ASBI

AMERICAN SEGMENTAL BRIDGE INSTITUTE

2011 Bridge Awards of Excellence

Photo Courtesy of FHWA

2011 Bridge Awards of

In recognition of the owners of bridges which exemplify concrete

In the fifth biennial American Segmental Bridge Institute (ASBI) Bridge Award of Excellence competition, nine projects were selected as outstanding examples of segmental concrete bridge construction. Judging for the 2011 program took place at the Florida Department of Transportation office in Tallahassee, Florida, hosted by Robert Robertson, Jr., State Structures Design Engineer, Florida Department of Transportation—Structures Design Office.

Excellence

segmental bridge design and construction excellence.

All concrete segmental or cable-supported bridges located within the 50 United States and completed between January 1, 2009 and August 1, 2011 were eligible for the 2011 awards competition. The jury also considered international projects involving ASBI members. Entrants in the competition were judged on the basis of the following criteria:

- **Innovation of Design and/or Construction**
- **Rapid Construction**
- **Aesthetics and/or Harmony with Environment**
- **Cost Competitiveness**
- **Minimization of Construction Impact on the Traveling Public (When Applicable)**

Bridge Awards Jury

John Crigler
VSL

Thomas Graf
Kokosing Construction Company, Inc.

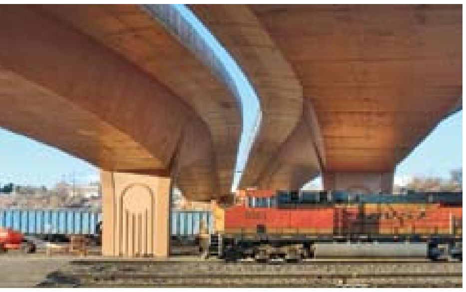
M. Myint Lwin
Office of Bridge Technology, Federal Highway Administration

Robert V. Robertson, Jr.
Florida Department of Transportation

Ron Watson
R.J. Watson, Inc.

BRIDGE AWARD OF EXCELLENCE WINNERS:

Awards will be presented to bridge owners' representatives during the 2011 ASBI Convention Awards Luncheon, Tuesday, November 8 at the Marriott Wardman Park, Washington, DC. Following are jury comments, project details, and participant credits for the winning entries (ASBI Members are noted in bold).



4th Street Bridge

The 4th Street Bridge is a major east-west route through the center of historic downtown Pueblo, connecting I-25, downtown, and western residential neighborhoods. It carries State Highway 96A over a small city street, the UPRR/BNSF Railroad Yard containing a total of 28 tracks, a floodwall painted with community art, the Arkansas River, and the Arkansas River trail and recreation area.

The Bridge Owner recognized not only the challenges of constructing a new bridge at this complex site, but also the importance of strong community involvement for a new bridge that would become a focal point defining the City of Pueblo. Minimizing disturbance to Railroad operations, the traveling public, and local businesses, while preserving environmental wetlands and recreational areas along the Arkansas River were coupled with developing a bridge project with community vision and consensus.

Innovation of Design and/or Construction

Geometrics of the railroad yard, its proximity to the river and local businesses, and the need to maintain busy yard operations during construction required a unique design and construction solution. After carefully studying many different layouts and structure alternatives, the bridge designer determined a long-span, cast-in-place concrete segmental bridge was the most cost effective solution with minimal disruption to both the Contractor and the Railroads during construction. Careful pier placement and longer spans ensure that required clearances were met, while building from above in balanced cantilever fashion allows rail operations and river use to continue.

Pier locations within the yard were chosen to satisfy railroad clearance requirements. To span the 23 UPRR tracks, a single, long-span was required. One main-span pier was located beyond the westernmost track along the toe of the floodwall, and the other along the edge of the east yard road, adjacent to the UPRR mainline track. These pier locations led to the Colorado-record 378-foot clear span over the UPRR.

Span balancing for the most efficient design and site constraints dictated pier locations outside of the yard. Side spans of approximately 230 feet provide clear spans over the BNSF yard with five tracks to the east and the floodwall and Arkansas River to the west.

The resulting layout reduced the number of piers in the railroad yard from five to one, enhancing safety and greatly opening the yard. Balanced cantilever construction from above eliminated the need for large, ground-based equipment within the rail yard and Railroad operations were virtually unaffected by bridge construction. Side spans were constructed on falsework, taking advantage of the readily available ground access on each side of the project. The side spans were joined to the cantilever construction through eight-foot long closure joints to establish continuity of the bridge.

Bridge Aesthetics

The 4th Street Bridge has a long history, being a critical link and focal point of the Pueblo community for more than 100 years. Although the complex site conditions drove the 4th Street Bridge design, a focus on community involvement during the design process created a unique, signature

Jury Comments

The difficult challenge of completing the project over 28 active sets of rail tracks, while minimizing disruptions to the traveling public and local businesses, was solved using segmental construction. The project included a Colorado record span and was completed ahead of schedule for $165/sq.ft.!

bridge for the City of Pueblo. Aesthetic and urban design features, such as project theme, color, sidewalk, pier and end treatments, lighting, and pedestrian railing style, were presented and selected through a consensus voting process.

Combined themes of Contemporary Sculpture, Natural Environment, and Pueblo Heritage chosen by the community led to bridge form and guided aesthetic treatments. Pueblo's local art focus is planned to be represented in special pier medallions, bridge end monuments, and pedestrian treatments. The new bridge is a landmark structure defining the landscape and providing a gateway to Pueblo.

Cost Competitiveness

The winning Contractor was awarded the contract for a total price of $27.7 million, resulting in a cost of $165 per square foot. At the time of bid, the Owner allowed Contractors the option to bid on alternate designs to consider other structure types and increase competition. The two alternate bridge designs did not specifically address impacts to the Railroad operations during construction and were approximately $5 million higher than the segmental design.

Minimization of Construction Impact on the Traveling Public

In addition to keeping the rail yard operational during construction, traffic also needed to keep moving on the existing bridge. Continual traffic flow during construction was one of the Owner's major goals. To keep traffic moving through the corridor, the westbound bridge structure was constructed first, and then all four lanes of traffic were temporarily transferred to the new westbound structure while the eastbound bridge was completed. Construction began in December 2007 and was completed in December 2010, approximately six months ahead of the contract completion date.

CREDITS

Owner:
Colorado Department of Transportation

Owner's Engineers: **FIGG**

Designer: **FIGG**

Contractor: **FLATIRON**

Construction Engineering Services:
Finley Engineering Group, Inc.

Constructability Review/Estimating Services: **FIGG**

Construction Engineering Inspection:
FIGG

Form Travelers for Cast-in-Place Segments: **VSL**

Post-Tensioning Materials: **VSL**

Bearings: **The D.S. Brown Company**

Expansion Joints: **Watson Bowman Acme – A BASF Company**

Prepackaged Grout: **Sika Corporation**

Pier Forms: **EFCO Corp.** and **DOKA**

All Photos Courtesy of FIGG

CLARK COUNTY, NEVADA & MOHAVE COUNTY, ARIZONA

Hoover Dam Bypass Bridge

A dramatic new concrete arch joins the setting of the historic Hoover Dam, spanning the Black Canyon between the States of Arizona and Nevada. The 1,900-foot-long Colorado River crossing is the centerpiece of the $240 million, four-lane Hoover Dam Bypass Project, which included 3.5 miles of new approaches on both sides of the river and seven other bridges.

