments, with a maximum width of 12 ft to minimize transportation difficulties.
- Alternate backfill materials should be considered, with flowable fill rather than granular material offering a strong option.
- Maximize construction access. Precast substructure elements can weigh as much as 30 tons and may require large cranes.
- Details at vertical joints between elements should be standardized. Attention to shear key preparation, grout material, and grout installation is critical.
- Standardize as many components as possible. It is a key to success in accelerated construction.

The ease of construction and the overall effectiveness of the details have demonstrated the viability of this system and opened the door for many applications in the future. Such techniques are not limited to NHDOT but can be applied by other transportation agencies across the country. We look forward to confronting the challenges created by using rapid bridge construction techniques on future projects.

Peter Stamnas is Project Manager and Mark Whittemore is Administrator, Bureau of Public Works both with the New Hampshire Department of Transportation.

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

The 500-ft-long gantry sits atop a completed cantilever section.



Precast Segmental Bridge Forges Link for Toll Road

by Wayne A. Endicott

Designers faced challenges with four-lane-wide structure that stretches nearly three-quarters of a mile over an environmentally sensitive area in San Diego

The new South Bay Expressway near San Diego, California, provides a 12.5-mile addition that closes a gap in the area's congested highway system. The project includes several innovations for highway construction in California including a three-quarter mile long precast concrete segmental bridge built using the balanced cantilever method, only the second of its kind in California.

profile

THE OTAY RIVER BRIDGE / SAN DIEGO COUNTY, CALIFORNIA

CONSTRUCTION MANAGER: Parsons Transportation Group, San Diego

ENGINEER: International Bridge Technologies, Inc., San Diego

PRIME CONTRACTOR: Otay River Constructors, a joint venture of Washington Group International, Boise, Idaho, and Fluor Daniel, Sugarland, Tex.

CONCRETE SUPPLIER: Hanson Construction Materials, Calif.

PRECASTER: Pomeroy Corp., Perris, Calif., a PCI-Certified Producer

The precast segmental approach proved more cost effective than other alternatives.

The environment played a key role in selecting this technology for the Otay River Bridge, according to Benjamin T. Soule, Senior Bridge Engineer at International Bridge Technologies (IBT) in San Diego, engineers for the project. The bridge is located in an environmentally sensitive part of the San Diego area. "Although the river is not really filled with water for much of the year, the valley is an environmentally sensitive area," he explains.

Several Options Considered

With the bridge crossing the river more than 160 ft above the valley floor, several possible construction materials and methods were considered, including steel and cast-in-place concrete. "The biggest drawback to these methods would have been the falsework required," Soule says. "To work at that height, the extensive falsework would have posed serious challenges to the ecology of the valley."

After considering several alternatives, the construction team, consisting of IBT and the general contractor, Otay River Constructors (a joint venture of Washington Group International and Fluor Daniel) settled on the precast concrete solution. In addition to the environmental benefits, research indicated that the precast concrete segmental approach would be more cost effective than other alternatives, he notes.

The bridge superstructure is approximately 3280 ft long and consists of side-by-side trapezoidal box girders—one for each roadway alignment. The precast

segments are supported by cast-in-place pier caps, which are, in turn, supported by cast-in-place piers that reach as high as 164 ft. The drilled-shaft foundations for the piers include 6-ft diameter by 85- to 131-ft-deep shafts at the bent locations and 4-ft-diameter by 46-ft-deep shafts at the abutments. The shafts are arranged in groups of 10.

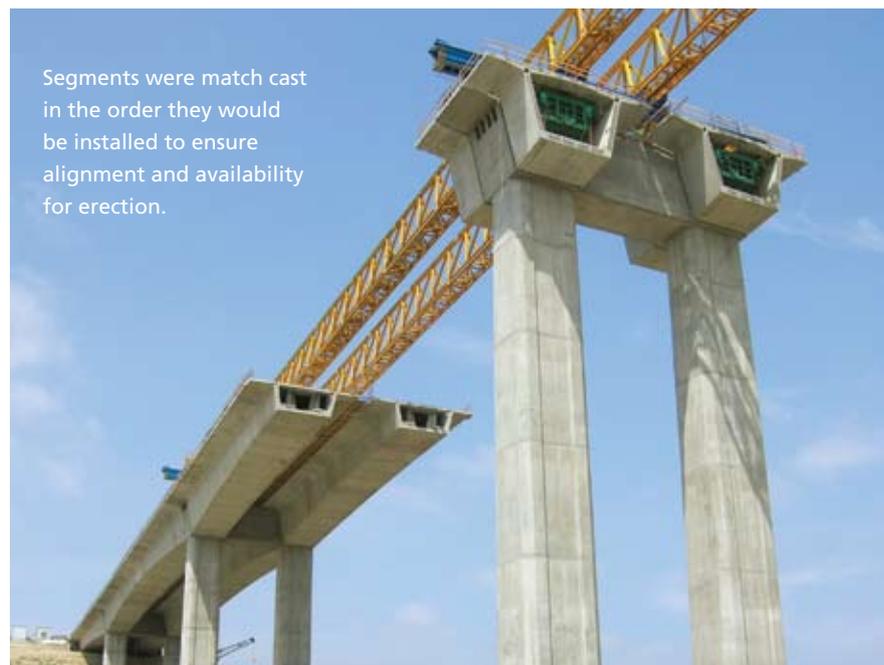
The bridge consists of 12 spans. Ten spans have a length of approximately 297 ft. The two end spans are 175 ft long. The bridge was constructed using the balanced cantilever method, with an overhead gantry for setting the segments. The segments, each weighing from 65 to 70 tons, were cast by Pomeroy Corp. in its Perris, California,

casting plant and then trucked 90 miles to the site by special heavy-hauling equipment trailers consisting of two low-boys and two transformer decks, according to Daniel Neufeld, project manager for Pomeroy.

Special Forms Created

The segment cross sections ranged from a depth of 16.5 ft at the pier to approximately 10 ft at midspan. Each segment is approximately 10 ft long. The segments were cast in forms manufactured specifically for the job by Rizzani de Eccher of Udine, Italy, Neufeld says.

"The forms are very sophisticated and of very high quality," he explains. They



Segments were match cast in the order they would be installed to ensure alignment and availability for erection.

PRECAST SEGMENTAL BRIDGE / SOUTH BAY EXPRESSWAY, CHULA VISTA, CALIFORNIA, OWNER

GANTRY SUPPLIER: Rizzani de Eccher, Udine, Italy

DRILLED SHAFTS: Anderson Drilling, Lakeside, Calif.

BRIDGE DESCRIPTION: Two side-by-side trapezoidal box girders each slightly more than 3250 ft long broken into 12 spans, built using the balanced cantilever method with an overhead gantry

STRUCTURAL COMPONENTS: 640 precast concrete segments varying in depth from approximately 16.5 ft at the pier to 10 ft at midspan. Each segment is approximately 10 ft long. Each segment weighs between 65 and 70 tons



The decision to build a segmental precast bridge came about through a desire to minimize disturbance to the floor of the river valley.

A Private Highway

The bridge is part of State Route 125, a new highway that will provide direct access from the Otay Mesa border crossing from Mexico to the existing San Diego freeway network. Part of the southern portion of the highway, also known as the South Bay Expressway, is being built by a private consortium and will be operated by that group as a tollway for 35 years before being turned over to Caltrans.

The entire southern portion of the highway, for which the bridge is a major link, will cost an estimated \$630 million and is being privately financed. In a unique financing structure, funds for the roadway include bank loans, a \$140-million federal loan provided by the U.S. Department of Transportation under the Transportation Infrastructure and Innovation Act of 1998, and private equity capital. In addition, area developers have a dedicated right of way valued at \$40 million.

Construction on the northern end of the project will cost approximately \$138 million and will provide toll-free links connecting the tollway with the existing San Diego freeway network.

contained a hydraulic manipulator that positioned the previously cast segment. The segments were match cast with each segment becoming the end piece of the formwork for the next casting to ensure an exact fit between segments. As a result, the segments were cast in the order in which they were erected. The reason for this precision was the exacting quality control demanded by the owner, Neufeld notes. Tolerances between segment surveys were to be between 0.3 and 0.6 mm (0.012 and 0.025 in.).

The segment decks were transversely post-tensioned before they were transferred from the plant to the site, he says. The concrete used in the segments includes 15 percent fly ash and a high-range water-reducing admixture, allowing it to develop high early strengths. Segments contain ASTM A 706 steel reinforcement. Specifications called for the precast concrete production to satisfy the Precast/Prestressed Concrete Institute's quality standards embodied in its Plant Certification Program, as well as the Caltrans Standard Specifications.

In all, 56 precast segments plus the pier segments comprise each span. The

The concrete forms contain a hydraulic manipulator that positioned the previously cast segments.

Limited on-site storage area made tight coordination between delivery and erection a must.



Using segmental construction with an overhead gantry allowed many construction activities to be completed away from the site.

precast segments were erected using a gantry, designed by Rizzani, working in opposite directions off each pier. Fourteen pairs of segments cantilever out in each direction from each pier. Shear keys cast into the segments guaranteed a perfect fit, Neufeld says. The 500-ft-long gantry is capable of sliding from one alignment to the other in order to erect both alignments on the same pass; thereby reducing the number of launching stages.

