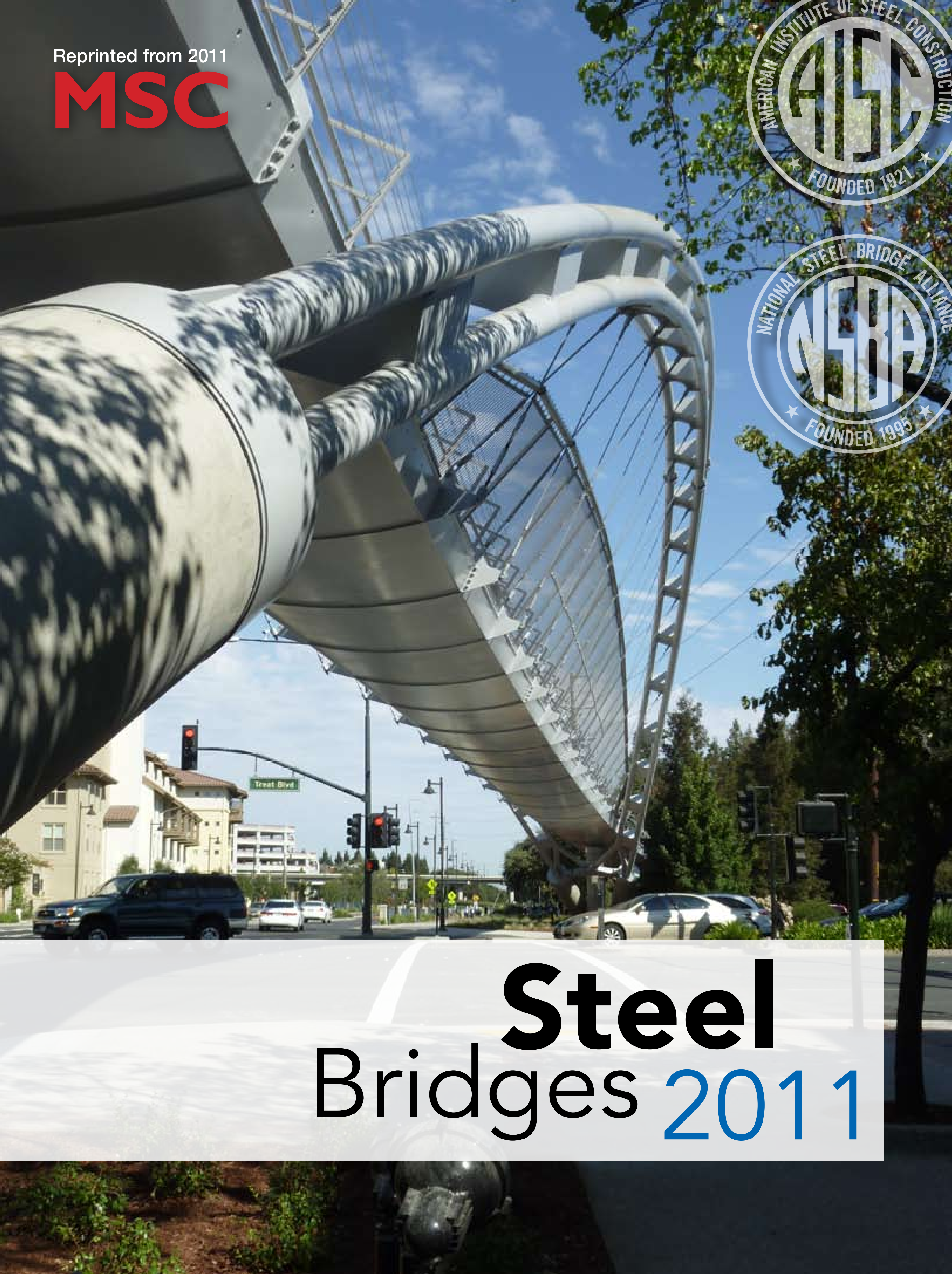
Reprinted from 2011

MSC



AMERICAN INSTITUTE OF STEEL CONSTRUCTION
AISC
FOUNDED 1921

NATIONAL STEEL BRIDGE ALLIANCE
NSBA
FOUNDED 1995

Steel Bridges 2011

Welcome to Steel Bridges 2011!

This publication contains all bridge related information collected from *Modern Steel Construction* magazine in 2011. These articles have been combined into one organized document for our readership to access quickly and easily. Within this publication, readers will find information about Steel Centurions, Accelerated Bridge Construction, and plate availability among many other interesting topics. Readers may also download any and all of these articles (free of charge) in electronic format by visiting **www.modernsteel.org**.

The National Steel Bridge Alliance is dedicated to advancing the state-of-the-art of steel bridge design and construction. We are a unified industry organization of businesses and agencies interested in the development, promotion, and construction of cost-effective steel bridges and we look forward to working with all of you in 2012.

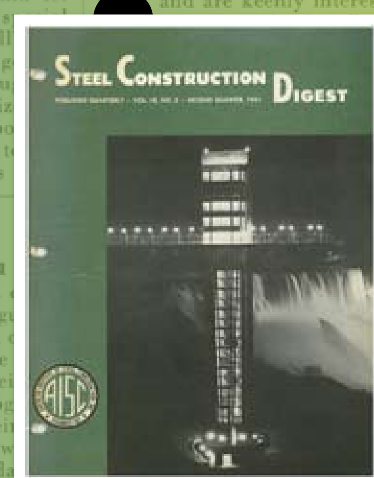
Sincerely,

Marketing Director
National Steel Bridge Alliance

Table of Contents

50 Years of Steel

A look back at the first half century of *Modern Steel Construction* magazine.



FOR THE PAST 50 YEARS, *Modern Steel Construction* has chronicled the growth of the fabricated structural steel industry. Whether it was the first North American use of high-strength steel or the industry shift to A992, *MSC* illustrated the trends in steel design and construction through thousands of pages of project profiles, technical reports, and new product information.

The magazine's roots actually go back to 1930, when AISC launched *Aminsteel News* to keep members informed about the fledgling association's work. By 1938, it had morphed into *The Steel Constructor*, which included association news and technical updates. By 1944, it was supplanted by *Steel Construction Digest*, a newsletter with a reach extending for the first time beyond the association's membership.

Finally, in 1961, *Modern Steel Construction* was born.

For half a century, *Modern Steel Construction* has presented the latest information on both buildings and bridges. We covered the nation's first welded suspension bridge in 1964 and just last year we wrote about innovative folded plate girder systems. In the 1960s, we wrote about structural innovations such as composite construction and today we're covering such topics as self-centering frames and slit steel-plate shear walls. We wrote about the beginning use of spray-applied fire protection in 1970 and we're now covering shop-applied intumescent paints.

The following pages present a pictorial of 50 years of *MSC*. But if you want more, please visit www.modernsteel.com. We've posted every issue for your reading enjoyment (just click on the archives link in the upper right hand corner).

1961: *Modern Steel Construction* debuts as 16-page periodical, William C. Brooks serves as first editor.

1961: A36 introduced

1961: High-strength steel makes its North American debut on the One East Wacker Dr. building in Chicago; coincidentally, AISC moved its headquarters to this building in 1989.

FIRST STEEL FOR ST. LOUIS ARCH

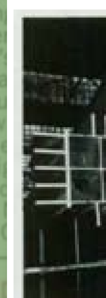
In mid-February the first 40-ton triangular section of the Jefferson National Memorial was set in place by Pittsburgh-Des Moines Steel Company. The Saarinen-designed arch will soar 630 ft above the park on the St. Louis waterfront and will contain 4000 tons of steel. The all field-welded structure will be completed in 1964 for the Bicentennial celebration.

1961

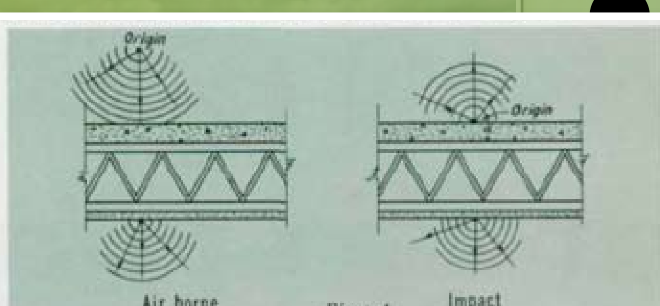
1962

1963

1962: Steel designers are introduced to a new shape when steel tubes make their first appearance in *MSC* in an article entitled "New Member Joins Structural Family."

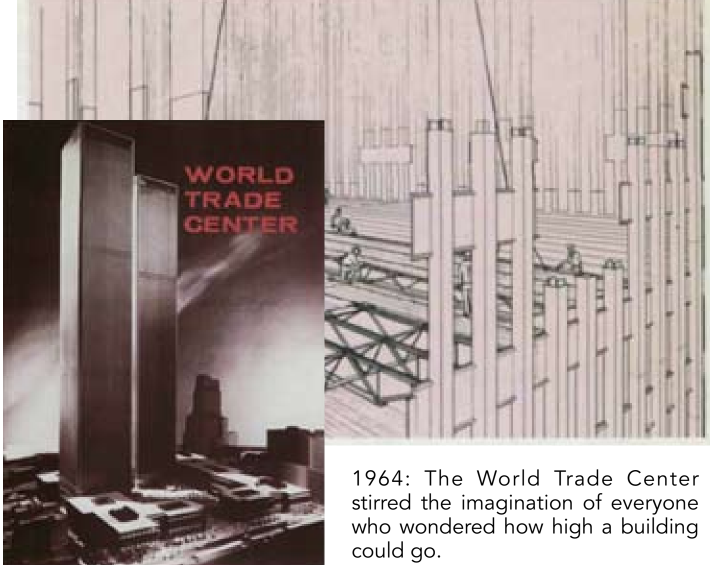


1963: Leslie N. Gillette begins serving intermittently as acting editor of *Modern Steel Construction.*



1963: In a discussion that persists today, *MSC* asks "How quiet are steel floors" and discusses methods of mitigating sound transmittal in steel-framed buildings.