With a 1,060-foot main span, the Mike O'Callaghan-Pat Tillman Memorial Bridge or Hoover Dam Bypass Bridge is the fourth-longest, single-span concrete arch bridge in the world and exemplifies innovation at work. The project team overcame formidable obstacles and, as a result, a world-class structure was born. It now frames the view of the Black Canyon from Hoover Dam for the coming generations of tourists, and is the cornerstone in a new, efficient highway system funneling commercial traffic between the states of Nevada and Arizona. The project reflects the skill and determination of the people who built it, all of whom take pride in their accomplishment. Delivered on time and within budget, America's newest wonder bridges between the iconic marvel it protects and the brilliant problem solving of modern engineering. A groundbreaking dedication ceremony was held on October 14, 2010. The bridge opened to traffic on October 19, 2010.

Innovation of Design and/or Construction

The bridge design satisfied objectives for both architectural and performance. The environmental document required an open structure that would not encroach on the views of the dam or the surrounding terrain of the national historic landmark at Hoover Dam. The engineering performance needed to withstand the demands of wind, earthquake, and service loads well beyond the codified 75-year life.

The approach to design addressed each criterion with a deliberate engineering evaluation and design. The twin arch ribs evolved from the assessment of seismic performance. The arch ribs are reinforced concrete members, designed to be cast with the stayed-cantilever construction method. Cantilever construction of a reinforced concrete box section is rare. This approach was carefully engineered during design on the basis of controlled crack width as well as strength. The elimination of temporary post-tensioning for the arch was a significant savings for construction.

The design team conducted special site studies to address the seismicity of the site and performed an extensive geological reconnaissance as part of a probabilistic site hazards analysis. The resulting design was based on a 1,000-year event, and the PGA was set at approximately double the then codified value. The new AASHTO PGA, established four years after the start of design is approximately the same value as selected for design.

The Hoover Dam Bypass Bridge was built using a variety of limited access techniques in order to gain access from the canyon rims. Excavation was pioneered from the Nevada cliff using mining techniques for limited road access. Two unique 2,500-foot cableways carried workers and 45 tons of material and equipment into place during construction. With cables hanging from 330-foot-tall towers, a 13.5 ton trolley and load block assembly was the key to delivery of men and materials to the work front. The concrete segments for the arches were poured using four headings of self-advancing form travelers. Most of the arch segments were placed at night to avoid the triple-digit desert temperatures reaching as high as 120˚F.

Jury Comments

This project resulted in an iconic landmark structure set in the Colorado River's Black Canyon with a view to Hoover Dam. The Hoover Dam Bypass Bridge is an extreme solution to an extreme challenge. Spectacular!

Liquid nitrogen was required to control the peak curing temperature of the high performance concrete. Every second arch segment was supported by a temporary stay cable, with tuning required at many stages in order to control geometry. The arch was closed in August of 2009.

Computer models run on site were used by the contractor to calibrate controls used to set headings for the arch cantilevers. This real-time process led to greater construction efficiency, allowing the contractor and designer to communicate in live time with construction, providing for immediate reviews of adjustments to the erection procedures and target geometry. An automatic surveying and monitoring system helped the team to record and analyze how construction operations impacted behavior of the bridge structure, as well as measuring the deflections due to wind and temperature. This data was critical to the arch ribs being properly aligned within ¾ of an inch at closure as the ribs met in the middle of the canyon. A specialized wind monitoring system throughout the project site, including atop the cranes, helped to provide continuous readings to address wind effects on construction operations.

With an average of 14,000 vehicle crossings per day, the stretch of U.S. 93 crossing Hoover Dam impeded the safe flow of traffic along the corridor. The new bridge reroutes traffic from the two-lane bottleneck across the dam, therefore improving driver and pedestrian safety, as well as air quality. Bypassing the dam reduced travel time and fuel consumption for motorists traveling between Las Vegas and Phoenix. Following the 9/11 terrorist attacks, trucks were detoured 23 miles from the dam, costing $30 million annually in delays and fuel consumption along a critical North American Free Trade Agreement (NAFTA) trade route. The Hoover Dam Bypass Bridge benefits the local economy by restoring a critical NAFTA trade route for about 2,000 trucks per day ensuring a safer and faster U.S. 93. America's newest wonder helps protect the iconic Hoover Dam from possible future threats, while reducing travel congestion for millions of motorists, as well as enhancing the visitor experience for the 3,000 daily tourists visiting the Hoover Dam.

Aesthetics and/or Harmony with Environment

With the project site in the shadow of an American landmark, the entire project team felt a responsibility to respect the historical context and complement the design of the Hoover Dam. The design team reported to an independent advisory panel regarding historic, aesthetic and cultural aspects of the project. The challenge of the design advisory panel was to "...strive for engineering excellence in the design of today that honors the engineering excellence that went into the Dam in its day."

All Photos Courtesy of FHWA

CREDITS

Owner:
States of Nevada and Arizona
Program Manager **FHWA Central Federal Lands Division, Denver, CO**

Owner's Engineers:
HST **(HDR Engineering, Inc., Jacobs Engineering Group** (formerly Sverdrup), and **T.Y. Lin International)**

Designer:
T.Y. Lin International (River Bridge Lead) and **HDR Engineering, Inc.** (Overall Bypass Lead)

Contractor: Obayashi-PSM JV

Construction Engineering Services:
OPAC and **McNary Bergeron & Associates**

Construction Engineering Inspection:
FHWA/CFL with **Parsons Brinckerhoff, PBS&J**

Precast Producer: Obayashi PSM, JV

Formwork for Precast Segments:
EFCO Corp.

Form Travelers for Cast-in-Place Segments:
NRS

Post-Tensioning Materials:
Schwager Davis, Inc.

Stay Cable Materials:
Schwager Davis, Inc.

Bearings: **R.J. Watson, Inc.**

Expansion Joints: **Watson Bowman Acme—A BASF Company**

Epoxy Supplier: **Sika Corporation**

Prepackaged Grout: **Sika Corporation**

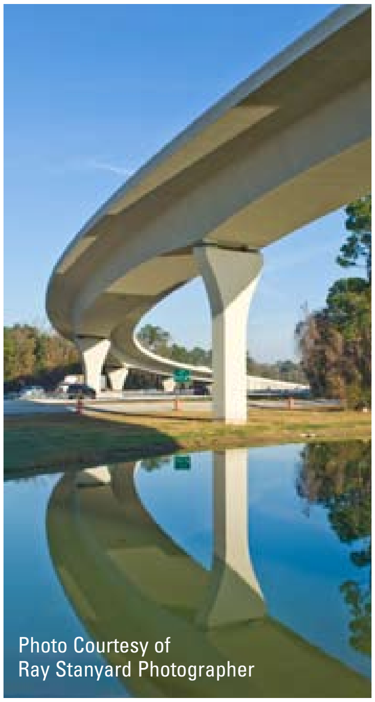


Photo Courtesy of
Ray Stanyard Photographer

I-95/I-295 North Interchange

The I-95/I-295 North Interchange project, located 1.5 miles south of the Jacksonville International Airport, is divided into three separate construction phases due to funding constraints. The purpose of this project is to improve capacity and operations by replacing the existing partial cloverleaf interchange with an all-directional four-level, system-to-system, high-speed interchange.