Total casting time for the 640 segments was approximately 16 months, beginning in June 2005, with the final segment cast in October 2006. Three sets of forms were used to complete the job, plus a special form with an expansion diaphragm that was used to cast special segments to be used at each of three midspan expansion joints.

As the gantry placed each segment, the segments were temporarily secured with post-tensioning bars until the final post-

tensioning tendons were installed and stressed. The bridge contains a small horizontal curvature over a portion of the alignment, Soule notes. The tendons were grouted according to Caltrans specifications by American Segmental Bridge Institute certified technicians.

Location Offers Challenges

The location of the bridge presented some unique challenges, Soule says. "We wanted to minimize the environmental impact of the bridge, which is located in one of the last remaining open spaces near San Diego," he explains. "Preservation of the site received top priority from the owners. By choosing segmental construction with an overhead gantry, we were able to complete many of the construction activities away from the site. This allowed us to reduce falsework and pull as many construction tasks as possible out of the valley floor."

The site also presented limited storage

capacity, preventing the staging of large numbers of segments at the bridge location. At most, 45 segments could be stored on site at any time. This required closely coordinated delivery and erection schedules, Soule notes.

The bridge will be completed in July 2007. To match the character of the surrounding area, the concrete bridge will receive a tan stain. The result is an attractive, highly functional, and environmentally friendly concrete bridge that will serve the area for many decades to come.

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

Hurricane-Damaged Span Replaced in 156 Days

by Stanley W. Woods

The 10,050-ft-long CSX Transportation railroad bridge in Bay St. Louis, Mississippi, connecting key transportation hubs, was reconstructed in only 156 days after Hurricane Katrina destroyed the original structure.



Precast concrete girders and close cooperation between designer, fabricators, and contractors ensure critical railroad bridge returns to service quickly

Executives at CSX Transportation needed a fast replacement when Hurricane Katrina destroyed the superstructure of their 10,050-ft-long railroad bridge across Bay St. Louis, Mississippi. Close communication and cooperation among the railroad officials, designer, fabricators, and contractors accomplished this task in only 156 days from the time of damage until it opened to traffic, beating the already tight schedule requested. A design featuring AASHTO Type IV precast, prestressed concrete beams contributed to this rapid reconstruction.

On August 29, 2005, the bridge superstructure was knocked out by one of the worst hurricanes in the nation's history. The key heavy-freight railway bridge carried 25 to 35 trains per day and served as the main corridor from New Orleans through Biloxi, Mississippi, to Mobile, Alabama. The 30-ft storm surge over-topped the entire length of the bridge, wrenching all but three of the 165 spans from the piers.

Miraculously, the 289-ft-long center swing-span truss weathered the waves, although there was track and operating system damage. Overall, about 75 miles of track and six other significant bridges were damaged on the line. These repairs were completed before the Bay St. Louis Bridge was opened, according to Gary Sease of CSX Transportation.

profile

CSX TRANSPORTATION RAILROAD BRIDGE / BAY ST. LOUIS, MISSISSIPPI

ENGINEER: STV/Ralph Whitehead Associates Inc., Jacksonville, Fla.

PRIME CONTRACTORS: Scott Bridge Co., Opelika, Ala., and Jordan Pile Driving, Inc., Mobile, Ala.

PRECASTERS: Sherman Prestressed Concrete, Pelham, Ala., and Madison Materials Co., Ridgeland, Miss., PCI-Certified Producers

BRIDGE DESCRIPTION: 10,050-ft precast concrete railroad bridge with ballasted deck

When the bridge was damaged, trains had to be detoured through Memphis, Tennessee; East St. Louis, Illinois; and Birmingham, Alabama, at an estimated detour cost for this primary east-west bridge of \$1 million per day. "The railroad employees did an excellent job of rerouting trains so there was minimal delay to suppliers in the East," says Sease. Even so, the costs were heavy and access to the route needed to be restored quickly.

The damaged portion of the bridge comprised 162 spans, of which 160 were 60-ft-long ballast-deck precast, prestressed concrete box beams. The remaining two were 50-ft 6-in.-long steel open-deck approach spans adjacent to the swing-span truss. The original precast concrete box beams were cast with closed-end diaphragms.

When the incoming storm surge rose above the top of the boxes, air inside the boxes could not escape. The hydraulic force of the storm surge overcame both the strength of the anchor bolts and the weight of the box beams due to buoyancy. It sheared the boxes from their bearings, carried them away from the substructure, and eventually took them to the bottom of the bay. Immediately after the hurricane, underwater inspectors assessed the structural integrity of the existing piers and determined that they had suffered minimal damage and could be used in the reconstruction.

Six-Month Challenge

The owner immediately contacted two general contractors and an engineering firm to assess damage and propose reconstruction activities. The owner challenged the design and construction team to restore the critical line to service in only six months. It was decided not to replace the 39-year-old existing spans "in kind," since the original custom

After the beams were erected, diaphragms, composite deck, and ballast curb were cast.



forms were no longer available and the fear still existed of a washout during future storms.

After conversations with local suppliers, the owner and designer replaced the original box beams with four precast, prestressed concrete AASHTO Type IV modified beams incorporating cast-in-place concrete diaphragms, composite deck, and ballast curbs. Two precasters were contracted to provide 640 precast concrete beams to complete the bridge reconstruction. The suppliers' familiarity with AASHTO beams and the availability of numerous Type IV forms ensured the proposed bridge beams could be mass-produced with minimal startup time. To maintain the original profile of the track, the top flange depth was reduced 2 in. so the overall depth would match the depth of the original box beam.

The superstructure's design and project plans were completed in only three weeks by STV/Ralph Whitehead Associates' Jacksonville, Florida, office. "Four designers worked 60 hours per week to complete the plans that quickly," says Nathan Porter of

Whitehead. The original piers consisted of 54-in.-diameter prestressed concrete cylinder piles with a cast-in-place pier cap. To increase the lateral support of the beams on the piers, 2-in.-diameter by 2-ft 6-in.-long steel dowels were embedded 1 ft 6 in. into the existing pier caps at both ends of each beam to anchor them to the piers. In addition, steel-pipe and tubular sleeves were embedded in the beams to allow the steel dowels to project 1 ft into the bottom flanges. The tubular sleeves were incorporated in the design to permit longitudinal movement of the span at the expansion end.

The demanding schedule required the precasters to produce and deliver approximately 60 beams per week. "We had to scour the country for 10 sets of forms to create two beds with five beams each, because Alabama no longer uses AASHTO Type IV beams," notes Harold Bush of Sherman Prestressed Concrete in Pelham, Alabama. The company used regular work shifts but shifted some projects to produce the needed 10 beams per day with a design strength of 6 ksi and a release strength

AASHTO TYPE IV PRESTRESSED CONCRETE BEAMS WITH CAST-IN-PLACE SLAB / CSX TRANSPORTATION, OWNER

STRUCTURAL COMPONENTS: AASHTO Type IV precast concrete beams

BRIDGE CONSTRUCTION COST: \$60 million

PRESTRESSED CONCRETE BEAM PACKAGE: \$4.5 million

of 4.5 ksi. Madison Materials Co. in Ridgeland, Mississippi, also began beam production, with cooperation from Alabama and Mississippi Departments of Transportation to ensure rapid delivery to the job site. Both producers are certified under the Precast/Prestressed Concrete Institute's Plant Certification Program.

The first beam was cast on September 26, 2005, with the first shipment arriving on October 10, 2005. The final delivery took place almost exactly two months later, on December 12, 2005.

Meanwhile, the contractors made minor repairs to the cylinder piles and pier caps as well as to the swing-span truss. It needed to be rebalanced, and the destroyed track work needed replacing. Each pile cap was drilled for eight core holes, with each beam's anchor dowels held in place with epoxy adhesive. All the piers were surveyed to verify the span lengths, which were found to be consistent at 60 ft.

No Support Infrastructure

Complicating the construction was the fact that there was no support infrastructure remaining in place in the area, as Hurricane Katrina had devastated a vast area, points out Chuck Davis of Scott Bridge Co. Workers had to sleep in their trucks or tents during the first two weeks, until quarters could be provided. These ultimately arrived in the form of tour buses. Communication immediately after the storm could be conducted only via satellite telephones.

All items required to run the project and support the workers were trucked in from out of the area.

Meals during those weeks were also hit and miss, Davis says. A mess hall was established on-site to serve 400 to 500 meals per day, with three local women preparing the meals. "Our behind-the-scenes supply-line planning and operations was key to getting this rebuild underway quickly," Davis says.

The two approaches were built simultaneously from the end abutments towards the swing-span truss. Scott Bridge worked on the west side and Jordan Pile Driving worked on the east side. "The two contractors raced to see who would reach the swing span first to set the final rail," Davis notes. Scott Bridge used 10 cranes of 100- to 250-ton capacity. The team worked 24 hours a day and used 20 light plants for night operations. With weather cooperating, there were few missed days.