1963: Parking structures were a growing market and AISC showcased several projects using high-strength steel to minimize columns and reduce costs.



1964: The World Trade Center stirred the imagination of everyone who wondered how high a building could go.

1963: *MSC* looks at the future and discusses the possibility of using "electric computers" for steel detailing.

1964: The future is now. *MSC* discusses the potential use of digital computers for engineering calculations.

1964: AISC unveils a new technical publication, *Engineering Journal*.

1965: Steel's advantage in office building design is evident in the Continental Center project, which featured 42-ft square bay spacing—a previously unheard of figure in Chicago.

1965: Leslie N. Gillette returns as acting editor of *MSC*.

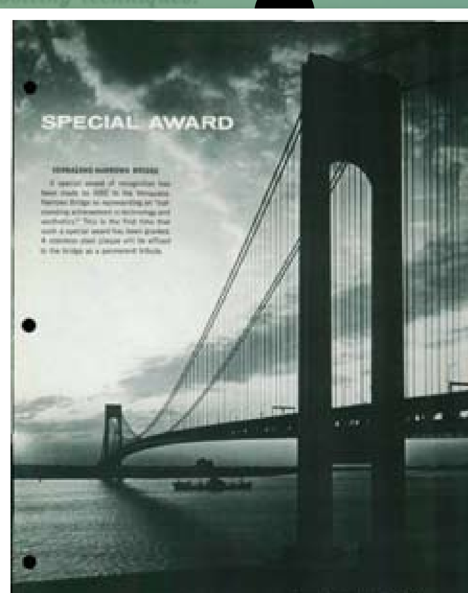
1964

1965

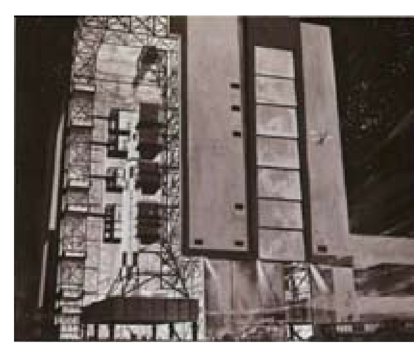
1964: The Vincent Thomas Bridge in Los Angeles Harbor made the pages of *MSC* as the nation's first welded suspension bridge.

1964: A.M. Hattal named editor of *MSC*.

1964: The New York World's Fair and its iconic steel globe captured the imagination of the world.



1965: The Verrazano-Narrows Bridge receives a special award from AISC for its "outstanding achievement in technology and aesthetics."



1965: With 125,000,000 cubic feet of enclosed space, the Vertical Assembly Building (used to build the 362-ft high Saturn rocket) at the Kennedy Space Center is touted as the world's largest building.

1965: Zinc rich coatings gain popularity as the coating is used on a rehab of the Golden Gate Bridge.

HAWAII'S

First Steel High Rise

1966: Despite high freight costs, steel proved to be most economical material for the 10-story Federal Aviation Agency office building, the first steel high-rise in Hawaii.

1966: Daniel Farb named editor of *MSC*.

1967: Setting what might be a record for a building of its size, a 2.6-million-sq.-ft Chrysler plant was designed and constructed in just 11 months.

1968: A572 is introduced.

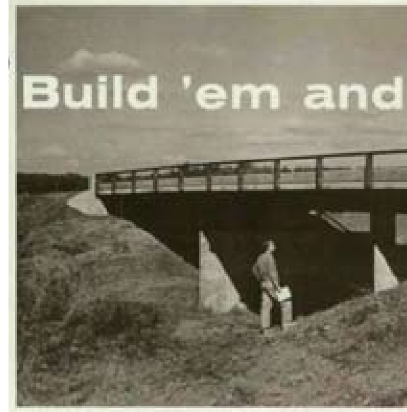
1968: The United States Pavilion at EXPO '67, received an AISC Special Achievement Award for "an outstanding achievement in technology and aesthetics."

1968: In an effort to capture more of the multistory residential market, the steel industry introduces an open-web steel joist system with gypsum plank for apartment construction.

1969: 888 7th Ave. in New York is an early use of composite construction.

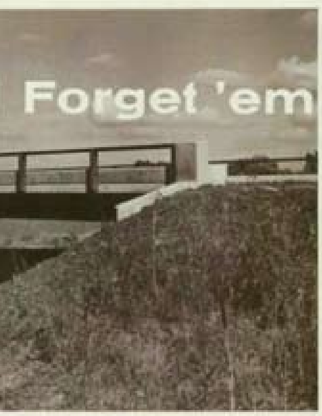
1966 | 1967 | 1968 | 1969

1970: Dan Farb named AISC Director of Publications; Mary Anne Donohue named Editor of *MSC*.



1970: *MSC* touts the use of weathering steel for short-span steel bridges.

1970: AISC/AISI announce the development of a computer program for column design.



1971: Both the John Hancock Building in Chicago and the U.S. Steel Building in Pittsburgh are among the structures honored in AISC's Architectural Awards of Excellence.

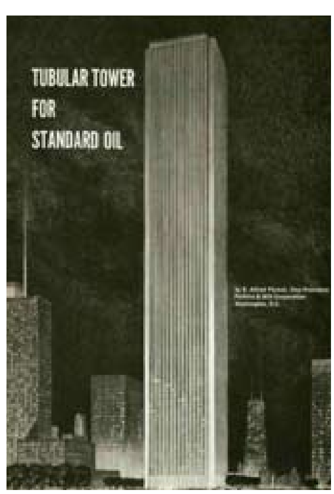
1972: St. Louis' Eads Bridge is designated a national historic landmark.

1971: Spray-applied fire protection is introduced after its efficacy is demonstrated in a 1970 UL test.

1970: AISC announces a new award: The T.R. Higgins Lectureship Award. The first winner is Egor Popov in 1972 for his lecture on "Connections Cyclic Reversal."

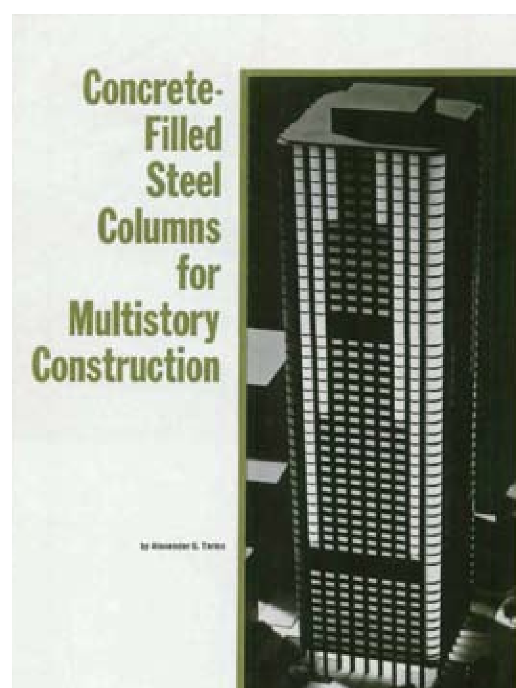
1970 — 1971 — 1972

1970: The designers of the Bell Telegraph Building in Pittsburgh use 100 ksi steel for its X-bracing.



1970: The Standard Oil Building (now Aon Center) rises in Chicago; it features the first steel shell tube and at 1,136 ft. it was the fourth tallest building in the world when completed in 1973.

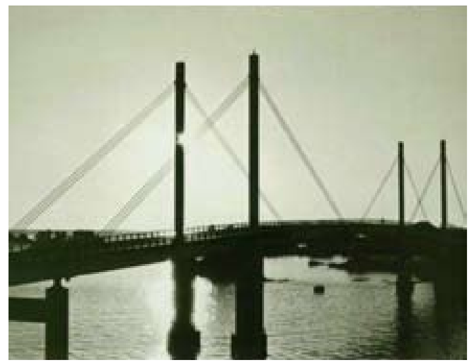
1971: Load Factor Design is introduced for steel bridges.



1972: *MSC* introduces its readers to the concept of concrete-filled steel tubes for high-rise buildings.

1973: The Latah Creek Canyon Bridge in Spokane is an early example of a steel box girder bridge.

1973: The first coverage of AISI's Scranton fire tests, which demonstrate that fire protection is not needed in open-air steel parking structures.



1974: The Sitka Harbor Bridge in Alaska is the first cable stayed vehicular bridge in the U.S.

1975: The Sears Tower wins an Architectural Award of Excellence.

1973

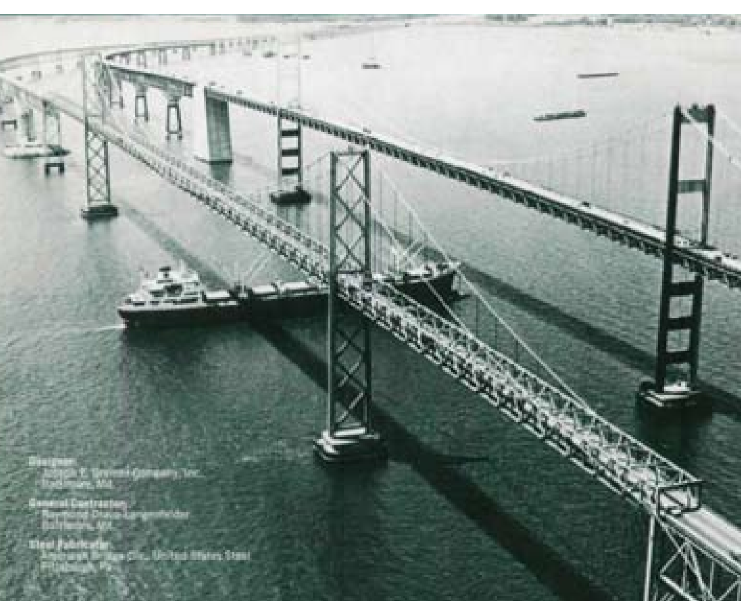
1974

1975

1973: Fazlur Khan is presented with the J. Lloyd Kimbrough medal, AISC's highest honor.