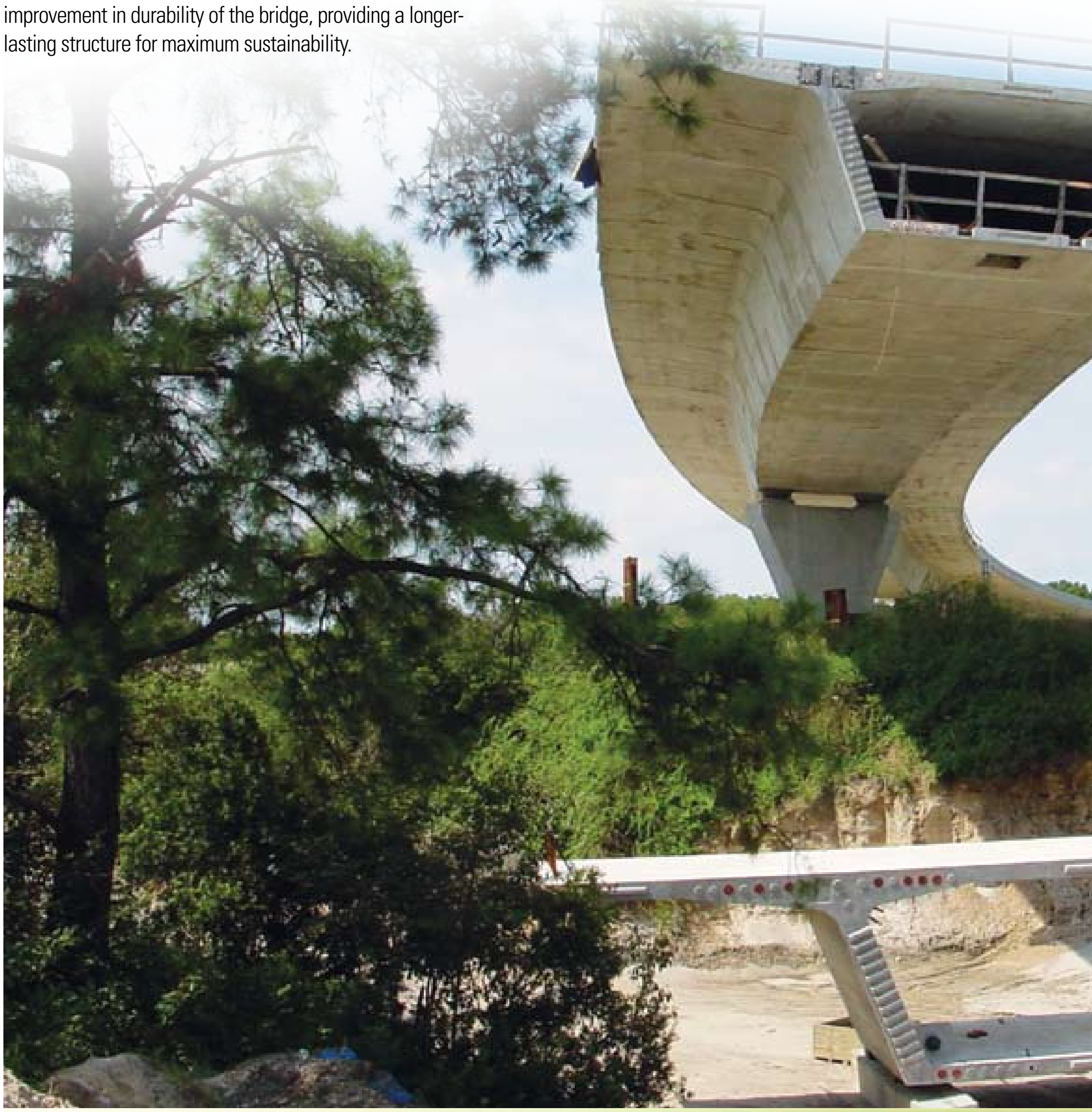
The first phase, completed in November 2010, included a new 2,256-foot-long, $16.3-million precast segmental concrete box girder flyover bridge that provides for the southbound I-95 to eastbound I-295 movement. The bridge consists of 10 spans and has a maximum span length of 274 feet and an overall width of 49 feet 3 inches. The bridge has a horizontal curvature of more than 90 degrees with a radius of 1,250 feet.

Innovation of Design and/or Construction

The I-95/I-295 flyover bridge complies with Florida Department of Transportation's latest requirements for post-tensioning systems. One of the biggest changes to the industry was the introduction of the segment duct coupler used at the interface between precast segments for internal tendons. The segment duct coupler increases the protection to the prestressing strands leading to an overall improvement in durability of the bridge, providing a longer-lasting structure for maximum sustainability.

Aesthetics and/or Harmony with the Environment

A deciding factor for the superstructure was aesthetics. This extremely long flyover was going to be a third-level structure with its underside highly visible to drivers traveling on I-95 and I-295. Since the interchange acts as a north gateway for tourists and visitors traveling from the local airport into the City of Jacksonville, FDOT agreed with city officials to emphasize aesthetic elements of the bridge.



Jury Comments

The use of precast segmental construction allowed the contractor to complete the structure during nighttime hours, lessening the impact to the traveling public. This project incorporates the owner's latest durability requirements for post-tensioning systems to improve long term sustainability and reduce life-cycle costs.

The resulting precast segmental concrete box girder is an elegant structure due to the closed box shape, clean lines and smooth bottom soffit. To further enhance the bridge aesthetics, octagonal columns were used and the capitals were flared at the top, matching the slope of the webs of the box girder. The tapered shape of the capital provides an elegant transition between the box girder and the supporting column. The columns measured 9 feet transversely and 7 feet longitudinally at their base.

Cost Competitiveness

Three types of superstructures were considered during the initial Bridge Development Report (BDR). However, only steel box girders and segmental concrete box girders were ultimately considered feasible. Each alternative was compared for aesthetics, constructability, maintenance costs, and construction cost, with consideration of the present value based on life-cycle analysis. The most influential parameter was construction cost. Construction professionals in Florida agree concrete superstructures are the most economical choice.

Typically precast concrete box girder bridges are considered economically efficient when there are over 500 segments. Since the I-95/I-295 project contained only 234 segments, a major goal of the design was to develop cost-efficient details to reduce the overall bridge cost. This goal was achieved by minimizing the number of variable depth segments, splitting the pier segments to reduce the maximum lift weight, using clean yet simple shapes for the box and specifying repetitive post-tensioning details.

The estimated construction cost for the precast segmental alternative was approximately five percent lower than the steel alternative. The segmental flyover bridge was built at a cost of $147 per square foot.

Minimization of Construction Impact on the Traveling Public

The Traffic Control Plan (TCP) was developed to minimize lane closures. The heavy skew of the bridge as it crossed the mainline of I-95 made it difficult to place segments without working over multiple lanes simultaneously. To address this issue, the TCP provided for multiple lane shifts on temporary pavement and restricted the extended lane closures to nighttime only. Segments were precast off-site and erected at night during hours of minimum traffic volume. This allowed the contractor to maintain the interstate mainline at its required operational level of service while meeting a very aggressive construction schedule.

Photos Courtesy of RS&H CS

CREDITS

Owner:
Florida Department of Transportation, District 2

Owner's Engineers:
Parsons Brinckerhoff

Designer: **Parsons Brinckerhoff**

Contractor:
Superior Construction Company

Construction Engineering Services:
Corven Engineering, Inc.

Construction Engineering Inspection:
RS&H CS, Inc.