Meanwhile, Jordan Pile Driving brought in its own equipment and worked primarily during the day, performing maintenance operations at night. Both contractors notified the other states in which they had projects so that other operations would stop there until this work was completed. The states were sympathetic with their request to bring workers to this job, smoothing the operation considerably, Davis adds. Because of the tight schedule, the contractors worked on a time and materials basis.

15 Beams Erected Daily

After the beams were delivered, they were loaded on barges and moved to the spans being erected. Beams were erected at an average rate of about 15 beams per day. Once the beams were set, stay-in-place metal forms were placed between the girders, and plywood forms were placed for the overhang soffits. The concrete deck and curbs were then placed. A pump truck was set on a sand causeway to supply concrete for the new superstructure. Replacement of the superstructure took only four months and was completed in early January 2006. The rock train arrived on January 14, 2006, when laying track and ballast operations began. The bridge was opened to rail freight traffic on February 1, 2006.

After the bridge reopened, Scott Bridge was the low bidder on a separate contract for removing the box beams from the bottom of the bay and began work immediately. Some of the beams weighed up to 250 tons, as water had filled the box voids. To hoist the beams, divers cleared muck up to 4 ft deep around the boxes and attached lifting slings. The beams were lifted out of the water with two 230-ton Manitowoc cranes, and the water was allowed to drain before moving to shore. Once on shore, the beams were crushed and the concrete was used to refurbish a man-made island. The prestressing strand and reinforcing bars were taken to a landfill, as they proved too difficult to recycle.

Once the structure was back in place, needed supplies and materials could be delivered to the communities destroyed by Hurricane Katrina. The project provides an excellent example of what close cooperation between owner, designer, and contractor can achieve when rapid reconstruction is needed. The use of the precast, prestressed concrete beams played a significant role in facilitating the rapid reconstruction of this vital railway asset in only 156 days, well below the hoped-for six-month deadline that the owners had originally set.

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



The AASHTO Type IV precast, prestressed concrete beams were erected at an average of 15 beams per day.

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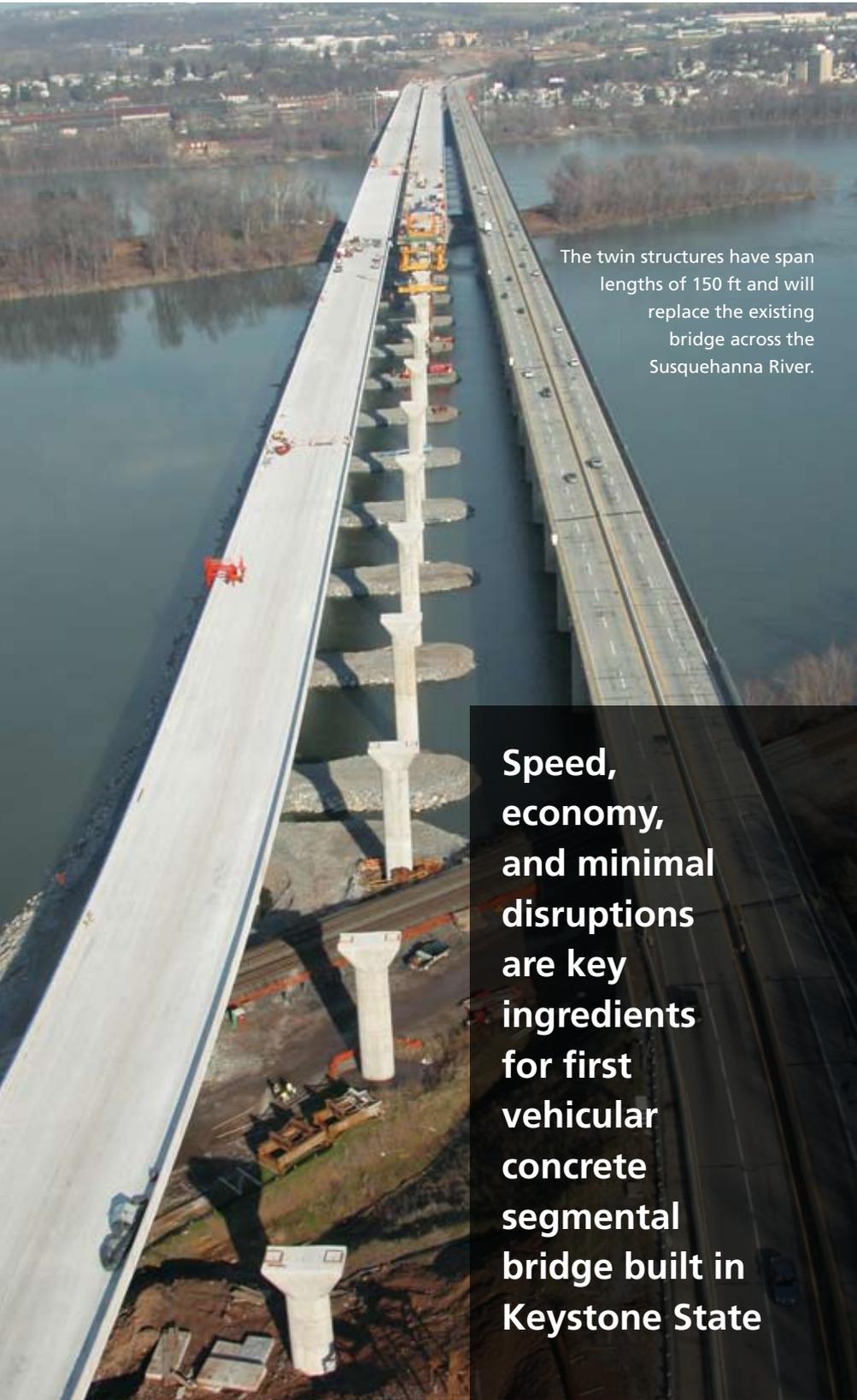
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The twin structures have span lengths of 150 ft and will replace the existing bridge across the Susquehanna River.

Speed, economy, and minimal disruptions are key ingredients for first vehicular concrete segmental bridge built in Keystone State

Segment Setter Blazes New Trail on Turnpike

by Craig A. Shutt

Officials at the Pennsylvania Turnpike are finishing the state's first vehicular segmental concrete bridge, to be opened in May. The mile-long structure provided a variety of benefits, including speed of erection and a construction approach that provided little disruption to the tight site. The design has worked so well that more such projects are planned along the turnpike.

The bridge, spanning the Susquehanna River in York and Dauphin Counties, is part of the Turnpike's massive \$1-billion total reconstruction project, which will cost approximately \$5 million per mile. The program is the first complete restoration of the toll road since it was built in 1940 and involves widening bridges and overpasses along the route in advance of adding a third lane in each direction. The construction project requires tight scheduling and rapid construction to ensure traffic can move smoothly during the multi-year project.

profile

SUSQUEHANNA RIVER BRIDGE / YORK AND DAUPHIN COUNTIES, PENNSYLVANIA

ENGINEER: FIGG Engineering Group, Tallahassee, Fla.

PRIME CONTRACTOR/PRECASTER: Edward Kraemer & Sons, Inc., Plain, Wis., and G. A. and G. F. Wagman, Inc., York, Pa., a joint venture

CONCRETE SUPPLIER: Hempt Brothers, Camp Hill, Pa.

“Because we charge drivers for the use of our road, we have to ensure we can maintain traffic while construction is underway, so speed is critical for all our projects,” explains Gary Graham, Bridge Engineering Manager with the Harrisburg, Pennsylvania-based Turnpike Commission. Even so, costs also are a key factor in design decisions. “We approached this design as we would any other project, by looking at what was the most economical format,” he says. “Cost is always one of the highest criteria in our evaluations, and this approach won hands down.”

The design features twin structures, each 5910 ft long and 57 ft wide, with precast concrete, segmental spans, typically 150 ft long, erected span-by-span on cast-in-place piers founded on drilled shafts. In addition to carrying three lanes of traffic in each direction across the Susquehanna River, the new bridge spans the Norfolk Southern Railroad, Amtrak railway lines, the Steelton-Highspire Railroad, State Route 230, and Culver Island.

The concrete bridge replaces a combination steel truss and plate-girder bridge built in the 1950s. A feasibility study in 2000 indicated that, because of the deterioration to the webs and flanges, replacement would be cheaper—but just barely.

“We decided it wasn’t economical to renovate the existing bridge due to the time involved in the rehabilitation and the constructability issues,” says Graham. “And we’d still have a 50-year-old bridge at its core.” By constructing a new bridge alongside the existing one, traffic would be disrupted only during the final tie-in of approaches.

Turnpike officials initially planned to use 120-ft-long precast concrete I-beams as the most economical and rapid design, he says. But after seeing several segmental concrete bridge designs by FIGG Engineering Group in Tallahassee,

‘A key attraction was the rapid construction that we saw was possible with this format.’



Florida, Graham contacted the company to evaluate if that approach would work in this case. “We had worked with FIGG on other alternative designs, which ultimately hadn’t been chosen, so we were familiar with their work,” he says.

In particular, the Garcon Point Bridge in Florida had been notable for its construction at \$50 per ft². “That was unheard of,” he says, as typical turnpike costs have run \$150 to \$170 per ft². A key obstacle was that Pennsylvania

A formliner was used to create the appearance of quarried limestone on the columns to complement the commission’s headquarters.