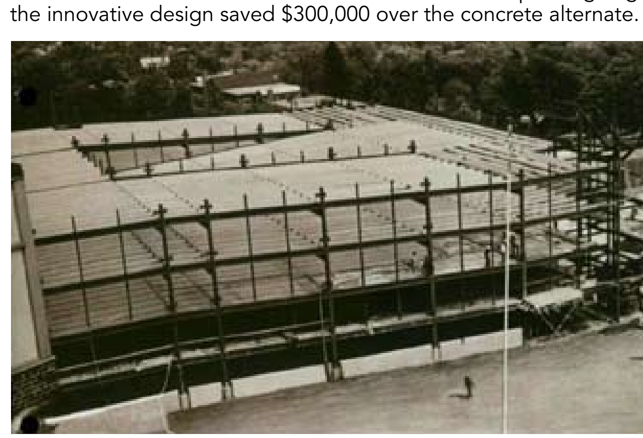
1974: Mary Anne Stockwell takes over as editor of *MSC*.

1974: The 12-story Ramada Inn in Los Angeles is one of the first buildings to feature a Skipcon System (a type of staggered truss).

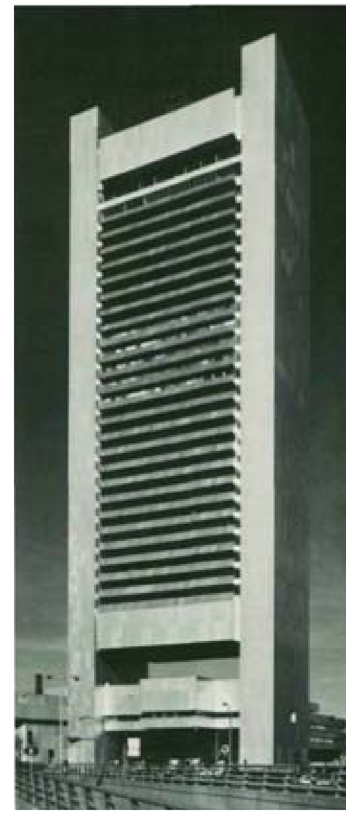


1973: The Chesapeake Bay Bridge combines four steel systems to create an incredibly economical bridge: continuous welded girder spans, suspension bridge, deck cantilever truss spans, and through cantilever truss spans.

1974: The 590-space Faulkner Hospital Garage in Jamaica Plain, Mass., is billed as the nation's first steel-concrete composite garage; the innovative design saved $300,000 over the concrete alternate.



1976: The Louisiana Superdome is the world's largest fixed domed structure and its steel frame covers a 13-acre expanse.



1978: The Federal Reserve Bank of Boston utilized an X-braced "supertruss" design.

1976: The 56-story First International office building in Dallas features a trussed tube design with diagonal X-bracing and stub girders.

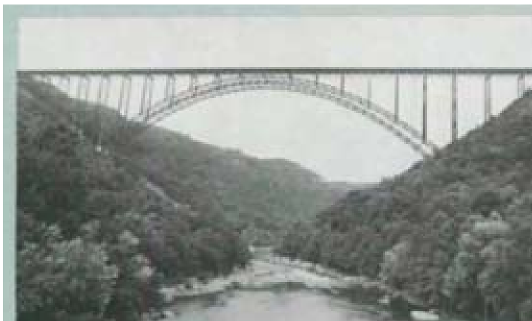
1976 1977 1978 1979

1977: The landmark Los Angeles Bonaventure Hotel features a cluster of five towers, all tied together to meet seismic design requirements.

1978: AISC introduces the AISC Quality Certification Program.

1975: The Russian Residence in New York City utilizes a slip form concrete core and a unique top-down construction technique.

1975: *MSC* discusses the impact of E119 on steel construction and the provisions for credit of the use of sprinklers.

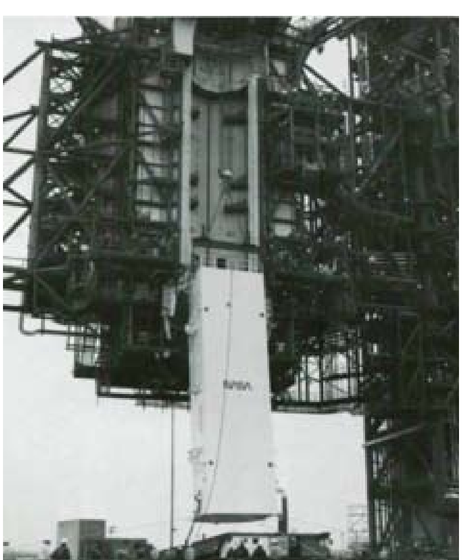


1979: Demonstrating that no one is perfect, the New River Gorge Bridge in Fayetteville, W.Va., only receives a merit award in the AISC Prize Bridge Award competition.

1980: The O'Connor Hospital in San Jose, Calif., is an early use of eccentric braced frames for seismic design.

1980: George E. Harper begins his tenure as editor of *MSC*.

1981: One Corporate Center in Hartford, Conn., demonstrates the growing trend toward vertical expansions as it rises 16 stories on top of an existing building.



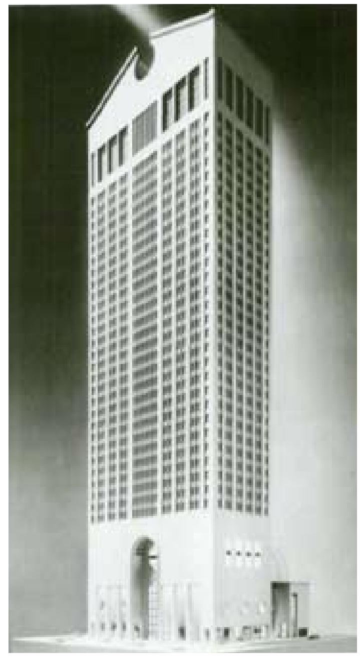
1981: The Kennedy Space Center ignites the dreams of every child.

1980

1981

1982

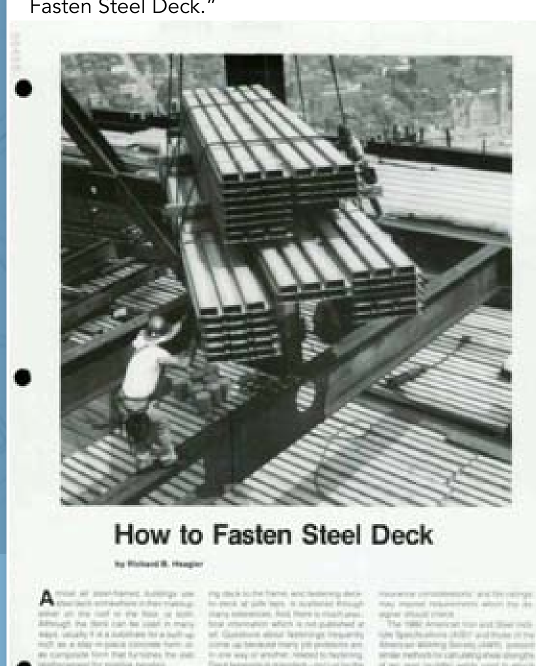
1983



1982: *MSC* features Philip Johnson's controversial design for the AT&T Headquarters Building (now the Sony Building) in New York City.

1982: The first ads appear in *MSC*: Nicholas J. Bouras (now owned by Commercial Metals Company), TRW Nelson, W.A. Whitney, Cooper & Turner (now TurnaSure), and St. Louis Screw & Bolt.

1982: Continuing its tradition of publishing practical information, *MSC* features an article on "How to Fasten Steel Deck."



How to Fasten Steel Deck

1983: Michigan bans weathering steel prompting a multi-state study and new details that vastly improve the performance of this material that results in its renewed use.

1983: The Barnes Building Rehabilitation team touts their extensive use of computer analysis using STAAD-III.

1983: Four Allen Center in Houston is designed as a circue-ovular building to reduce wind loads.

1983: First AISC/AIA Student Design Competition.

1985: Fast track construction is all the rage; the 172,000-sq-ft Federal Express storage facility in Memphis goes from ground breaking to occupancy in just nine months.

1987: The AISC Steel Sculpture is created by Duane Ellifritt at the University of Florida.

1987: *MSC* increases its frequency from 4x to 6x a year.

1987: Since 1980, bidding alternate designs has gained in popularity and has allowed steel to be more competitive, resulting in such structures as the I-20/I-459 Interchange in Jefferson County, Ala.

1984: Maria von Trapp (yes, from the Sound of Music) looks over the steel framing for the new von Trapp Family Lodge in Stowe, Vt.

1984 — 1985 — 1986 — 1987

1985: For the first time, estimates put computer use in structural engineering firms at greater than 50%.

1986: The AISC Shapes Database is created for use on PCs.

1986: LRFD debuts and quickly becomes an obsession with *MSC* editors.

1987: The United Airlines terminal in Chicago helped popularize both the use of curved steel tubes and exposed structural steel.