Precast Producer:
Superior Construction Company

Formwork for Precast Segments:
EFCO Corp.

Post-Tensioning Materials:
DYWIDAG Systems International, USA, Inc. (DSI) and **General Technologies, Inc.** (Duct Coupler)

Bearings: **The D.S. Brown Company**

Expansion Joints:
The D.S. Brown Company

Epoxy Supplier: **Sika Corporation**

Prepackaged Grout: **Sika Corporation**

TACOMA, WASHINGTON

SW Line Bridge Nalley Valley Interchange

The Nalley Valley Interchange, in Tacoma, Washington, is undergoing a major reconstruction of the original interchange opened to traffic in 1971. It is being redesigned and reconstructed in several design bid-build packages that will extend over several years. The westbound viaduct is the "jumping off point" for motorists on I-5 heading west to the Tacoma Narrows Bridge and the Olympic Peninsula on State Route 16. Because this SW Line flyover was first bid as a steel box girder bridge and ended up as the Washington State Department of Transportation's (WSDOT) first precast concrete segmental bridge, the project proved to be a "jumping on point" for WSDOT as well. Volatile steel prices at bid time in October 2008 were the primary incentive for the contractor to consider redesigning the two steel bridges on the project. However, this "first" use of a precast segmental bridge would not have happened without the contractor's and owner's desire to advance segmental precast concrete technology in the state.

Innovation of Design and/or Construction

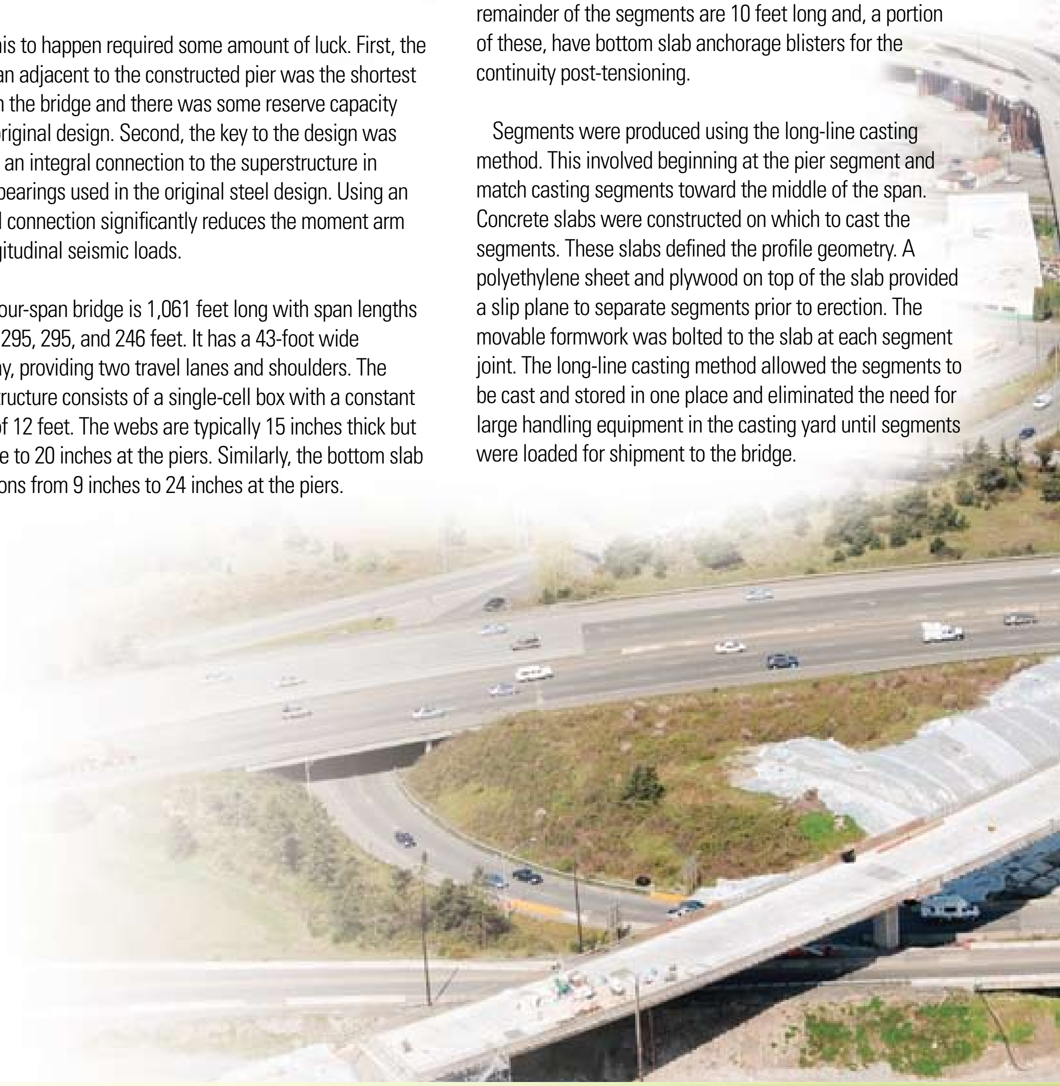
Redesigns can be challenging simply because the bulk of the engineering is performed post-bid. The larger challenge on this project was designing a concrete bridge that could be supported on a pier column that was not only designed for a steel bridge, but already had been built in a previous contract.

For this to happen required some amount of luck. First, the end span adjacent to the constructed pier was the shortest span on the bridge and there was some reserve capacity in the original design. Second, the key to the design was making an integral connection to the superstructure in lieu of bearings used in the original steel design. Using an integral connection significantly reduces the moment arm for longitudinal seismic loads.

The four-span bridge is 1,061 feet long with span lengths of 225, 295, 295, and 246 feet. It has a 43-foot wide roadway, providing two travel lanes and shoulders. The superstructure consists of a single-cell box with a constant depth of 12 feet. The webs are typically 15 inches thick but increase to 20 inches at the piers. Similarly, the bottom slab transitions from 9 inches to 24 inches at the piers.

To minimize weight and satisfy shear demands in a relatively shallow structure required the introduction of inclined post-tensioning tendons. To increase ductility and continuity for seismic demands, the inclined tendons are located in the webs and anchored at each pier. A typical cantilever consists of 15 segments in all. The first five segments from the pier are 8 feet long with thickened webs and bottom slab as well as draped web tendons. The remainder of the segments are 10 feet long and, a portion of these, have bottom slab anchorage blisters for the continuity post-tensioning.

Segments were produced using the long-line casting method. This involved beginning at the pier segment and match casting segments toward the middle of the span. Concrete slabs were constructed on which to cast the segments. These slabs defined the profile geometry. A polyethylene sheet and plywood on top of the slab provided a slip plane to separate segments prior to erection. The movable formwork was bolted to the slab at each segment joint. The long-line casting method allowed the segments to be cast and stored in one place and eliminated the need for large handling equipment in the casting yard until segments were loaded for shipment to the bridge.



Jury Comments

This first precast segmental bridge project was trend setting for the State of Washington and led to a new construction method for the owner. The owner and contractor worked together to advance precast segmental construction to overcome difficult constraints, resulting in a project that was cost effective while minimizing impact to the traveling public.

Match-casting the cantilever segments with the precast pier segments eliminated the need for a cast-in-place concrete joint and associated starter segment brackets during erection. Making the pier segment integral with the pier column was achieved by blocking out the webs and the bottom and top slabs to allow placement of the diaphragm reinforcement. The precast "shell" was erected by lowering it down over the pier column onto supporting brackets. There it could be aligned and made integral by the cast-in-place concrete diaphragm pour.