PRECAST SEGMENTAL BRIDGE / PENNSYLVANIA TURNPIKE COMMISSION, OWNER

BRIDGE DESCRIPTION: Twin 5910-ft-long precast concrete segmental bridges consisting of a total of 80 spans with a typical length of 150 ft

STRUCTURAL COMPONENTS: Drilled shafts, 39 cast-in-place concrete piers, and 1040 precast concrete segments

BRIDGE CONSTRUCTION COST: \$82.42 million



An underslung erection truss was used with the span-by-span method of construction.

Department of Transportation design manuals do not encompass segmental bridges. “Some criteria ultimately take them out of the mix,” he says, such as needing to allow for deck replacements.

Without examples to view in Pennsylvania, turnpike officials went with FIGG engineers to view examples in Maine and Boston. They then had to convince turnpike commissioners, as well as the local contracting community, of the benefits. “There was a real concern that we were excluding local contractors by creating a design with which they had no experience,” he says. Ultimately, the winning bid was secured by a joint venture between Edward Kraemer & Sons Inc. of Plain, Wisconsin, and G. A. and G. F. Wagman, Inc. of York, Pennsylvania.

The segmental design offered key advantages, explains Jay Rohleder, Senior Vice President with FIGG. “Segmental bridges offer an economical approach because they are constructed quickly without falsework,” he explains. The Susquehanna River is non-navigable, which also ruled out the option of transporting components to the site via barge, he adds. “Economy was paramount to the selection, as well as the ability to advance quickly through the permitting process.

Graham agrees. “A key attraction was the rapid construction that we saw was possible with this format,” he says. “Our goal is to build as fast as possible, get in, and get out. With the precast concrete components, we could work through the winter. It offered the shortest duration of all bridge types, and that was a major advantage.” FIGG

created an erection scheme to lead turnpike officials through the process and schedule prior to commencing construction, he notes.

The new bridge was constructed parallel to the existing structure—so closely, in fact that between less than 1 ft and no more than 30 ft separate the two structures. Temporary shoring was provided at abutments on the east side, where the bridges are separated by inches, to maintain fill between the structures, Rohleder says.

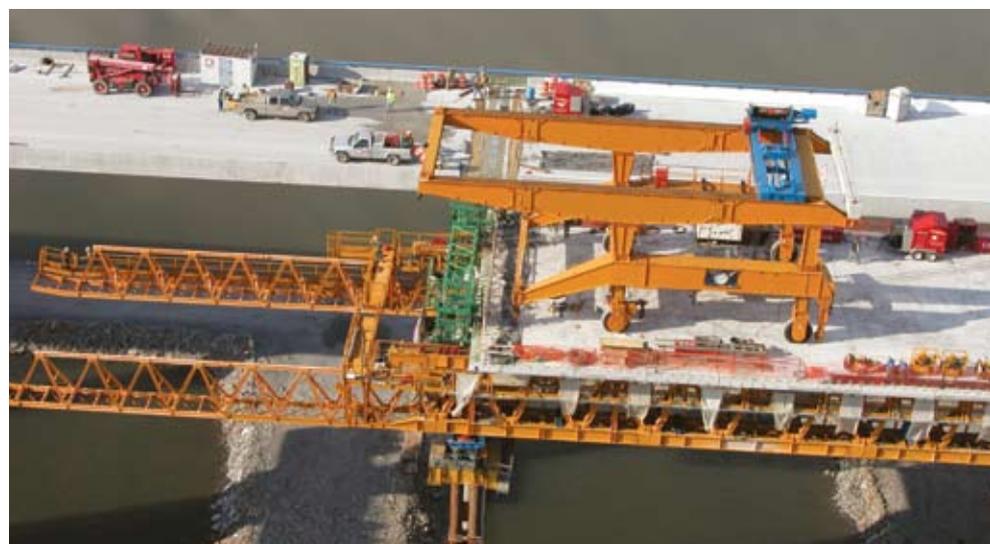
The contractor gained access to a slag pile located just above the east abutment site, where components could be cast. After casting and curing, the precast concrete segments were loaded onto a low-boy trailer and driven to the bridge site via an access road. The segments were driven onto the bridge to the segment setter, placed at the edge of the previously constructed span.

The segment setter lifted each segment off the low-boy trailer and set it onto the erection truss. A trolley then transported the segment along the truss.

The segments were aligned one by one, the joints coated with epoxy, and the segments pulled together with temporary post-tensioning. This process continued until the complete span was assembled. A 6-in.-wide cast-in-place closure placement was then placed at both pier segments. The closure placements were allowed to set overnight prior to post-tensioning the segments. Then the truss was advanced to the next span. The final post-tensioning consisted of eight 27-strand tendons.

Construction progress was done in three phases due to specific site logistics, Graham explains. The process began with the bridge’s east lanes, which were built out to a central island in the river. Then construction returned to the east side and the westbound lanes were built completely across the river, after which the final half of the

A custom-made segment setter was used to move the segments from the low-boy trailer onto the twin erection trusses.



We wanted to create something of a signature bridge for the turnpike.

eastbound lanes were completed from the island to the west side of the river.

This approach was needed because a causeway was constructed to aid in installing the drilled shafts and piers. “We couldn’t shut off the river completely with the causeway in the east channel, so we used the causeway out to the island to advance the shoring towers,” explains Rohleder. The causeway then was removed from that half of the river and built into the other half to extend the shoring towers completely across the river, during which the entire westbound lanes were constructed.

Work at the island was complicated by the discovery of archeological artifacts, including arrowheads. “Evaluating those and ensuring they were secured slowed us down,” Graham says. Ultimately, the Turnpike Commission purchased the island to provide complete access for both the archeological exploration and the construction needs.

The segmental design produced further savings due to its handling of utility lines, Rohleder notes. The bridge spans railroad lines with electrical transmission lines overhead. The initial proposal by Amtrak called for extra tall temporary towers to be installed to lift the lines out of the way of construction. Once the bridge was finished, the lines would be returned to lower, permanent towers included in the construction plan.

But the segment setter eliminated the need for a tall crane to be located on the bridge to handle the segments. It had low enough clearance to ride beneath the existing transmission towers, so they didn’t need to be replaced temporarily. That saved both time and money, as the lines could simply be shifted from the existing towers to the new ones when the bridge was completed.

The designers added a particular aesthetic touch to the project—which, like the segmental design itself, opened new doors for the system’s structures. The bridge is the longest on the turnpike, and it sits adjacent to the



Precast segments were produced and stored adjacent to the bridge site.

commission’s headquarters building, which was renovated in 2001. “We wanted to do something to make it stand out and create something of a signature bridge for the turnpike,” Graham explains.

To achieve that, the contractor used a formliner to mimic quarried limestone, which matches the design of true stone used on the headquarters building. “We originally considered taking a cast of the building’s façade to use as a mold, but they were able to develop it simply from a picture of the building,” says Rohleder. The formliner was used to create a ribbon of texture up the center the piers. At the top, the texture splays out across the pier cap in the shape of a keystone, to reflect Pennsylvania’s status as the Keystone State.

Highlighting this design more is accent lighting placed along the girders, he notes. A slight curvature was put on the soffit at the girders’ bottom web, where lights could be installed on the lip. The lights catch the edge of the curvature and create dimension and shadow lines to show off the textured piers.

“This was our first project for really jumping into creating a more aesthetically pleasing design, but now we’re planning to do it for all of our bridges,” says Graham. “This one really led the way.”

That’s also the case with the segmental concrete construction approach, he says.

The westbound lanes are completed, with the final half of the eastbound lanes planned to be completed in May. That won’t be the last bridge to be constructed this way, he says. “We saw a lot of benefits from this construction, including the ability to work from above to create less impact from the ground. Any time you can stay off the ground and out of the way of railroad tracks and utility lines, you’re better off. Segmental construction will help us in many ways to avoid those issues.”

The economy, speed, and flexibility make the segmental design a strong choice for other situations, he says. A cast-in-place design planned to span the Allegheny River near Pittsburgh is considering a segmental approach, he says, and it also will be evaluated for use on other projects over the course of the massive reconstruction.

Officials also are designing the Mon-Fayette Expressway in western Pennsylvania, a north-south highway that will connect West Virginia with Pittsburgh, he notes. “There will be a lot of opportunities for us to use segmental construction there.” Rohleder agrees. “There are 13 bridges now being designed, and segmental construction will be reviewed for several of those. We believe there will be many more opportunities for segmental bridges in this program.”

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

Precast Concrete Bridge Approach Slabs Speed Construction

by George D. Nasser

An innovative application of post-tensioned precast concrete approach slabs reduces construction time, adds durability, and provides more user comfort

In the past five years, the use of precast, prestressed concrete pavement (PPCP) has been advancing rapidly. Completed projects in Texas, California, Missouri, and Iowa have shown that PPCP is not only viable and cost competitive, especially when life-cycle costs are considered, but also possesses some distinct advantages. A new project involving bridge approach slabs in Iowa shows the concept has even more versatility.