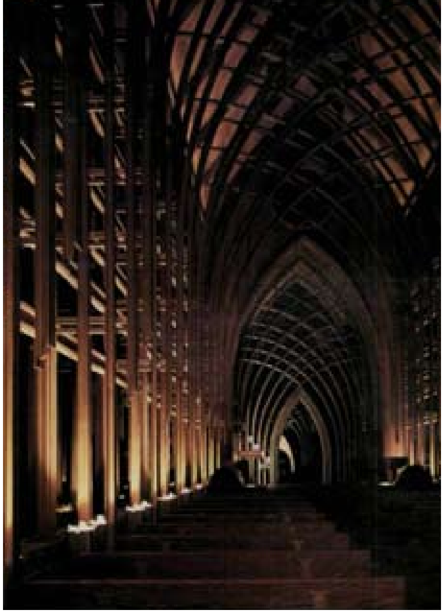
1986: The staggered truss system makes a comeback and is used on the 40-story Resorts International hotel in Atlantic City.

1983: National Bureau of Standards and AISI conduct tests that confirm the accuracy of FASBUS II fire computer modeling.

1986: *MSC* introduces a new cover design—and color photographs!

1987: The Quaker Tower in Chicago uses its central core as its complete lateral load resisting system.

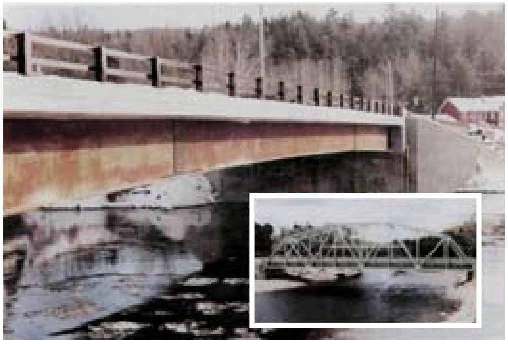
1988: A tube of wide flange sections creates an "infinity room" and a new tourist attraction at the House on the Rock in Spring Green, Wis.



1990: Cooper Chapel in Bella Vista, Ark., is arguably the most beautiful use of exposed structural steel ever.

1989: National Engineering Conference and the Conference of Operating Personnel join to become the National Steel Construction Conference (which would evolve into today's NASCC: The Steel Conference).

1990: The East Outlet Bridge in Maine is one of the first bridges designed and built to the new ALFD AASHTO specification.



1990: Scott Melnick named editor of *MSC*.

1991: Nucor-Yamato Steel introduces the first domestically produced 40 in. beam.

1988 | 1989 | 1990

1989: LRFD is just starting to show up on projects. The designers of the AEGIS pre-commissioning building in Bath, Me., report that using LRFD reduced the weight of the structure by around 10% and that the learning curve to switch from ASD to LRFD was "not severe."

1989: Snug-tight bolt provisions are promulgated.

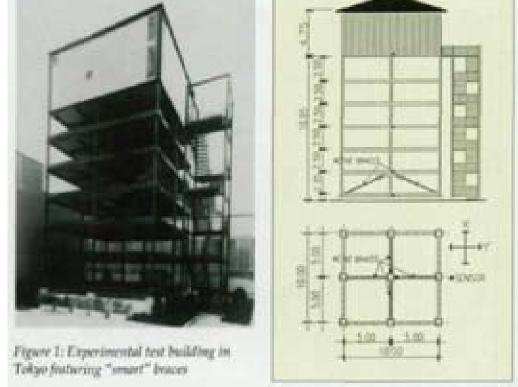
1990: Setbacks required by the New York City zoning code required the use of 84 transfer girders on the 35-story 750 Seventh Ave. building.

1989: AISC issues 9th edition ASD Manual; sells 60,000 copies in one year.

1990: Pilot Field in Buffalo ushers in a new era of stadium design featuring exposed structural steel. The design proves popular and is a forerunner to most of the major league ballparks built since then, including Camden Yards in Baltimore, the Cleveland Indians Stadium, PNC Park in Pittsburgh, Coors Field in Denver, and the Rangers Ballpark in Arlington.

1990: The bridge on State Route 739 over US33 in Union County, Ohio, was an early adopter of integral abutments.

1991: The Morton International Building in Chicago was built over active railroad tracks. As a result, the entire structure is suspended from huge exterior overhead trusses.



1993: Active bracing systems come through their full-scale testing with flying colors.

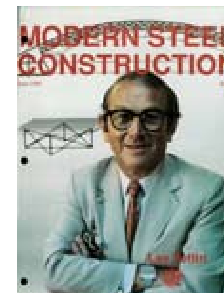
1993: *MSC* introduces an annual listing of shape availability. The list has since moved to the AISC website and rather than being updated yearly, it's now updated each time a producer makes a change.

1993: *MSC* focuses an entire issue on design responsbility following a day-long session at the NSCC.

1991: *MSC* makes its first references to Electronic Data Interchange (EDI), the precurser to today's BIM.

1991: *MSC* begins talking about the recycled content of structural steel and its environmental advantages.

1993: A feature story on Lev Zeltin (written before his death but published afterwards) starts a series of profiles in *MSC*. Other notables featured include: Bill LeMessurier, Stan Lindsay, Eli Cohn, Larry Griffis, Richard Weingardt, Bob Disque, and Shankar Nair.



1992: The Boston University Medical Center Campus is one of the first buildings designed using the new AISC LRFD Seismic Provisions.

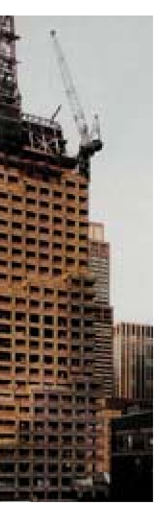
1992: Steel Interchange premieres.

1991

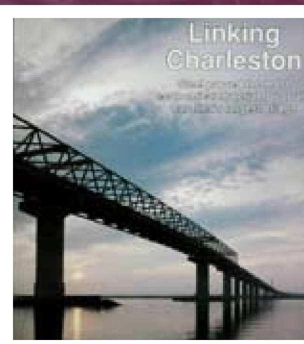
1992

1993

1991: *MSC* begins publishing monthly!



1992: From groundbreaking to occupancy took only 22 months on the 1.2 million sq. ft. GTE Telephone Operations Center in Dallas. The building was designed using LRFD and featured A572 Gr. 50 steel.



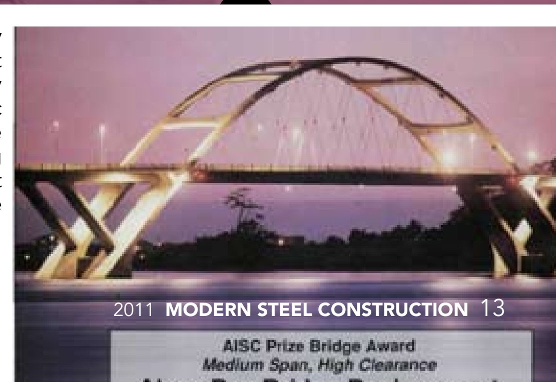
1992: Parallel chord trusses on the Cooper River Bridge helped to create one of the nation's most beautiful bridges.

1993: The use of in-wall beams and web openings for mechanical ductwork allowed the designers of Harborside Hyatt in Boston to achieve an 8 ft 9 in. floor-to-floor height while also beating concrete on cost.

1991: An accident on Chicago's Calumet Expressway destroys two of an overpasses three columns—yet the structure stays up!

1992: *MSC* tackles economic steel design with an entire issue devoted to advice on how design engineers can reduce fabrication costs.

1993: The Alsea Bay Bridge Replacement was noteworthy for its economic design but it was the bridge's outstanding aesthetics that earned it a Prize Brige Award.



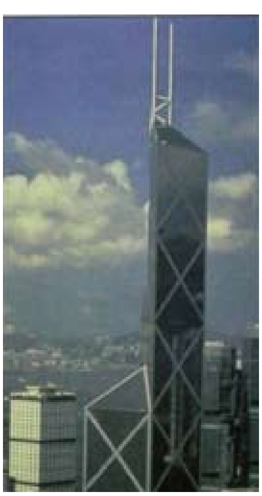
1994: Moment connections provided both long spans and structural stability on the Bullocks department store building in Burbank, Calif.

1994: *MSC* notes that only four states require continuing education for renewal of P.E. licenses.

1994: *MSC* extensively covered the Northridge earthquake and the resultant seismic research.

1994: For the first time, *MSC* printed the complete list of AISC Certified fabricators.

1994

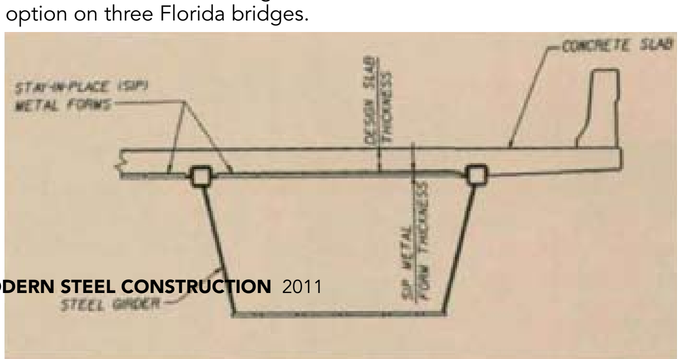


1994: Larry Griffis' T.R. Higgins lecture offered everything you need to know about composite frame construction, using the Bank of China in Hong Kong as one example.

1995: Finally answering the question of why we put a Christmas tree atop a building during the topping out ceremony.

1995

1995: Post tensioned box girders were an aesthetic and cost-effective option on three Florida bridges.

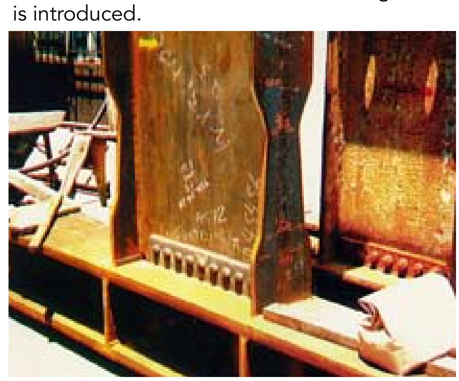


1996: H. Louis Gurthet begins a 10-year tenure as president of AISC (yes, the same Lou Gurthet who now handles *MSC* ad sales!).