Cost Competitiveness

Some say that precast concrete segmental construction is considered to be cost effective for projects having 300 or more segments. While this structure only contained 112 segments, its success can be attributed to the economic alternatives that precast concrete offers and the ability to adapt these designs to suit difficult urban settings. And as this project illustrates, innovation and cooperation between owners and contractors can yield successful alternatives for the most difficult projects.

Minimization of Construction Impact on the Traveling Public

Most of the precast segments were erected using balanced cantilever methods, allowing the contractor to limit lane closures and minimize falsework.

CREDITS

Owner:
Washington State Department of Transportation

Owner's Engineers:
Washington State Department of Transportation

Designer:
McNary Bergeron & Associates
with Campbell Construction Engineering

Contractor:
Guy F. Atkinson Construction LLC

Construction Engineering Services:
McNary Bergeron & Associates

Constructability Review/ Estimating Services:
Guy F. Atkinson Construction LLC

Construction Engineering Inspection:
Guy F. Atkinson Construction LLC,
Washington State Department of Transportation

Precast Producer:
Guy F. Atkinson Construction LLC

Formwork for Precast Segments:
Aluma Systems

Erection Equipment:
Sicklesteel Cranes, Inc. (Crane Erection), Ness, Van Dyke Trucking (Segment Delivery)

Post-Tensioning Materials:
Schwager Davis, Inc.

Bearings: **The D.S. Brown Company**

Expansion Joints:
The D.S. Brown Company

Epoxy Supplier: Mason Supply (for Euclid Chemical)

Prepackaged Grout: US Spec

Rebar Furnish/Install: Apex Steel, Inc.

All Photos Courtesy of
Guy F. Atkinson Construction, LLC

RANDOLPH, MASSACHUSETTS

DCR Access Road Bridge Over Route 24

The DCR Access Road Bridge is a functionally unique bridge in that it links the popular "Blue Hills Reservation" recreation area with the nearby city of Randolph. While the bridge was built to provide critical access across State Route 24, it also serves as an important link to miles of hiking and equestrian trails. An existing steel bridge provided access over a busy highway and had served in that capacity since 1958. However, the bridge was both functionally obsolete due to inadequate clearance, and increasingly difficult to maintain.

The owner wished to increase the available clearance and reduce maintenance costs, but was faced with geometric constraints. Due to the scenic nature of the parkland on either side, as well as the usage by pedestrians and equestrians, increasing the approach grades was not a viable option.

The solution was the use of an innovative precast channel bridge. A channel bridge is a type of precast segmental deck with the primary support girders integrated with the parapets. With this section, the designers were able to increase the clearance by 2'-2" and eliminate two of the three existing piers, all while maintaining the existing approach grades and minimizing highway lane closures.

Innovation of Design and/or Construction

The project was largely driven by one overarching challenge—how to increase the clearance by two feet without changing the approach grades. The secondary considerations were to reduce maintenance costs and reduce the impact of construction.

The bridge is 248 feet long, comprising two 124 foot spans with a width of 29.7 feet. The substructure consists of two new, reinforced concrete subtype abutments supported on steel piles and a new center pier consisting of two 59-in. diameter, reinforced concrete columns supported on a common concrete spread footing. Utilizing only a center pier, the DCR Bridge eliminates the need for side piers at each outside roadway edge. This adds safety for highway users, and also reduces material cost and construction time.

Rapid Construction

The final concept was developed to directly address the project goals with the creative use of precast segments. The channel bridge design addresses the clearance, while also bringing to the table the inherent advantages of precast concrete. As a fully post-tensioned design, the deck is highly durable and requires little maintenance. Because the deck is part of the precast section, the entire superstructure was erected in only two weeks. A total of 31 precast concrete channel segments were match-cast for the project with concrete having a specified compressive strength of 6,500 psi. Typical segments were 8.2 feet long, with the two abutment segments being 5.1 feet long.

To avoid deflection issues resulting from unequal weight distribution, all of the segments were placed onto the erection beams prior to their actual assembly. Segment placement took only four days. Then, groups

Photo Courtesy of MassDOT
(Massachusetts Department of Transportation)

Jury Comments

The "recycling" of the existing bridge to erect the structure was innovative and enabled construction to be completed in two weeks, minimizing traffic disruption, reducing cost, and improving safety. This project showcases the advantages of segmental construction to address the goals of accelerated bridge construction.

of two to four segments were assembled incrementally using epoxy joints and post-tensioning bars, starting from the center of the bridge and moving towards the abutments in a balanced sequence. Each group of segments was assembled in a one day shift resulting in a total time of 10 days. Once all of the segments were assembled, the permanent post-tensioning was stressed in the edge beams and deck slab, and the temporary steel erection beams were removed.

When the erection of the superstructure segments was completed, contractors finished casting the abutments and wingwalls and added the riding surface. The bridge's channel shape provides a 4-foot high concrete parapet railing along both sides of the bridge, to which a Type II Modified Protective Screen was mounted on each of the parapets.

Aesthetics and/or Harmony with Environment

The Owner has a Green DOT policy encouraging sustainable design. Sustainability is often thought of in terms of what can be done to improve the final product. In this project, however, the sustainability focus was on things that were not done. The impact of the project was reduced by diminishing the scope—without sacrificing the performance.

This focus began with the alignment of the bridge. While it was imperative to increase the clearance below, all participants were keenly aware of the importance of the scenic character or the open space on either side. The design was specifically developed to eliminate the conflict between the two, and provide highway safety with no changes to the parkland. This spirit was continued in the design of the substructure. A spread footing was used for the central pier, located in the same place as the existing foundation. Instead of excavating and replacing the previous foundation, it was incorporated into the design of the new foundation, reducing the disruption to the area. During construction, the existing bridge was "recycled" twice. After the deck was removed, the steel girders were welded together to form box beams with adequate capacity to support the segments during erection. The old bridge enjoyed a second life as falsework before ultimately being recycled. At all levels of design and construction, the goal of minimizing the impact on parkland guided key decisions.

The channel design results in a sleek low-profile appearance that provides functional clearance benefits while keeping it unobtrusive in scenic areas. Best of all, it minimizes long-term maintenance needs that will improve safety of workers and users while reducing costs over its service life.

CREDITS

Owner:
Massachusetts Highway Department (MassHighway)

Owner's Engineers: Thomas Donald

Designer:
Purcell Associates / **International Bridge Technologies, Inc.**

Contractor: R. Zoppo Corp.

Construction Engineering Services:
Finley Engineering Group, Inc.

Constructability Review/ Estimating Services: R. Zoppo Corp.

Construction Engineering Inspection:
Massachusetts Highway Department (MassHighway)

Precast Producer: **Unistress Corp.**

Formwork for Precast Segments:
EFCO Corp.

Post-Tensioning Materials: **VSL**

Epoxy Supplier: **Sika Corporation**

Prepackaged Grout: **Sika Corporation**

(Photo Courtesy of Unistress Corporation)

KANAWHA COUNTY, WEST VIRGINIA

I-64 Kanawha River Bridge

The innovative Kanawha River Bridge is a record-setting, low cost, durable and aesthetically pleasing segmental box girder structure built as part of the I-64 Widening Project in Kanawha County, West Virginia. The bridge carries I-64 eastbound traffic consisting of three through lanes, one auxiliary lane, and shoulders. The overall bridge length is 2,975 feet, including a record 760 foot main span. The superstructure was built using the balanced cantilever construction method with cast-in-place segments supported by form travelers. Bridge construction was completed ahead of schedule and the structure was opened to traffic for the first time on July 31, 2010.