First and foremost among PPCP's benefits is speed of construction. Highways can be opened to traffic as soon as the panels are installed, without waiting for the concrete to reach its specified strength, as would be required for conventional cast-in-place construction. The installation also can be done at night and during nonpeak traffic hours, without having to rely on favorable weather conditions. Experience has shown that the construction season can be extended in northern states.

Prestressing Adds Benefits

Pretensioning the panels in the plant and post-tensioning on-site induces

compression in the concrete, effectively preventing cracking. Prestressing also provides significantly thinner slab sections. A recent project in Texas used precast panels as thin as 8 in., compared to 14-in.-thick conventional cast-in-place concrete pavement.

The thinner sections require less material, which saves costs and permits "in-kind" replacement of existing pavement. Being lighter, the panels provide easier handling; being thinner, they reduce the overall thickness of the pavement sections, which provides greater clearances beneath underpasses. Prestressing also permits longer sections of pavement to be constructed between expansion joints, requiring fewer expansion and contraction joints overall.

Because the panels are fabricated under plant-controlled conditions, the products offer high quality, resulting in pavements that are strong, durable, long lasting, and virtually maintenance free. All these benefits combine to create a highly cost-effective project when costs are considered over the full life cycle. Although initial costs may be higher, the

lifetime costs will be significantly lower.

The potential of PPCP has not gone unnoticed. The Federal Highway Administration (FHWA) has already funded four PPCP demonstration projects and several more are on the drawing boards. Also, the Precast/Prestressed Concrete Institute (PCI) has established a technical committee on PPCP. In October 2006, it conducted sessions on PPCP from the viewpoint of both the owner and the precaster at the PCI Convention in Grapevine, Texas.

Iowa Approach Slab Project Underway

The latest application of PPCP, which focuses on bridge approach slabs, is currently underway with the sponsorship of the FHWA and the Iowa Department of Transportation. Instrumentation and monitoring are being carried out by researchers at Iowa State University at the Bridge Engineering Center in Ames, Iowa. The project is one of several demonstration projects being conducted as part of the FHWA Concrete Pavement Technology Program.

profile

IOWA HIGHWAY 60 / O'Brien County, Iowa

SPONSORS: Federal Highway Administration, Washington, D.C.

Office of Bridges and Structures, Iowa Department of Transportation, Ames

Iowa Highway Research Board, Ames (instrumentation and monitoring)

RESEARCHER: Iowa State University Bridge Engineering Center, Ames



The precast approach slab system is intended for use in either new construction or rehabilitation/reconstruction applications. It can be installed in single lane widths to permit staged construction with minimal disruption to traffic.

One objective of the research is to eliminate the annoying “bump at the end of the bridge” that vehicle drivers often experience. This phenomenon is caused by pavement settlement from consolidation or erosion of the underlying embankment material and can be as much as several inches.

While precast concrete approach slabs will not prevent this settlement, they provide a rapid reconstruction solution for approach slabs that have failed due to settling. The Iowa DOT also is developing a tied connection between the approach pavement and the integral abutment bridge, as well as a detail for a prefabricated paving notch.

In the Iowa DOT project, a comparison will be made between the performance of an integral abutment using the precast, post-tensioned concrete

system and conventional cast-in-place construction. Approximately 160 ft of approach slab has been constructed on a section of Highway 60 in O'Brien County near Sheldon, Iowa, using the precast system on the northbound lanes and cast-in-place pavement on the southbound lanes.

The precast bridge approach slab for the northbound lanes was attached directly to the abutments of a 300-ft-long, prestressed concrete I-beam bridge. Eight 12-in.-thick panels were placed at each end of the abutments for a total length of 160 ft at the roadway centerline. A bond breaker was provided between the precast slabs and the subbase. The two panels adjacent to each abutment were skewed at 30 degrees, and the six remaining panels were cast in 14-by 20-ft-rectangular sections. The panels were pretensioned transversely in the plant and post-tensioned both longitudinally and transversely in the field to a concrete compressive stress between 100 and 200 psi, using single 0.6-in.-diameter, 270 ksi strands. The post-tensioning ducts were grouted.

The demonstration project in O'Brien County, Iowa, uses precast, pretensioned and post-tensioned concrete approach slabs.

The cost of casting the panels for the Iowa DOT project was approximately \$190,000, or \$44 per ft² compared to \$13 per ft² for cast-in-place double reinforced approach pavement. This higher cost was anticipated, however, due to the experimental, small-scale nature of the project. As contractors become more familiar with precast paving techniques, and as the projects become more plentiful, the initial cost will steadily decrease—and the true value of this system will be seen in the life-cycle benefits.

The performance and evaluation of the precast and cast-in-place slab sections will be monitored by the Iowa State University Bridge Engineering Center. The final results of the Iowa study will not be known for some time but it is expected that the precast system will provide a viable solution for rapid reconstruction of bridge approach slabs.

For More Information

A comprehensive report on a PPCP project in California by David K. Merritt, B. Frank McCullough, and Ned H. Burns was published in the *PCI Journal*, Vol. 50, No. 2, March-April 2005, pp. 18-27. The article is titled “Design-Construction of a Precast, Prestressed Concrete Pavement for Interstate 10, El Monte, California.” Copies are available from PCI at www.pci.org or info@pci.org.

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

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Accelerated Construction and Rapid Response

by M. Myint Lwin

The vision of the Federal Highway Administration (FHWA) is to improve transportation for a strong America. In support of this vision, the FHWA's bridge community is dedicated to working with national and international partners in the areas of research, deployment, and education with innovative technologies to provide safe, durable, and strong bridges.

There are about 600,000 bridges on the public roads in the United States. The average age of these bridges is about 43 years. These bridges represent a sizable investment of resources. Many of these bridges are in need of rehabilitation, widening, or replacement. New bridges are being added to the inventory. It is vitally important for us to protect, maintain, and preserve the aging population of bridges and to achieve durability in new construction. We need innovative techniques, strategies, and technologies in modern construction to improve quality in construction, reduce traffic congestion, improve work-zone safety, and achieve economy.

Accelerated bridge construction (ABC) is an innovative technology to reduce construction time on highway projects, improve construction quality and work-zone safety, and reduce adverse impacts on the traveling public. ABC uses prefabricated systems extensively to ensure quality in the constructed projects, minimize on-site disruption to traffic, and improve safety in the work zone. Prefabricated elements for the substructure and superstructure and complete bridge systems for rapid replacement are available and have been used for several years. Prefabricated systems allow bridges to be built in days or weeks rather than months or years.

In 1995, the George P. Coleman Bridge in Virginia, the largest double-swing bridge in the United States was dismantled and replaced in only 9 days using barges. In 2006, the Florida

Department of Transportation used self-propelled modular transporters (SPMTs) to remove and replace a bridge superstructure in northeast Orlando as described in the article in this issue by Mary Lou Ralls.

ABC has been deployed effectively in rapid response to bridges damaged or destroyed by over-height vehicles, ship collisions, and natural disasters, such as hurricanes, earthquakes, and floods. In 2006, the Louisiana Department of Transportation and Development removed and replaced the superstructure of the eastbound and westbound I-10 bridges in Rayne in a few hours using SPMTs. The bridge damage was by an over-height truck.

'Accelerated bridge construction can help build bridges safer, faster, and better.'

In 1999, the Transportation Research Board formed Task Force A5T60 to promote accelerated construction in the highway infrastructure. The task force uses a process called Accelerated Construction Technology Transfer (ACTT) with the aim of reducing construction time, dramatically saving money, and improving safety and quality by minimizing delays and hazards associated with work zones. In 2002, the task force completed two very successful ACTT workshops. Since then, FHWA in collaboration with the AASHTO Technology Implementation Group continues the effort and conducts workshops in various states. The ACTT process begins with a 2- to 2½-day workshop in which a multidisciplinary team of 20 to 30 national transportation experts works with an equal or greater number of their local counterparts to

evaluate all aspects of a project and develop recommendations for reducing construction time and enhancing safety and quality.

The Safe, Accountable, Flexible, Efficient Transportation Equity Act: Legacy for Users (SAFETEA-LU) establishes the "Highways for LIFE" pilot program with the purpose of promoting innovative technologies and practices for fast construction of efficient and safe highways and bridges, and an "Innovative Bridge Research and Deployment" program with the purpose of promoting innovative designs, materials, and construction methods in the construction, repair, and rehabilitation of bridges. To be eligible to participate in these two programs, states must submit applications to the United States Secretary of Transportation. For details on the application process, visit www.fhwa.dot.gov/hfl and www.fhwa.dot.gov/bridge.

Accelerated bridge construction can help build bridges safer, faster, and better. We must balance speed, quality, and economy to achieve long-lasting and efficient bridges.



U.S. Department of Transportation
Federal Highway Administration



National Ready Mixed Concrete Association

Founded in 1930, the National Ready Mixed Concrete Association (NRMCA) is the leading advocate for the industry. Our mission is to provide exceptional value for our members by responsibly representing and serving the entire ready mixed concrete industry through leadership, promotion, education, and partnering.