1996: Five years before 9-11, owners and designers were already concerned with the potential for terrorism. New York City's new 911 service center is designed to resist a terrorist attack.

1996

1996: The Reduced Beam Section (dogbone) is introduced.



1996: AISC introduces its first website.

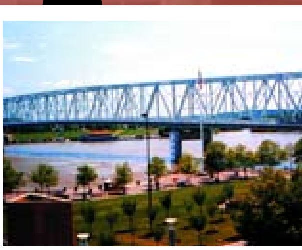
1996: Seismic design is in the forefront of everyone's mind. This issue featured new information on weld toughness and introduced *MSC* readers to the first of a series of proprietary seismic solutions: the MNH-SMRF Connection, now known as the SidePlate® connection.

1997

1997: The Niles West Field House in Skokie, Ill., minimized its internal volume (and therefore the space that needed to be heated and cooled) by moving the structural system outside the building.

1997: The Blue Water Bridge between Port Huron, Mich., and Sarnia, Ontario, is an early example of the use of LRFD in bridges (it was also designed with all SI units).

1997: A lecture at the 1997 NSCC explained the concept of unrestrained and restrained fire ratings. As the speaker noted, almost all interior steel can be considered restrained in fire calculations.



1997: Combining Grades 70W, 50 and 36 on the Central Bridge between Newport, Ky., and Cincinnati allowed the designers to maintain a constant girder depth.

1998

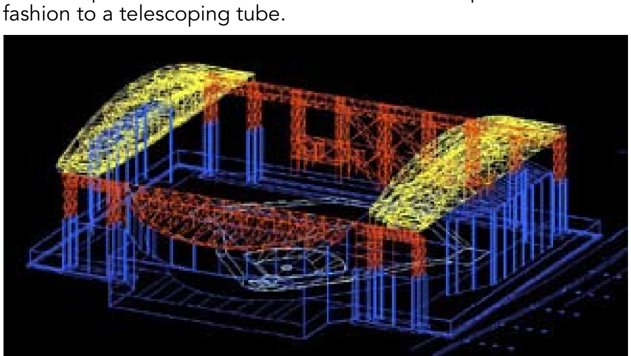
1998: The Guggenheim Museum in Bilbao, Spain, ushers in the Age of Gehry.

1998: AISC introduces its Erector Certification program.

1998: *MSC* publishes an in-depth analysis of the cost-saving potential of A572 Grade 50 compared with A36.

1998: The Cardington fire tests encourage designers to contemplate performance-based fire design as a practical alternative to prescriptive designs.

1998: Moveable roofs are all the rage for ballbarks. For the Bank One Ballpark in Phoenix, the two halves collapse in a similar fashion to a telescoping tube.



1999

1999: The Steel Conference heads north to Toronto and is renamed the North American Steel Construction Conference.

1999: AISC pushes EDI to the forefront of steel design.

1999: It only took 26 months from the start of design to the completion of construction on the 1.5-million-sq.-ft Boeing Rocket Booster facility in Decatur, Ga.

1999: A992 is introduced.

1999: Damen Ave. arch creates a new neighborhood landmark in Chicago while also demonstrating the economy and speed of construction of steel.

2000: The steel-plate shear wall installed during the rehabilitation of the Oregon State Library in Salem was a precurser to a system that gained popularity later in the decade.

2000: A new system using concrete plank atop a grid of asymmetric steel members is used on a new Drexel University dormitory building. The result is low-floor-to-floor heights and incredibly rapid construction. The system ultimately leads to the development of the increasingly popular Girder-Slab® System.

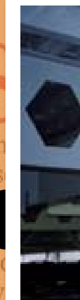
2000: Nucor-Yamato Steel adds a surcharge to A36; the move to A992 is complete.

2000

2000: Design-Build is the buzzword for the year.

2000: Fire engineering saved $750,000 by reducing the need for passive fire protection of the exposed steel at the Mashantucket Pequot Museum in Ledyard, Conn.

2001: Utilitarian doesn't have to mean pedestrian, as this chiller plant in Philadelphia proves.



2001

2001: A new Eiffel Tower rises in—where else?—Las Vegas.

2002: Who says steel can't be fun? Few visitors to Seuss Landing in Orlando are aware of the complex geometry for the steel frame supporting everyone's favorite cat in a hat.

2001: AISC's parking structure and multi-story residential initiatives are in full-swing.

2002

2001: AISC opens the Steel Solutions Center.

2002: Everyone, including Case Western Reserve University in Cleveland, wants their own Frank Gehry building.

2002: After a pair of errant barges knocked down the I-40 bridge at Weber Falls in Oklahoma, the steel industry mobilized to get a new bridge up and open in just two months.

2003: For the Dallas Children's Medical Center, steel was the answer for adding six stories to the existing concrete structure.

2004: Houston's Reliant Stadium sets a U.S. record for the size of an opening in a moveable roof stadium.

2003: Steel framing dominates the early ranks of LEED-certified buildings, including one of the first Gold projects, the Department of Education Building in Sacramento.

2003

2004: An entire issue devoted to green construction includes a discussion of the designing for deconstruction as well as a look at a 454,000-sq.-ft green roof atop a Ford Motor Co. plant in Dearborn, Mich.

2003: The Gaylord Texan featured cellular steel beams—and will play host to NASCC: The Steel Conference in 2012.

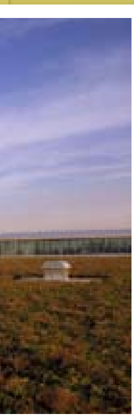
2003: *MSC* publishes an AESS *Specification*.

2005: The parking structure for the Legacy Salmon Creek Hospital in Vancouver, Wash., is an early example of the SmartBeam™ system in a parking structure.

2005: Building 1 at Santa Row in San Jose, Calif., was one of the first to use the proprietary ConXtech system.

2004

2005



2004: The US20 brige over the Iowa River is the first in the U.S. to use the incremental launch method for erecting an I-girder bridge.

2005: Buckling Restrained Braced Frames (BRBF) became very popular later in the decade. Shown is an early example at the Intermountain Medical Center in Murray, Utah.

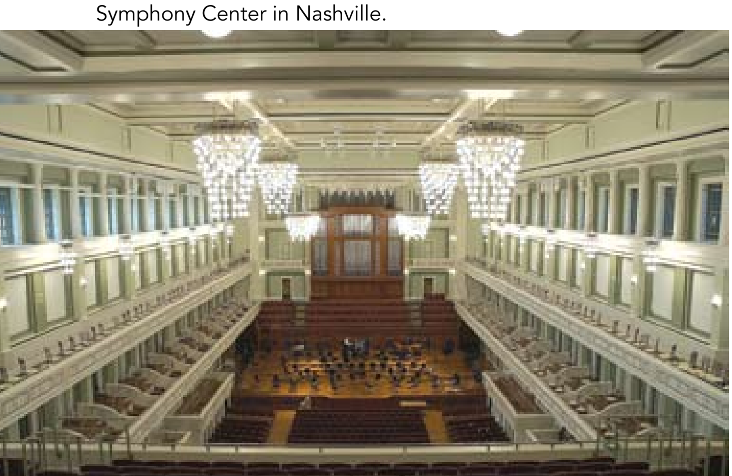
2004: Santiago Calatrava's Sun Dial Bridge in Redding, Calif., works as both a sculpture and as a bridge.

2005: Roger E. Ferch becomes AISC's new president.

2006: A diagrid steel frame gained attention for the 46-story Hearst Building in New York City.

2006: The roof of the old center was salvaged and reused when the Richmond (Va.) Convention Center was expanded.

2006



2006: Acoustic isolation was a critical success on the Schermerhorn Symphony Center in Nashville.

During the meeting, the structural engineer asked some unusual questions to test the team's and owner's commitment to cost-effective, efficient design. While structural design itself contributes very few possible points to a project's LEED "point total," it can result in increased points for other disciplines. Some of the questions were:

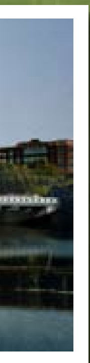
- How does the selection of a particular structural system affect a construction schedule or accelerate construction?
- How little structure is required to complete the structure?

2007: The Main Street Bridge in Columbus, Ohio, is the first inclined single-rib arch bridge in the U.S.

2007: The Gateway Bridges on I-94 near Detroit mark the first time tied arches are built with longitudinal ties buried under the road. The innovative system solves the redundancy issue with tied arches.

2007

2007: Cellular beams help Boise's Banner Bank achieve green goals while also providing long open spaces and low construction costs.



2008: The Bank of America Tower in New York City features 15-ft cantilevers to create column-free executive offices.

2008: Southpark Hospital in Shreveport, La., remained fully operational while an additional floor was added.

2008

2008: A steel framed, post-tensioned slab system proved economical for a parking structure at Ruby Memorial Hospital in Morgantown, W.Va.

2007: The Blennerhassett Bridge over the Ohio River between West Virginia and Ohio used 30 million lbs. of HPS for its 4,000-ft span.

2008: The Dallas Cowboys Stadium boasts the largest single-span roof structure in the world.

2009: Shop-applied intumescent fire protection cuts the construction schedule on the the BJC Institute of Health in St. Louis.

2010: A look at thermal bridging in steel structures.

2009

…'s Federa…
…ope's tall…

Rising

BY BRAD MALMSTEN, P.E.