The bridge designers were confronted with the challenge of designing a 2,975-foot long eastbound structure for the new alignment. The requirement to locate the main piers outside the main channel of the Kanawha River dictated a 760-foot main span. The span arrangement studies included five different alternatives for this river crossing. Detailed evaluations considering aesthetics, constructability, cost, and maintenance requirements resulted in the selection of the segmental concrete box girder alternative for the final design.

Innovation of Design and/or Construction

The Kanawha River Bridge designers employed a combination of existing segmental bridge technologies and innovative approaches to solve the challenges of this complex project with a scale larger than usual. Since barges use the river regularly, the structure had to span the entire waterway in order to avoid obstructions to navigation, thus resulting in the longest box girder span in the United States.

The 66-foot wide bridge section is a slender single cell box girder with 1 foot 6 inch thick webs, 16-foot long cantilever overhangs and structural depth varying between 38 and 16 feet. This section is more slender and lighter than traditional concrete box designs and utilizes the construction materials to their full potential. The highway alignment with circular curves, spiral transitions, and a super elevation varying from minus 8% to plus 8%, made the definition of pier geometry and the form travelers details more complex than usual.

This 2,975 foot continuous structure was designed to have expansion joints at the abutments only. The advantages of this groundbreaking design are to reduce maintenance, improve ride ability, and simplify construction, as intermediate hinges are not needed. In order to address the potentially large transverse displacements due to creep, shrinkage, and temperature changes on a curved alignment, the designers used the innovative approach of setting bearing restraints in the radial direction and designed piers and abutments for the resulting radial forces.

Rapid Construction

The superstructure was built overhead with minimal impact to the public by using two pairs of form travelers supporting the cast-in-place segments, resulting in an efficient construction cycle reaching peak production rates of four segments per week. Segment construction continued during the winter although some concrete pours during winter months required external heat application.

Jury Comments

The project incorporates concrete segmental bridge technology to produce a record main span over water to avoid obstructions to the river barge traffic. The use of expansion joints at the abutments was innovative and improves ride ability for the traveling public while reducing the bridge's long-term maintenance needs.

Aesthetics and/or Harmony with Environment

The superstructure cross section, with long overhangs and inclined webs, results in a light appearance. The shadow created by the overhangs reduces the perceived superstructure depth. The inclination of the webs lessens the volume of the superstructure. The curved approach spans give a sense of openness and continuity with the graceful main span. The edges of the main span piers embrace the webs of the superstructure, thus subdividing the box girder depth. The piers have a modified rectangular section, with 45-degree chamfers, which reduces the perceived width of the columns in skewed views. The transverse faces of all piers and abutments have a textured architectural treatment. An applied concrete finish was used on all the surfaces of substructure and superstructure elements.

Environmental and public impact was minimized by the use of cast-in-place long span balanced cantilever construction. The use of post-tensioned concrete and the expected long design life bring significant sustainability benefits. With the completion of the project, traffic congestion and the pollution associated with congestion have been minimized.

Cost Competitiveness

The advertisement of the Kanawha River Bridge included two bridge alternatives. Competitive bidding of steel versus concrete alternatives was used to determine the most economical solution. The bid price for the segmental concrete bridge alternative was $82.9 million, $30 million less than a competing alternative. Considering bridge items only, the bid price of the segmental concrete box girder bridge was $75 million. This represents an average cost of $379 per square foot, a very competitive cost considering the long bridge spans.

Minimization of Construction Impact on the Traveling Public

Site constraints such as the existing residential and commercial properties, three local roads, a railroad track, and the Kanawha River waterway traffic, were addressed with long span balanced cantilever construction. The superstructure was built overhead with minimal impact to the public with two pairs of form travelers supporting the cast-in-place segments.

CREDITS

Owner: West Virginia Department of Transportation, Division of Highways

Owner's Engineers: **T.Y. Lin International**

Designer: **T.Y. Lin International**

Geotechnical Subconsultant: Triad Engineering, Inc.

Contractor: **Brayman Construction Corporation**

Construction Engineering Services: **Finley Engineering Group, Inc.** and **Michael Baker Jr., Inc.**

Construction Inspection: West Virginia Department of Transportation, Division of Highways

Concrete Supplier: Arrow Concrete

Formwork for Cast-in-Place Segments: **Doka USA, Ltd.**

Form Travelers for Cast-in-Place Segments: **STRUKTURAS**

Post-Tensioning Materials: **VSL**

Bearings: **R.J. Watson, Inc.**

Expansion Joints: **Watson Bowman Acme Corporation**

Prepackaged Grout: **BASF**

All Photos Courtesy of T.Y. Lin International

MOAB, UTAH

US 191 Colorado River Bridge

The US 191 Colorado River Bridge is the gateway to Arches National Park, Canyonlands National Park, Dead Horse Point State Park, white-water rafting down the Colorado River, and hundreds of miles of world famous, multi-use trails.

Utah's first concrete segmental bridges were built from above, cast-in-place in balanced cantilever, to minimize impact to the channel and to allow for continual recreational use of the river and surrounding trails during construction. The 440 foot main span minimizes the bridge footprint, and spans a sensitive environment home to several endangered species.

The 1,022 foot long twin structures were completed in 21 months, in December 2010, and one year ahead of the original Engineer's schedule, and for less than $290 per square foot, nearly $3M under the Engineers Estimate.

Innovation of Design and/or Construction

The US 191 Colorado River Bridge primarily serves as a transport for tourism, and the revenue generated from tourism is the mainstay of the local economy. The Project Team recognized that the success of this project ultimately depended on providing the community with a new river crossing that was designed to blend in and allow the natural landscape to remain in the forefront, and could be constructed while minimizing impacts to tourism and the environment.

The Project Team developed and presented to the community a concept that mimicked the graceful form of an iconic local landmark: Landscape Arch. The shallow, arched profile of Landscape Arch is naturally structurally efficient and lends itself well to variable depth, post-tensioned, concrete segmental box girder technology constructed in balanced cantilever. This structure type allows the bridge to be built top-down with the use of traveling forms, with little environmental impact to the river. The resulting long spans allowed for only one pier in the river, three fewer than the previous bridge. In addition, the concrete mix was engineered to have a service life of over 100 years, which will dramatically reduce the life-cycle impact to the environment. Artfully applied, non toxic, water-based mineral stain blends the concrete structure seamlessly with the complex palette of the surrounding sandstone cliffs. The bridge is also Utah's longest concrete span.

Rapid Construction

The first of the twin structures was constructed completely off-line so as to not interrupt traffic, demolition was completed off-line after traffic had moved over to the new bridge, and traffic was switched seamlessly between the twin structures to allow for staining operations to progress unimpeded. The Contractor achieved casting rates of six segments per week with two sets of form-travelers, and the twin 1,022 foot bridges were completed in just 21 months, nearly a year faster than the original project schedule.

Aesthetics and/or Harmony with Environment

One of the Project Team's main objectives was to design a bridge that was aesthetically in harmony with the surrounding environment and that physically minimized impact to the Colorado River and the surrounding wetlands.