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

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

NRMCA is a principal sponsor of CONEXPO-CON/AGG. This show features over 1.5 million square feet of exhibits including an information technology pavilion and an emphasis on live demonstrations throughout the exhibit areas. The show brings together contractors, producers, and equipment manufacturers at the largest exposition in the Western Hemisphere for the construction industry.

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

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



Silica Fume Association

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

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

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

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

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



Concrete Bridges in Texas

by Randy Cox, David Hohmann, Amy Eskridge, Michael Hyzak, Gregg Freeby, Lloyd Wolf, Brian Merrill, and John Holt, TxDOT

The State of Texas has a long history of successful implementation of concrete bridges, from simple I-beam spans to graceful segmental elevated freeways. Texas itself has a wide variety of geographic areas—plains, mountains, rivers, and coastline—each demanding different construction methods and durability considerations. With 33,000 on-system and 17,000 off-system bridges, the Texas Department of Transportation (TxDOT) finds it imperative to maintain economy, durability, and function. Using precast concrete, Texas continues to report one of the lowest bridge costs in the country.

TxDOT has been in the precast, prestressed concrete arena for over 50 years. The first bridge of this type, the San Bernard River Bridge in Austin County, was a post-tensioned, cast-in-place slab span built in 1952. This was followed by the first precast concrete beams on the Corpus Christi Harbor Bridge in 1956. Notable structures now abound all across the state.

Standard Prestressed Concrete Elements

Precast, prestressed concrete beams are the predominant element used in Texas bridges. This is a reflection of the durability, low cost, and adaptability of prestressed concrete. A key factor in TxDOT's widespread use of precast, prestressed concrete beams is cross-section standardization, facilitating economical mass production of these bridge elements. No one cross-section is optimal for all bridges, leading to variations of beam type and size, each targeted to address specific bridge geometries and construction challenges.

I-beams are the most frequently used beam section due to their adaptability to a wide variety of span lengths, skew angles, and bridge curvatures. TxDOT uses five specific cross sections—its own Types A, B, and C beams along with AASHTO Types IV and VI. TxDOT's I-beam bridges are a case study in simplicity—the beams rest on elastomeric bearings, no

TxDOT builds one segmental bridge every two years.



permanent diaphragms between beams are used, and a deck slab, formed with precast sub-deck panels, is placed continuously over a number of spans, forming multi-span units. This simplicity results in TxDOT's low bridge costs.

Box beams are employed by TxDOT when the section depth of an I-beam exceeds specific bridge constraints and on rapid construction projects. These beam sections are TxDOT's own and have widths of 4 and 5 ft. They can be made with four depths ranging from 20 to 40 in. Placed side by side on bent caps and set normal to the roadway, the large shear keys are typically filled with concrete and the beams are then topped with either a concrete deck or an asphaltic concrete pavement (ACP) overlay. Transverse post-tensioning is applied only to the beams that will be topped with ACP.

Similar to box beams, TxDOT uses nonvoided slab beams, without shear keys and with a cast-in-place concrete deck. Details are provided for beam widths of 4 and 5 ft, allowing them to be fabricated on box beam precasting beds. They are available in depths of 12 and 15 in. Slab beams are excellent for short span bridges and especially when high span-to-depth ratios are necessary.

The TxDOT standard beam section best suited for rapid construction is the double tee. Details are provided for three depths ranging from 22 to 36 in. and widths of 6, 7, and 8 ft. Beam to beam connections have evolved over the years and the current connection utilizes a longitudinal

bar welded in a v-groove formed by steel plates in the flanges. When speed of construction is imperative, the beams are topped with an ACP overlay; otherwise the beams are covered with a concrete deck.

The most unique standard sections are U-beams, developed in the mid 1980s by TxDOT in close collaboration with industry. These beams are tub-shaped with sloping webs and provide a more aesthetic option than I-beams. Standard depths are 40 and 54 in., with maximum span lengths of 105 and 120 ft, respectively. Although more expensive than I-beams, U-beam bridges require fewer beams—due to their high structural efficiency—which can result in an economic advantage. U-beams are being used in urban settings and, when coupled with an aesthetic substructure, present an attractive, clean appearance.

Prestressed concrete panels (PCPs) used as stay-in-place forms for bridge decks have become the main forming system for most beam-type bridges built in Texas. Approximately 85 percent of the prestressed concrete I-beam bridges use stay-in-place PCPs. This currently amounts to over 4.5 million ft² per year. The panels effectively replace the bottom half of the bridge deck and act as a safe and convenient work platform. The use of PCPs, first researched by TxDOT in the early 1960s and with widespread use in the early 1980s, represents a major improvement in the speed, cost, and safety of superstructure construction.



The new beam section can vary in depth from 70 in. on the left to 28 in. on the right.

New Generation Beams

Recently TxDOT began developing a new I-beam with the goals to improve the span-to-depth ratio, facilitate wider beam spacings, have a stable beam that is safe to handle and erect, and to take advantage of material improvements. The precast concrete industry joined TxDOT in the beam development process, providing valuable insight into beam production needs.

The new beam sections have a wide top flange resembling a bulb tee, but with a substantially larger bottom flange. Seven depths were created, covering all the sizes TxDOT uses from 28 to 70 in. The new beam has options to use 1/2- or 0.6-in.-diameter strand and the 7-in.-thick web allows for additional clear cover over the shear reinforcement to increase durability.

Numerous parametric studies were conducted during the preliminary development. Results from the studies indicate that, when compared to TxDOT's current I-beams, the new beams frequently allow for the elimination of at least one beam line from a given span. At a given span length, the new beams require a lower

Precast bent caps produced cost savings, reduced traffic disruption, and improved work zone safety on the Jim Cowan Bridge, Lake Belton.



initial concrete strength than the current I-beams. Span-to-depth ratios are increased, with the greatest benefit being achieved in the shallower beam sections.

Innovation and Rapid Construction

TxDOT repeatedly looks to innovative solutions for both rapid construction projects and unique site constraints. Combining precast elements with existing standard beams increases the flexibility of construction and aesthetic options. Precast bent caps have gained popularity over the past 15 years, being used in applications over both water and busy interstate traffic.

The Jim Cowan Bridge over Lake Belton features both prestressed concrete U-beams and precast concrete bent caps. This 3800-ft-long structure won a Precast/Prestressed Concrete Institute (PCI) Design Award in 2005. The bridge employed an innovative cap-to-column connection. This connection facilitated the use of a precast concrete design, which featured relatively large precast hammerhead bent caps. Precasting the large, aesthetically pleasing caps produced significant cost savings, reduced traffic disruption, and improved both work-zone safety and product quality. The bridge has 54-in.-deep U-beams, topped with PCPs and a cast-in-place topping. Cast-in-place twin columns, which facilitated underwater construction, support the precast caps.

In 2004, the pretopped U-beams debuted. The beams were developed at the initiative of the Texas precast concrete industry to provide an alternative section for rapid construction projects. The pretopped U-beam is a version of the standard U-beam. Instead of using PCPs to form the deck, a 7-in.-thick slab is cast on the beam by the fabricator, providing a total beam depth of 34 in. The beams are spaced with a 1- to 8-in.-wide gap between flanges, and the deck is completed with a closure pour over the gap and a 4-in.-thick topping. The pretopped U-beam is best suited for long-span structures that require a shallow superstructure.

The pretopped U-beam was first implemented on a totally prefabricated bridge project, Loop 340 over I-35 in Waco, Texas. Because I-35 is a major interstate route through Texas, minimizing impact on the traveling public was of utmost importance. Along with the pretopped U-beams, unique precast columns that support each beam line were designed for the project. A direct result of the speed of construction emphasis was beam placement with only one traffic closure. The

precast deck also reduced the amount of forming that must be done over the traffic lanes, making a safer environment for the workers.

Another beam developed for rapid construction is the decked slab beam. This beam falls into a class with box beams, double-tee beams, and slab beams—well suited to off-system replacements that must be opened quickly to minimize disruptions caused by long detours.

The decked slab beam was developed for an off-system bridge project built in February 2006. This bridge, over Battleground Creek near Austin,

Pretopped U-Beams provide an instant work surface as illustrated in the bridge project, Loop 340 over I-35 in Waco, Texas.



Texas, won a 2006 PCI Design Award. The decked slab beam is a standard 5-ft-wide, 15-in.-deep slab beam with an integral 8-in.-thick, 7-ft 6-in.-wide slab on the top creating a T-shaped beam. The bridge was completed in just six weeks.

The advantages of the decked slab beam are a reduction of cast-in-place concrete in the bridge, quick installation, a very shallow superstructure, and a wide cross-section that minimizes the total number of beams. All of these benefits were essential to the success of this particular project. The weight of these beams, 1700 plf, required special considerations for transporting and erecting. Also, the project used precast abutments connected to steel piles, an ACP overlay, and bolted rails, all aimed at simplifying installation.

Segmental Concrete Bridges

Texas leads the nation in the number of concrete segmental bridge spans. The first precast segmental structure, built in 1972, was the John F. Kennedy Memorial Causeway in Corpus Christi. Currently, TxDOT builds approximately one segmental bridge every two years. Segmental



The decked slab beam was developed for rapid construction (completed in just 6 weeks) in the County Road 453 Bridge over Battleground Creek.