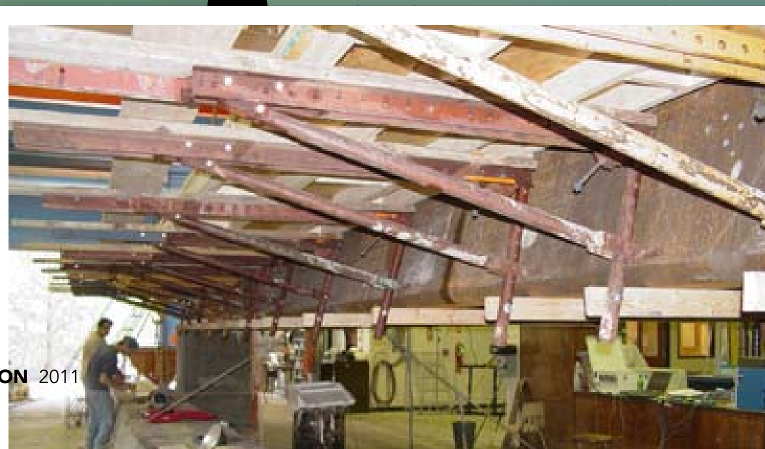
2009: Exposing the New York Times Building's structural system on the exterior of the building is part of a design to exemplify the ideal of transparency in journalism.

WHILE THE NEVER-ENDING RACE for world's tallest building has shifted to the Middle East for now, tallest on the continent is nothing

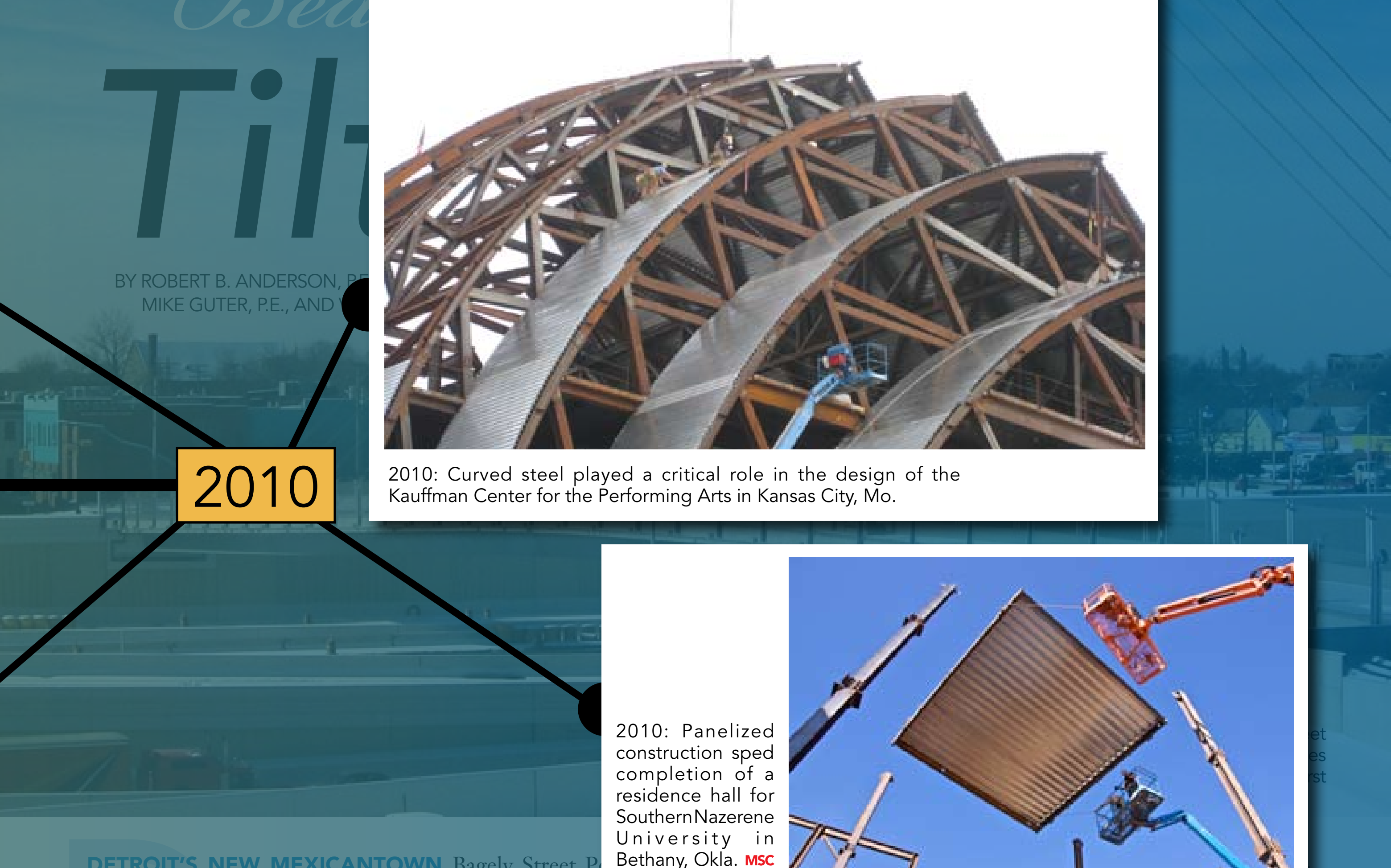
2010: The climbing structure at the Children's Museum in Phoenix required more than 400 bolted connections.

walls—facilitating the MEP design and the layout of refuge floors.

The complex geometry of the tower also made these particular areas more conducive to steel framing. The extraordinary amount



2009: Folded plate girder bridge systems have the potential to revolutionize the short-span bridge market.



Til

BY ROBERT B. ANDERSON, P.

MIKE GUTER, P.E., AND

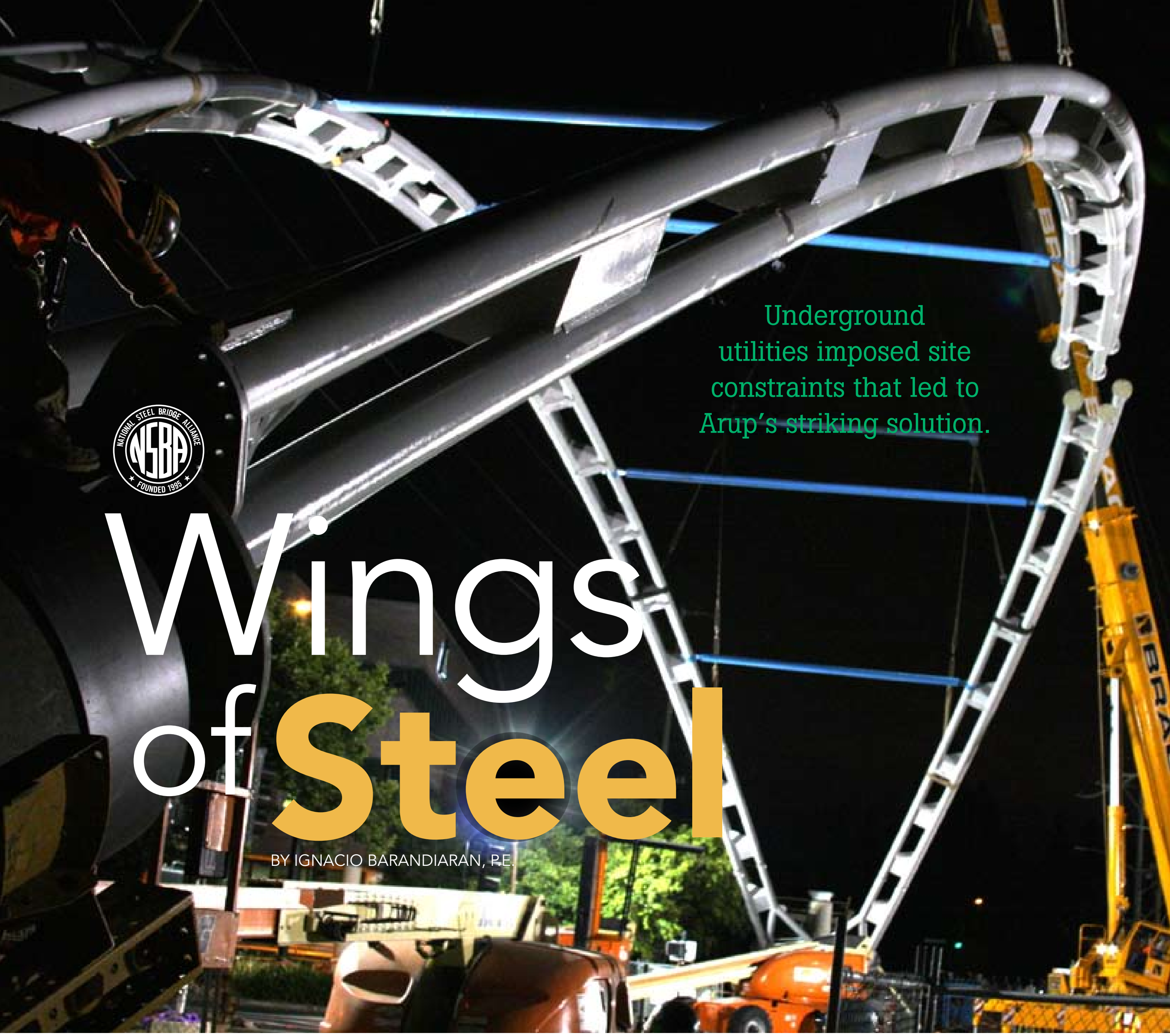
2010: Curved steel played a critical role in the design of the Kauffman Center for the Performing Arts in Kansas City, Mo.

2010: Panelized construction sped completion of a residence hall for Southern Nazerene University in Bethany, Okla. **MSC**

DETROIT'S NEW MEXICANTOWN Bagely Street P

Bridge is the first cable-stayed bridge in the state and part of Mich-

structure. Each portion of the project, including abutments, entry



Wings of Steel

Underground utilities imposed site constraints that led to Arup's striking solution.

BY IGNACIO BARANDIARAN, P.E.