Jury Comments

This project reflects the vision of the local stakeholders by incorporating aesthetic concepts that blend the structure into the natural landscape of the Moab area. Both the owner and contractor were new to segmental construction and were willing to accept the risks necessary to successfully complete the bridge ahead of schedule and under budget.

The key stakeholders representing local government, business and property owners, community and recreational groups, and National Parks and Lands services developed the Project theme, "A Bridge in Harmony with the Environment." Key aesthetic concepts, such as the rock texture found on all bridge elements in contact with the ground and an environmentally conscious, water-based stain artfully applied to the whole of the bridge exterior to mimic the modeled look of the cliffs, were also developed. Finally, the bridge profile was modeled after Landscape Arch, which stands in the project-bordering Arches National Park.

The Colorado River is the major source of water for the Southwest and home to protected wetlands, several species of endangered fish, and many species of protected birds. The Project Team minimized impact to this watershed by developing twin, variable depth, post-tensioned, concrete box girder bridges, constructed top-down in balanced cantilever.

Cost Competitiveness

While a long span segmental bridge was the optimal solution for minimizing environmental impact and gaining community acceptance, the Project Team was aware that constructing a bridge of this nature in an isolated part of the country would be challenging. Therefore, several pre-bid meetings were held to educate and attract local contractors so that there would be more competition during bidding, and consequently a reduced cost of construction. This effort was successful in attracting 13 bidders to a relatively isolated project. A local contractor, new to segmental construction, provided the low bid, saving the Owner $3M compared to the Engineers Estimate.

Minimization of Construction Impact on the Traveling Public

The functionally obsolete and fracture-critical existing bridge was replaced with little impact to tourism and with great improvement to public health and safety. Staged construction of the twin bridges kept traffic moving though the corridor while utilizing the footprint of the existing bridge. The structure carrying the southbound lanes was constructed first. All traffic was then shifted to the new southbound structure while the existing bridge was demolished and the northbound structure was built in its place.

CREDITS

Owner:
Utah Department of Transportation

Owner's Engineers: **FIGG**

Designer: **FIGG**

Contractor:
Wadsworth Brothers Construction

Construction Engineering Services:
Summit Engineering Group, Inc.

Constructability Review/ Estimating Services: **FIGG**

Construction Engineering Inspection:
FIGG

Form Travelers for Cast-in-Place Segments:
NRS-Asia

Post-Tensioning Materials:
DYWIDAG Systems International, USA, Inc. (DSI)

Bearings: **The D.S. Brown Company**

Expansion Joints:
Watson Bowman Acme—A BASF Company

Prepackaged Grout: **Sika Corporation**

All Photos Courtesy of FIGG

BETWEEN POMEROY, OHIO & MASON, WEST VIRGINIA

The Bridge of Honor, also known as the Pomeroy Mason Bridge, is a concrete cable-stayed bridge with a 675 foot main span crossing the Ohio River. This bridge replaces a functionally and structurally deficient truss bridge connecting the towns of Pomeroy, Ohio with Mason, West Virginia, and provides a vital link between these two communities.

The Bridge of Honor was named to pay tribute to local veterans, specifically the three local Congressional Medal of Honor Recipients listed as honorees for the Bridge of Honor—the late Staff Sgt. Jimmy G. Stewart formerly of Mason, West Virginia, the late Gen. James V. Hartinger, and the late Cpl. Edward A. Bennett, both formerly of Middleport, Ohio. Signage commemorating these honorees was placed on the bridge and unveiled during the dedication ceremony on March 23, 2009.

The cable-stayed superstructure is a cast-in-place segmental concrete edge girder system with transverse floor beams constructed using form travelers. The concrete towers have a delta shape with two planes of cables supporting both edge girders of the superstructure. Each of the towers is supported on six 8-foot-diameter drilled shafts with a waterline footing.

Bridge of Honor

Innovation of Design and/or Construction

The owner of the Bridge of Honor had a keen interest in minimizing future maintenance demands, which drove the decision to develop this design as an all-concrete segmental bridge. The concrete bridge structure minimized needs for future maintenance by several means: the all concrete structure does not require painting; the concrete mix was specified with controls on permeability and concrete quality to enhance corrosion protection; the prestressed structure will minimize cracking and further inhibit future corrosion potential; and the design used only simple neoprene bearings that avoid more complex and maintenance intensive bearing devices. A segmental concrete bridge clearly was the bridge of choice to meet the owner's needs for this project.

A major challenge and opportunity for innovation for this project was the horizontal alignment curvature of the roadway near the Ohio bank due to the steep rocky hillside that parallels the Ohio shoreline. This horizontal curve forced a short 244-foot end span length for the cable-stayed bridge relative to the 675-foot main-span length to limit the amount of curvature on the bridge. This relatively short end span would normally result in an uplift condition at the anchor piers and the requirement for bearings or devices to resist the uplift. However, the owner tasked the designer to develop a design that avoided uplift devices since these elements typically introduce significant maintenance requirements. The solution was counterweighted end spans that include sufficient ballast concrete to balance the cable-stayed system and eliminate all uplift conditions at the rest pier bearings, eliminating the need for uplift restrainers.

All Photos Courtesy of URS/David Lawrence

Jury Comments

This is a beautiful structure over a major river in a rural setting. Both the owner and the design team worked together to introduce project durability requirements and technical details to minimize long term maintenance needs.

Another innovation on the project was related to providing an economical foundation design that could accommodate the 37-foot range of river levels during flood stages. Water level footings are typically overtopped at some stage of the river flood, creating a navigation hazard due to the shallow water over the submerged footing. The tower foundations and lower legs have a unique geometric configuration that is shaped to be "snag-free" to river traffic under the full range of river stages. This is accomplished by providing a near vertical 1:3 slope of the footing element to create a "snag-free" waterline footing, which eliminated the need for cofferdams and saved both time and money while reducing construction risk.

Aesthetics/Harmony with Environment

The choice of bridge type for this project included a series of public meetings that encouraged local communities to comment on potential bridge types for this site. The overwhelming preference by the public was for a state-of-the-art two-tower, three-span concrete cable-stayed bridge with a delta shaped tower. In addition to being one of the lowest cost options, this bridge type provided a design that gave the local townspeople a feeling of ownership and it brought a sense of pride in the betterment of their communities.

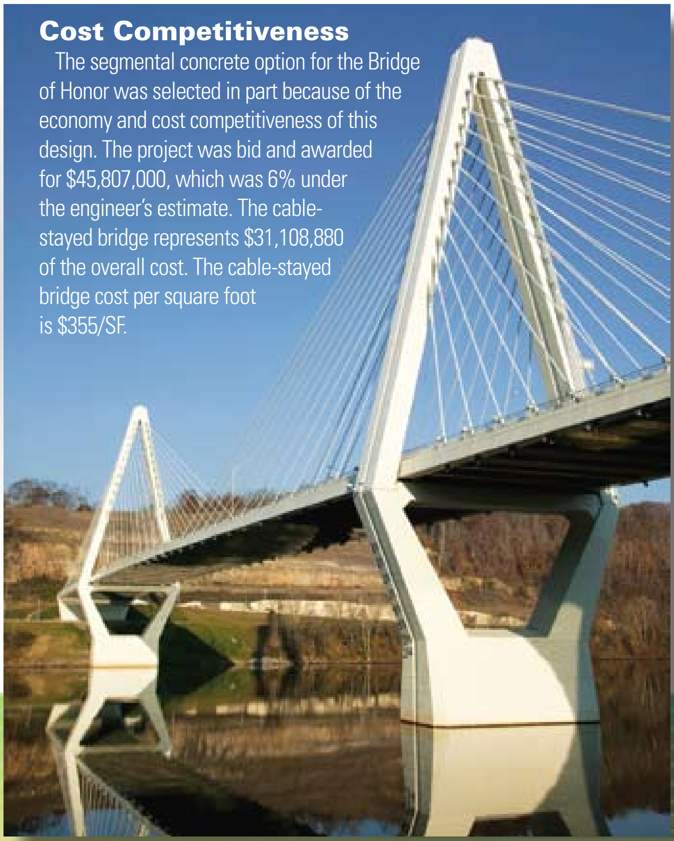
The crossing included a pedestrian pathway on the bridge, including a stainless steel handrail, to enhance opportunities for local access between the cross river communities.