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bridges are very economical for spans of 300 ft or greater, and have found much favor along the Texas coast, where seven structures are built or under construction. Segmental structures have also been beneficial in urban settings when repetition of spans can be achieved. Long, elevated segmental structures have been built in Wichita Falls, Austin, and San Antonio. After solving some grout placement issues in the early years, the durability of segmental bridges has proven excellent.

The only precast concrete segmental cable-stayed bridge in Texas is the Veteran's Memorial Bridge spanning the Neches River near Port Arthur. The bridge was built in 1991 and has a main span of 640 ft. The pier towers and bridge superstructure are made from precast, post-tensioned segments and the bridge is a tribute to the efficiency and durability of precast concrete construction.

Bridges in Texas

Concrete bridges are a hallmark of the Texas transportation system. In fiscal year 2005, Texas placed almost 1 million linear feet of precast, prestressed concrete beams, enough to stretch from Dallas to Austin laid end-to-end. Prestressed concrete beams and panels help Texas maintain one of the lowest bridge construction costs in the United States. Excellent durability of the precast elements minimizes life-cycle costs. Increased speed of construction minimizes the impact to the traveling public and increases safety in the work zone for both motorists and construction personnel. The development of standard beam designs and a constant look toward innovative solutions will ensure that precast concrete will continue to meet the needs of the Texas bridge building efforts.

For more information on Texas' bridges, visit www.dot.state.tx.us/bridge.



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Sedgwick County, Kansas, uses unique designs to aid construction of both concrete bridges and culverts



Concrete Bridges and Culverts Create STRONG OPTION

By David Rushton and Lynn Packer

Sedgwick County's engineers oversee the most bridges of any county in Kansas, including 652 bridges with a length of 20 ft or more and 7500 culverts with shorter lengths. That volume and diversity is both a blessing and a curse. Fortunately, we have developed creative design approaches to help facilitate construction of all types of structures.

The range of work provides a lot of opportunities for design, but it also creates a continual maintenance operation. As a result, we have been designing more concrete bridges recently, as we find steel creates maintenance problems. Part of our success in that regard centers on our design of post-tensioned haunched slabs because they create a superior product.

Post-Tensioned Haunched Slabs

The cast-in-place concrete spans feature post-tensioning running both longitudinally and transversely. The use of post-tensioning allows us to create spans about twice as long as a typically reinforced concrete, haunched slab could provide. The longest span used with the post-tensioned, haunched slab to date has been 106 ft.

Sedgwick was the first county in Kansas to use this design, and we have created approximately 24 of these projects since our first one in 1989. It has become a popular option with the Kansas Department of Transportation (KDOT), which created a family of designs based on this concept for span lengths from 50 to 92 ft. Thus, consultants working in our county can download drawings from the KDOT website and have our design at hand.

We build many bridges of all types and sizes including concrete slab spans, concrete girder

spans, and precast concrete spans—whatever best suits the situation.

Box Culverts

For our culvert projects, we typically use precast reinforced concrete box (RCB) structures below ground for controlling rainwater runoff throughout the county, in both rural and more developed areas. The program provides definitive advantages in economy and speed of construction that benefit citizens through more efficient use of funds and shorter traffic disruptions.



Installation of culverts is simple and quick.

The use of precast box culverts began in 1999 but really took off in 2002. Our second project involved a 114-ft-long double 10- by 4-ft culvert that was installed by our maintenance crews. It was a big undertaking, but it sold us on this approach. Today we're doing multiple applications each year.

In 2004, our budget allowed us to purchase 500 linear feet of 6- by 3-ft RCBs that we store in the yard. We took this approach following two deck failures, one through unexpected deterioration and one from an accident. If the boxes had been available then, we could have

had the culverts replaced in two days rather than the month or more that each required.



Precast concrete box culverts provide fast construction, economy, and erosion prevention.

We've now created a precast concrete "soil saver" with the help of our local precaster, Wichita Concrete Pipe. A soil saver prevents erosion when a sudden or steep drop in flow-line elevation is necessary in a channel. It basically consists of a RCB cell cut in half and placed on end at the upstream end of the culvert. It's physically attached to the culvert to prevent hydraulic uplift.

To date, we have completed two projects with lengths of 21 and 14 ft. They have proven to be cost effective and functional. The best part is that the soil saver can be delivered with the other precast concrete components, rather than having to have it installed after the fact and slow down completion.

David Rushton is Bridge Engineer and Lynn Packer is Engineer with Sedgwick County Public Works.

Kansas K-beams are typically used, but the use of T-shaped walls and box beams are offering new applications for concrete

Wichita Projects Expand City's CONCRETE USAGE

By James Armour

Two cable-stayed pedestrian bridges are underway to span the Arkansas Rivers in Wichita. The bridge design suggests a bow, with the pylons representing an arrow being shot into the air.



The City of Wichita constructs bridge projects using a variety of materials. Each situation is evaluated for the site logistics and benefits provided. The result is that more than 50 percent of the bridges we erect use concrete, often with Kansas Department of Transportation K-beams for the precast, prestressed concrete members. The Kansas K-beams have a similar cross section to the AASHTO I-beams. Today, our concrete projects involve some unusual designs, including a large number of precast concrete T-shaped walls and a drainage project using concrete bridge components that we are constructing in conjunction with Sedgwick County.

Our typical bridge projects are approximately 160 to 200 ft long and are designed as overpasses above roadways. Usually, these occur where freeways intersect with roadways that we need to keep at grade level. The bridges typically include a cast-in-place concrete deck with a 1- to 2-in.-thick silica fume topping to provide a durable surface.

Working with consultants on each project, we have used precast concrete components on a wide range of designs because it has proven to be advantageous, particularly for shorter spans. Generally, we have enough lead time to allow us the option of using any material. We usually don't need to take advantage of the speed of erection that precast concrete can provide. However, speed of construction is a critical element in our considerations, as we try to reduce traffic disruptions as much as possible.

The city is currently building two asymmetric cable-stayed pedestrian bridges with lengths of 331 and 251 ft across the Big Arkansas and Little Arkansas Rivers, respectively. The superstructure consists of match-cast, two-cell, box girder



Match-cast segments are being used for the cable-stayed pedestrian bridge.

segments 32 ft long, 12 ft 4 in. wide, and 4 ft deep at the longitudinal centerline. Each segment weighs 57 tons. The segments are erected on falsework and post-tensioned longitudinally by four tendons before the stay cables are attached and falsework removed. Specified compressive strength for the concrete is 6500 psi. A 1½-inch-thick silica fume concrete overlay is cast on the segments after the stay cables are attached.

Two recent projects have involved unusual concrete applications that have extended the ways in which we use concrete. The first of these is the use of precast concrete T-shaped walls to aid in a \$100-million railroad improvement program following the merger of the Union Pacific and Burlington Northern Santa Fe railroads. The goal was to elevate the tracks at the site of at-grade crossings to reduce disruptions to traffic.

Using T-shaped walls allows us to cast the sections in advance and have them ready when the train tracks are detoured from the construction site. The T-shaped walls then are placed and backfilled to create a retaining wall as high as 30 ft. The new tracks are placed on the retained area. Several thousands of these T-shaped wall sections are being used on the project, which began in 2004 and will continue until June 2008.

The second project underway is in conjunction with county officials and involves the use of precast concrete box beams as drainage pipes for the new arena being built in downtown Wichita. The project, which required countywide approval, features 9- by 5-ft box segments that connect the arena roadway with the river about a half-mile away.

This project also gave us the opportunity to upgrade the existing storm sewers to alleviate drainage problems in the downtown area. The larger cross-section of the precast box beams ensures a smoother flow of water than a traditional pipe with a smaller diameter. The second phase of that work began in February, with the project scheduled for completion by fall, 2007.

These examples of some of the different ways the city uses concrete components show the diversity of the projects we are involved with and the ways we can use the material to our advantage for applications other than as beams to create bridge spans.

James Armour is City Engineer for the City of Wichita, Kansas.

Process for Revisions and Additions



by Dr. Dennis R. Mertz

The AASHTO Subcommittee on Bridges and Structures (SCOBS), a subcommittee of the AASHTO Standing Committee on Highways, is responsible for maintaining the *LRFD Bridge Design Specifications* through annual revisions and additions. The subcommittee basically consists of the chief bridge engineers of the 50 states and other territories and agencies. It is currently chaired by Malcolm T. Kerley, Chief Engineer of the Virginia Department of Transportation.

At the annual meeting of SCOBS, revisions and additions to the various AASHTO bridge-related documents, including the *LRFD Bridge Design Specifications* and the *LRFD Bridge Construction Specifications* are brought to the floor as agenda items. These items are recommended by the appropriate technical committee for adoption by the entire subcommittee. Those revisions and additions approved by the subcommittee are published in the subsequent year as interim revisions to the documents or if enough revisions and additions have been made over the years, incorporated into new editions of the entire documents.