THE DESIRE FOR an iconic bridge, combined with constraints imposed by a spiderweb of underground utilities, led the designers of a new $6.8 million pedestrian and bicycle bridge to design an arched rib structure with curving members that meet at a common point to minimize substructure requirements. Adding to the complexity, the deck curves in plan, causing the arches to incline at slightly different angles. The new Robert I. Schroder bridge provides safe passage over busy Treat Boulevard in Contra Costa County to be an integral part of the Iron Horse recreational trail. The trail, formerly a railroad corridor, also serves as a right of way for several underground utilities and includes an easement for a future transit line. These constraints made foundation placement complex and were the main determinants for the design of the bridge structure.

Bridge Site

The bridge is sited within the Transit Village built around the BART Pleasant Hill/Contra Costa Centre station in Contra Costa County. This station is one of the busiest in the BART system for commuters. The surrounding development consists of high-density residential condos and apartments, extensive commercial and retail space, and high-rise garages for parking. The Transit Village and the bridge have both been developed by the Contra Costa County Redevelopment Agency, led by its director Jim Kennedy. The Contra Costa County Public Works Department was charged with managing the process for the final design, to get the project built, and to maintain it after its completion.

Parallel to the BART system is a railroad right of way called the Iron Horse Trail that by the late 1980s was no longer being used by its original owner, the Southern Pacific Railroad. Spearheaded by Robert Schroder, then mayor of nearby Walnut Creek and later a county supervisor, the county started purchasing this right of way in the 1980s. Currently the trail connects residential and commercial areas, business parks, schools, public transportation, open space and parks, regional trails, and community facilities. It runs north and south for some 30 miles in the San Francisco Bay Area.

The agency saw an opportunity to upgrade the trail in the area

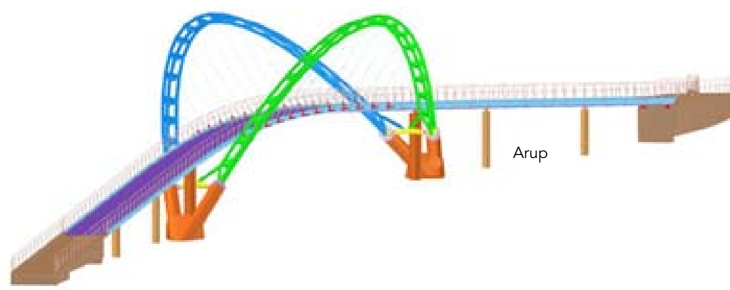
Glenn Fleming

Randy Olaes, Arup

▲ Spectacular night lighting effects showcase the dynamic and striking design of the bridge.

◄ The four steel arch sections suspended with two cranes and ready to be bolted together. The blue bracing shown between them was removed when all bolting was completed.

▼ The arches meet at a common base point at each end, resulting in a narrow foundation and thus avoiding existing underground utilities. The deck curves in plan, causing the arches to incline away from the deck at slightly different angles.



Arup

Jake Wayne, Arup

▲ The curved alignment of the deck was designed to make the bridge the backdrop to the new park.

near the BART station by adding a signature pedestrian bridge for foot and cycling traffic. The new bridge takes the trail over the heavily traveled, eight-lane Treat Boulevard.

Gaining Public Consensus

The agency selected Arup as the prime consultant for the bridge. Being conscious of the appropriate use of public funds, the agency called for a thorough community outreach program to achieve consensus on the need, exact location, and form of the bridge structure. The extensive outreach program required multiple meetings and design charettes with people and organizations that provided a representative sampling of the community.

Although a relatively small project, the bridge involved a significant amount of decision complexity given the prominence of the location and how the project could affect the neighboring stakeholders. The public meetings made a concerted effort to explain the physical constraints, cost issues, design trade-offs, and construction aspects.

Ignacio Barandiaran, P.E., is a principal in the San Francisco office of Arup and an AISC Professional Member. An accomplished structural engineer, he currently heads Arup's Transaction Advice business in North and South America, leading a team of technical and financial transaction specialists.

Ignacio Barandiaran, Arup

▲ Precast concrete inclined columns ready to receive the steel arches, which are bolted to the steel connections at the top of the inclined columns.

▼ The main span of the arch, with a length of 240 ft, crosses Treat Boulevard with a curving deck and independent arches inclined away from the deck.

Jake Wayne, Arup

The outreach process culminated in four buildable bridge designs for the main span's superstructure: steel cable-stayed, steel arch, steel truss, and concrete girder. Designs for the approaches were similar and the alignment was the same for all four.

Arup provided a detailed report on the design issues and the estimated cost of construction for each main span design. What followed in 2003 was a web-based preference survey of all those who participated in the outreach meetings and for the community at large. The survey requested that respondents rank the designs in order of preference from 1 to 4. More than a thousand people responded.

Through the preference survey the community ruled out the plain concrete alternative. The cable-stayed bridge was too costly. Considered to provide an appropriate balance among cost, function, and aesthetics, the arch edged out the somewhat less expensive steel truss.

Dealing with Site Constraints

Among the many constraints that are typical in the design of infrastructure projects in the public right of way, one most affected bridge design for this project: the existing underground utilities along the Iron Horse Trail. Each of the several utility owners had specific easement rights, concerns with maintenance and access, and plans for new facilities in the future. Underground utilities include a 60-in.-diameter sanitary sewer, an 84-in. storm sewer, a jet fuel line, underground power cables, a gas line, potable water mains and fiber-optic cables. A 115 kV transmission cable looms overhead. The underground utility constraints ruled out shallow spread footings that would limit their access and expansion. This required the alignment to weave its way around the utilities such that foundations of minimal width could be placed to avoid them.

In the case of the winning arch design, the solution used a pair of inclined arches coming down to a single narrow, deep foundation at each end of the main span. Vertical arches would have required two foundations and a pile cap on each end, which would have more than doubled the width and would have conflicted with utilites. For example, at the south end the arch foundation is wedged between the sanitary and storm sewer pipes. Each of the foundations consists of two, 90-ft-deep, 6-ft-diameter piles along the bridge alignment that are tied together by a narrow pile cap.

The Iron Horse Trail includes a linear park on the north side of Treat Boulevard adjacent to the bridge. A bridge straight across the roadway would have hidden the park as viewed from the adjacent street to the west of the park. The community outreach programs indicated that people wanted to avoid the park being hidden behind a bridge structure. As a result, the bridge curves in plan toward the east in an "S" shape as it approaches the north side. In this way the bridge preserves a grove of heritage oak trees, becomes an attractive backdrop for the park, and does not provide concealment for unwanted nighttime activities.

Designing the Arch Configuration

The utility constraints and lateral curve of the deck were the main drivers of the design of the bridge arches. The single deep foundation at each end meant that the arches had to incline outward and away from each other. The lat-

The top of stainless steel "projectile" fence follows the crossing points of the dual cables that support the deck, thus creating an arched shape for the fence. The higher of the two handrails is for cyclists.

eral curvature of the deck meant that the arches had to incline outward at different angles. The arch on the east side is more vertical that that on the west side.

One of the most important structural design aspects of the bridge is the lateral bracing of the arches which was placed just below the deck. This allows the full length of the arch ribs above the deck, over three-quarters of their length, having no cross-bracing connecting the two arches together. Bracing the asymmetrical outwardly inclining arches above the deck would have been awkward because of the increasing distance across from arch to arch as they incline outward. As it is, pedestrians and cyclists traversing the bridge have an open, roofless feeling. From afar the bridge resembles the wings of a butterfly.

The steel arch ribs are supported on inclined 42-in.-diameter concrete columns that follow the arch line of thrust. The length of the steel ribs from one column to the other is 240 ft. A curved steel box beam brace across the tops of the inclined concrete columns provides a stiff point to brace the steel arches below the deck. The two arches come down and bolt to the top of the columns and to the middle of the box beam.

Each arch rib consists of three 10-in.-diameter steel pipes in a triangular cross section. Steel box stiffeners connect the three pipes together at roughly 13-ft intervals so that the three pipes for each rib form a composite structural section. This choice over a more conventional single, large-diameter steel pipe had two advantages: first, smaller diameter pipes are more readily available than larger ones, and, second, the built-up arch rib has an open, more airy look that offers interesting light and shadow effects.

Connection plates welded to the underside of the stiffener boxes serve to attach a pair of cables at each of the 24 locations where the deck hangs from the arches. The cables in each pair cross each other and form a vertically elongated "X" shape as they stretch from the arches down to each side of the deck. California regulations require that pedestrian bridges have a "projectile fence" as they cross over streets and highways. This requirement posed a special challenge to the design team: how to provide for this safety feature and avoiding a "caged" feeling for the bridge users. Taking advantage of the leaning arches with an open top, the design of the projectile fence was integrated with the geometry of the arches. The fence, which is made from a woven stainless steel mesh, is complemented with a pair of low and high hand rails along the full length of the deck. This design makes the 10-ft width of the deck feel more spacious.

An important requirement for the bridge was to have adequate lighting on the deck and in the surrounding park for user safety, as well as appropriate decorative lighting. The design team developed a system of strip LED lights that is concealed in a cove integral with the deck structure, and supplemented by ground mounted fixtures to illuminate the sidewalks and the bridge superstructure.

Joe Reyes, Hanna Group

▲ The deck was designed as an integral boat-like structure in sections approximately 60 ft long that were shop fabricated and painted, then shipped to the site and field bolted.

▼ Each arch rib is built up from three 10-in.-diameter steel pipes bent to the appropriate radius and welded together with steel box stiffeners spaced at approximately 14 ft along the length of the ribs.

Joe Reyes, Hanna Group

Erecting the Bridge

In the spring of 2009 the Contra Costa County Public Works Department received eight bids for the construction of the project and awarded the contract to Robert A. Bothman of San Jose, Calif. The winning bid of approximately $6.8 million was almost 20% below the engineer's estimate, which along with the number of bids reflected the competitive market conditions at that time.