The project also included a large rock cut on the Ohio side resulting in an 18,000-square-foot retaining wall with height up to 35 feet. This large wall was turned into a project asset by incorporating a mural into the design with images that depict local river folklore, including images of steam boats, the flood levy, an image of the historic courthouse, children playing, and images of the landscape.

Aesthetic bridge lighting was provided to enhance the nighttime presentation of the bridge. A brilliant blue lighting of the above deck region of the towers and stay cables was provided that showcases the bridge, while not interfering with river navigation.

Cost Competitiveness

The segmental concrete option for the Bridge of Honor was selected in part because of the economy and cost competitiveness of this design. The project was bid and awarded for $45,807,000, which was 6% under the engineer's estimate. The cable-stayed bridge represents $31,108,880 of the overall cost. The cable-stayed bridge cost per square foot is $355/SF.



CREDITS

Owner:
Ohio Department of Transportation

Designer: **URS Corporation**

Contractor:
CJ Mahan/National Engineering Joint Venture

Construction Engineering Services:
Janssen & Spaans Engineering, Inc.

Construction Engineering Inspection:
Michael Baker Jr., Inc.

Post-Tensioning Materials:
DYWIDAG Systems International, USA, Inc. (DSI)

Stay Cable Materials:
DYWIDAG Systems International, USA, Inc. (DSI)

Expansion Joints:
The D.S. Brown Company

Prepackaged Grout: **Sika Corporation**

CHONGQING, CHINA

Jiayue Bridge

The new Jiayue Bridge crosses the Jialing River near the town of Yuelai, Chongqing in China, elevating transportation in the area and facilitating economic development. The signature "Y-shaped," partially cable-supported girder bridge, carries six lanes of traffic on its upper deck and two pedestrian/bicycle paths, located directly beneath the roadway wing slab.

The bridge has a main span of 250m and is about 90m above the normal water level. The aesthetically unique and economically constructed bridge represents a new community landmark for the latest urban development efforts of Chongqing's northern area. It completes the City's road network not only ensuring smoother, safer passage for all travelers, but also complementing the surrounding landscape without distracting from the natural beauty of the area.

To attract investment, the city government had to first develop the area, providing high quality infrastructure and an enjoyable living environment. Transportation infrastructure was one of their first priorities. Yuelai is a completely new township being built right next to the beautiful Jialing river valley and most of the properties along the river valley are to be high-end residential buildings. Consequently, aesthetics was one of the most important factors in the design. Actually the bridge is to be used as one of the attractions of the town to lure educated professionals to live here. This meant it had to be a signature structure and the completed bridge was opened to traffic to great applause on February 11, 2010.

Innovation of Design and/or Construction

The land on both sides of the river is at a high elevation. The bridge deck is about 90m above the normal water level of the Jialing River due to drastic fluctuations in the Jialing River's seasonal water levels.

After careful studies, the design team settled on a partially cable-stayed girder bridge. It is very similar to an extradosed bridge but with slightly taller towers. This results in more efficiency from the stay cables; they can carry a larger portion of the weight of the rather heavy girder. By increasing the tower height against a traditional extradosed bridge the cables are more effective but carry more live load. As a consequence, the cables are designed as stay cables and not as external tendons (as in an extradosed bridge).

A multimodal bridge that accommodates highway, pedestrian and bicycle traffic reduces vehicular traffic and improves air quality and safety. In addition, the Jiayue Bridge creates a new trade route between metropolitan areas. The new landmark enhances travelers' experience and improves quality of life for all current and future residents. It is the cornerstone of a massive urban development effort by the municipality of Chongqing to encourage and expedite the resettlement of rural residents to this new urban regional hub.

Chongqing is often referred to as one of the three "ovens" of China, indicating how hot it can be in the summer. Temperatures can reach over 40˚C for prolonged periods during the summer and it can be rather rainy in the winter. To offer pedestrians and bicyclists refuge from the sun and rain, pedestrian paths were placed underneath the wing slab of the upper deck. This resulted in a narrower bridge deck, which is structurally more efficient.

The pathways are suspended from the cross beams of the deck on one side and attached to the web wall on the other side. In addition, the walls of the pathways are available for local communities to exhibit art during special occasions and extra facilities to host cultural events that enhance the local community.

The noteworthy design of the Jiayue Bridge resulted in a new landmark to the area at a moderate cost while significantly improving the area's infrastructure and aesthetics.

Aesthetics and/or Harmony with Environment

The selection of a lower tower height than a conventional cable-stayed bridge above the deck was a result of aesthetic considerations. Because the girder is already 90m above the water level, a pair of very tall towers above the deck would have been disproportionate to a relatively minor span of 250m. Inclining the tower columns above the deck outwards offers the passengers on the bridge a very open and enjoyable view. Aesthetically, the inclining

Jury Comments

The visual effect of the partially cable-stayed girder bridge, with its "Y" shaped piers, results in an impressive, aesthetically pleasing structure. The suspended pathway is unique in that it offers protection to pedestrians during extreme weather events and it is available to the community as a venue to display art exhibits.

tower columns above the deck create a widening effect breaking up the monotonic appearance of the very tall and slender towers. The tower columns resemble a pair of open arms that symbolically welcome visitors and local residents. The lower portion of the "Y-shaped" piers has great rigidity, making it capable of resisting ship impacts.

The approach spans retain the same box girder cross section as in the main spans. The piers for the approach spans have a similar shape as the main towers. This makes the view from below the deck appear more harmonious.

Cost Competitiveness

Putting the pedestrian paths under the deck reduced the deck width to 28m, which was much more economical. The total construction cost of the bridge was about US $37 million. It is 756m long and 28m wide. only the upper deck area and is $123/sq. ft. if the pedestrian deck area is included.

CREDITS

Owner:
Chongqing Land Property Group

Owner's Engineers:
Chongqing City Construction Development Co., Ltd.

Designer:
T.Y. Lin International Engineering Consulting (China) Co., Ltd.

Contractor:
Chongqing Construction Bridge Engineering Co., Ltd.

Constructability Review/Estimating Services: Chongqing Research Institute of Building Science

Stay Cable Materials:
Jiangyin FASTEN SUMIDEN New Materials Co., Ltd.

All Photos Courtesy of T.Y. Lin International

SW Line Bridge, Nalley Valley Interchange
(Photo Courtesy of Guy F. Atkinson Construction, LLC)

I-95/I-295 North Interchange
(Photo Courtesy of Ray Stanyard Photographer)

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