Currently, SCOBS has 20 technical committees, designated T-1 through T-20:

- T-1 Security
- T-2 Bearings and Expansion Devices
- T-3 Seismic Design
- T-4 Construction
- T-5 Loads and Load Distribution
- T-6 Fiber Reinforced Polymer Composites
- T-7 Guardrail and Bridge Rail
- T-8 Moveable Bridges
- T-9 Corrosion
- T-10 Concrete Design
- T-11 Research
- T-12 Structural Supports for Signs, Luminaries, and Traffic Signals
- T-13 Culverts
- T-14 Structural Steel Design
- T-15 Substructures and Retaining Walls
- T-16 Timber Structures
- T-17 Welding

T-18 Bridge Management, Evaluation, and Rehabilitation

T-19 Computers

T-20 Tunnels

The technical committees consist of members of SCOBS or their representatives, and one or two representatives of the Federal Highway Administration (FHWA).

The agenda items under development by the technical committees are generated by several sources. The more significant revisions and additions to the AASHTO documents come to the technical committees through completed research projects from the National Cooperative Highway Research Program (NCHRP). The NCHRP is funded by the states and the FHWA and administered by the Transportation Research Board (TRB). Potential research projects to improve the suite of AASHTO documents are identified by Technical Committee T-11, Research, in conjunction with the other technical committees. The projects are recommended by the AASHTO Standing Committee on Research (SCOR) for consideration by AASHTO's Board of Directors. The original edition of the *LRFD Specifications* was the product of NCHRP Project 12-33.

Research problem statements come to Committee T-11 from various sources. The TRB committee system is one source of a prioritized list of research problem statements, which is submitted via the TRB Structures Section. Other research problem statements come directly from the other AASHTO technical committees. Research problem statements are welcome from a TRB committee, AASHTO technical committee, or directly to Committee T-11. For consideration by Committee T-11, the research problem statement must address one of the grand challenges identified in the 2005 strategic plan for bridges found on the SCOBS website.

Other agenda items result from deficiencies of the AASHTO documents brought to the technical committees by the states, FHWA, or other bridge industry sources. Sometimes, the deficiencies are brought to the technical committees along

with suggested revisions or additions to address the deficiencies. Other times, the technical committees work with concrete industry representatives to produce the necessary revisions or additions.

Technical Committee T-10, Concrete Design, is responsible for concrete bridge-related design issues, for both reinforced and prestressed concrete in the various AASHTO documents. Their main responsibility is Section 5, Concrete Structures, of the *LRFD Bridge Design Specifications*. The 16 member technical committee is currently chaired by David Hohmann, Design Section Director of the Bridge Division of the Texas Department of Transportation. At the 2006 meeting of SCOBS, Committee T-10 brought nine agenda items to the floor of the meeting. The committee had been developing these nine agenda items and other working agenda items over the past year or more. This technical committee typically meets during the SCOBS annual meeting, the Precast/Prestressed Concrete Institute (PCI) Committee Days in the spring, the PCI Annual Convention in the fall, and the American Segmental Bridge Institute (ASBI) Annual Convention, later in the fall.

Technical Committee T-10's nine 2006 agenda items were passed by the full subcommittee and are included in the Fourth Edition of the *LRFD Bridge Design Specifications*, which was published at the beginning of this year. The next edition of this column will highlight the revisions and additions represented by these nine agenda items.

For the most part, the annual meeting of SCOBS and its technical committees are open to the public. For more information on the AASHTO Subcommittee on Bridges and Structures and its technical committees, and the 2005 strategic plan for bridges, go to <http://bridges.transportation.org>. This year's annual meeting of SCOBS will be held on July 8 through 12, in Wilmington, Delaware. For more information, go to http://www.deldot.net/static/aashtobridge2007/one_pg_welcome.

HAMILTON FORM CREATES FUNCTION

2

CASE STUDY

ESCAMBIA BAY BRIDGE



"The forms work perfectly. Hamilton Form builds high quality, well-thought-out forms that have contributed to the success of many of our projects."

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



The Challenge:

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

The bridge elements include a heavily reinforced pile cap with a unique "on-site," cast tension connection to the precast/prestressed pile. This *moment connection* was designed to provide a continuous beam configuration and provide resistance to uplift from potential future storm surges.

The Solution:

Hamilton Form built the custom formwork including the piling, pile cap and BT78 forms. The pile cap form design includes two-piece, tapered voids at the connection locations to allow the top to be "popped" after initial preset of the concrete to accommodate final stripping.

The Results:

The forms are working perfectly. The project is progressing within budget and ahead of schedule. The eastbound bridge opened 11 days early to the delight of motorists. The westbound bridge is scheduled to open in November 2007.

To learn more about Hamilton Form visit www.hamiltonform.com



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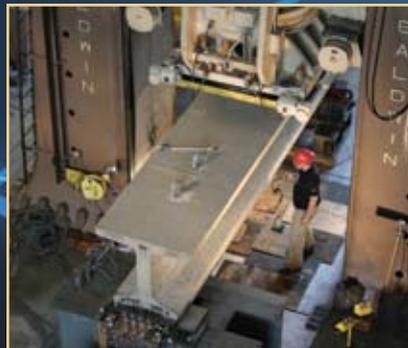
A Passion for Engineering

Eriksson Technologies was founded in 1998 with a singular objective: the passionate pursuit of technical excellence. This philosophy is evident in every aspect of our company, from our highly acclaimed technical support down to the smallest technical details of our software. It's what has made us the preferred provider of engineering software to many DOTs, consulting engineers, precast fabricators, and universities nationwide.

Software

First and foremost, Eriksson Technologies is a software company. We design and develop engineering application software to meet the needs of professional bridge engineers.

Our first product, PSBeam™, set a new standard for performance and technical excellence. Now, we've raised the bar again. Developed in the .NET Framework, ParaBridge™ will change the way you design bridges. Integrated, 3D design will become the new engineering paradigm.



Research

Eriksson understands bridge engineering. We stay abreast of proposed specifications changes and new design methodologies through our active involvement in industry committees and our participation in cutting-edge research.

Our typical role on a research team is to serve as the vital link between pure research and engineering practice, which gives us special insight into the behavior of bridges. Better understanding of the underlying theory gives us a strategic edge in developing better modeling tools.

Training

Through our technical seminars, we have trained hundreds of practicing engineers to successfully make the transition to LRFD and helped them stay current with yearly changes in the specifications.

In addition to our own highly qualified staff, we tap industry experts to create and deliver a training experience that is second to none.

Theory and application are combined to provide a highly effective vehicle for transferring technology to our most important asset: our clients.

DF Moment, Interior Girder
For Beam-Slab Bridge (type K), Two or More Design Lanes:

$$M_{DF} = 0.075 \left(\frac{S}{0.5} \right)^{0.75} \left(\frac{S}{L} \right)^{0.75} \left(\frac{K_y}{12.9L} \right)^{0.75}$$

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



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Precast concrete footings were set on a flowable grout bed, and leveling screws were installed near each corner to adjust the footings to the proper grade.







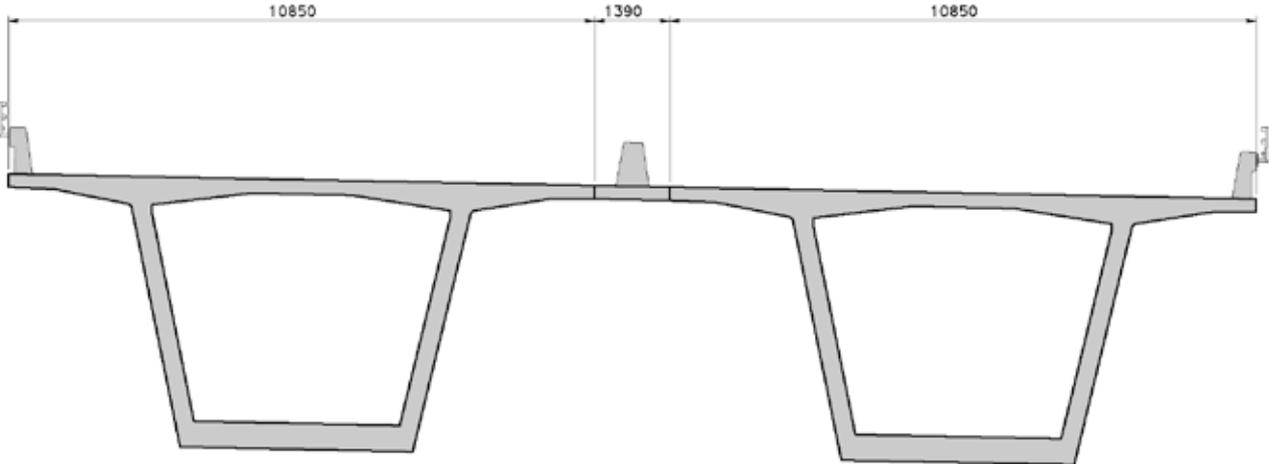
Seven precast concrete box beams were erected. They were cast with high-performance concrete, allowing the 115-foot bridge to be designed as a single span.



The bridge features a total precast concrete design, including box beams, abutments, wing walls and footings.



The new 115-foot, single-span precast concrete bridge carrying Mill Street over the Lamprey River in Epping, N.H., was finished with eight days of construction, which followed six weeks of preparation.



TYPICAL SECTION