Arup required the erection subcontractor, Adams & Smith, to develop a dimensionally accurate 3D CAD model for bridge fabrication and a detailed erection procedure. The complex geometry of the bridge ruled out reliance on conventional 2D shop drawings. Adams & Smith's chief engineer, Jeff Darby, developed the erection procedure and retained a construction engineer, OPAC, to perform a detailed structural engineering analysis of each stage of erection. The 3D CAD model was developed by Axis Steel Detailing and was required to be cross-checked with the construction engineer's own analytical model.

Adams & Smith subcontracted fabrication to Mountain States Steel, which fabricated each arch rib in two 120-ft segments for shipping to the site. Each of the four rib sections weighed approximately 20 tons. Mountain States fabricated the deck in 11 sections of various lengths weighing from 10 to 18 tons each. The design team selected splice locations in the arches and deck to maximize the sections for shop fabrication and to ensure that they could be shipped by truck. The design was such that no field welding was required.

Erection of the bridge took place over three nights in June 2010. The arch ribs arrived on site in four pieces, and were bolted together and to the inclined column supports during erection the first night using two cranes. On the following weekend night

Photos this page by Glenn Fleming

Two arch sections are lifted to their final positions with temporary bracing. The were erected on the first of three weekend night closures.

Arches being lowered onto the inclined concrete column supports, prior to being bolted down.

closures erection crews used one crane to hang the deck sections from the cables and bolt them together. Additional night closures allowed for final cable tension adjustments and installation of the projectile fence.

The extensive planning work that was done initially by the design team and then by the construction team paid off. Working as a team with the owner to anticipate and resolve issues as they arose, the site work proceeded quickly and on time and on budget ready for its inauguration on October 2, 2010.

The new bridge makes the Iron Horse Trail safer at a busy thoroughfare and provides an attractive structure for the community. The urban redevelopment project at the Contra Costa Centre Transit Village now has an iconic piece of infrastructure that is both a place marker and gateway. As reporter John King of the San Francisco *Chronicle* newspaper put it in his article reviewing the bridge, "The Robert I. Schroder Overcrossing shows what an icon can be. This larger cultural role is what civic infrastructure can achieve when built with ambition and the long-term view." MSC

Owner
Contra Costa County, Calif.

Prime Consultant
ARUP, San Franscisco

Steel Detailer
Axis Steel Detailing, Inc., Orem, Utah (AISC Member)

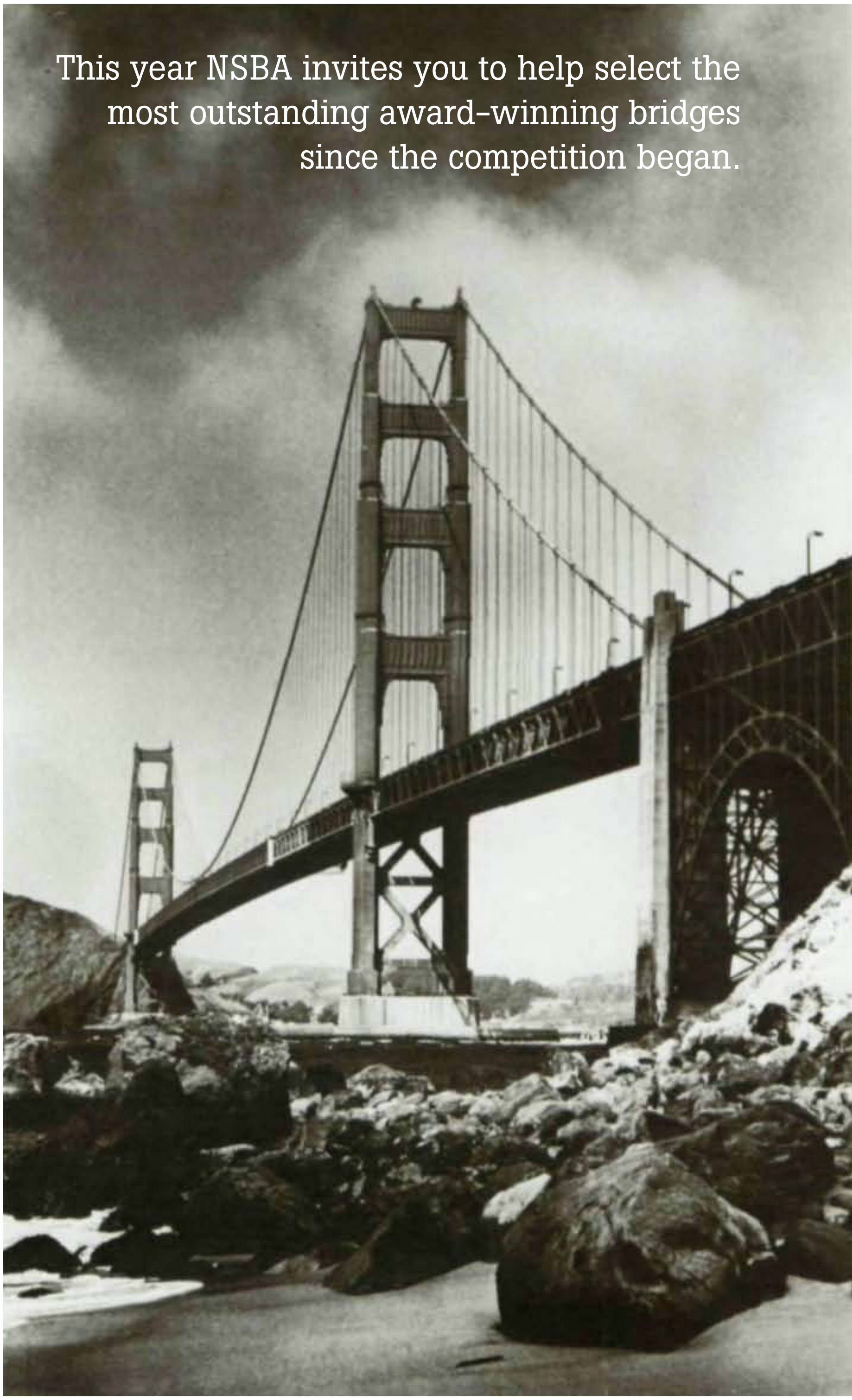
Steel Fabricator
Mountain States Steel, Lindon, Utah (AISC Member)

Steel Erector
Adams and Smith, Lindon, Utah (AISC Member)

Construction Management
TRC Solutions, Rancho Cordova, Calif.The Hanna Group, San Franscisco

General Contractor
Robert A. Bothman, San Jose, Calif.

In Search of the Top



▲ 1937 Prize Bridge Award:
The Golden Gate Bridge, San Francisco.

THE NATIONAL STEEL BRIDGE ALLIANCE Prize Bridge Competition honors significant and innovative steel bridges constructed in the United States. The competition began in 1928 with first place awarded for the Sixth Street Bridge in Pittsburgh, coincidentally just a few blocks down the river from where this year's NASCC: The Steel Conference will be held. Since then, more than 300 bridges have won first place in a variety of categories, which today include long span, medium span, short span, movable span, major span, reconstructed, and special purpose.

In the past, the Prize Bridge Competition has taken place every other year with the winners being announced at NSBA's World Steel Bridge Symposium. Because the next WSBS will be co-located with NASCC: The Steel Conference in 2012, we are taking this opportunity to spice things up a bit in 2011 with the most exciting steel bridge competition in history.

The 2011 Prize Bridge Competition will take a look back, focusing on the top Prize Bridge Award winners of all time, and you are invited to be part in this year's voting.

Winning bridges will be selected in two concurrent levels of competition, resulting in both Industry Choice and People's Choice award winners, selected from a pool of all the award-winning bridges recognized since the competition began in 1928.

NSBA will present the 2011 Top Prize Bridge Awards to the designers and owners of the top three steel Prize Bridge Award winners at the 2011 AASHTO Subcommittee on Bridges and Structures Annual Meeting in May in Norfolk, Va.

Voting will take place during the month of March 2011. Please stay up to date with competition developments by signing up for NSBA's monthly e-newsletter at www.steelbridges.org and following us on Twitter @SteelBridges. MSC

10 Steel Bridges

Select the Best Bridges
Industry Choice Awards

A panel of judges will select their top 10 Prize Bridges of all time based on:

- Innovation
- Aesthetics
- Environmental sensitivity
- Design and engineering solutions

Following the selection of those 10, the bridge design and construction community will vote online to determine the top three selections.

People's Choice Awards

Members of the general public will vote online for their favorite bridges. The pool of candidates will include all of the prize-winning bridges recognized since the inception of the Prize Bridge Competition.

▲ 2007 Prize Bridge Award—Major Span: The Burro Creek Bridge on U.S. 93 between Phoenix and Las Vegas.

▼ 2007 Prize Bridge Award—Movable Span: The Louisa Bridge, St. Mary Parish, Louisiana. Louisiana's longest steel girder double-leaf bascule bridge.

▲ 2001 Prize Bridge Award—Long Span: The Paper Mill Road Bridge in Baltimore County, Md., features a steel box arch.

This iconic bridge at St. Louis, still a vital link today, marked the first steel crossing of the Mississippi River.

The Eads Bridge: A Revolution in Bridge Building

BY JIM TALBOT

STEEL CENTURIONS
SPANNING 100 YEARS

Our nation's rich past was built on immovable determination and innovation that found a highly visible expression in the construction of steel bridges. The Steel Centurions series offers a testament to notable accomplishments of prior generations and celebrates the durability and strength of steel by showcasing bridges more than 100 years old that are still in service today.

THE EADS BRIDGE, named for its designer, chief construction engineer, and visionary champion James Buchanan Eads, officially opened on July 4, 1874. Eads, a self-taught engineer, essentially willed the bridge across the river, dealing with financing, legislative obstruction, balking steel companies, and the opposing interests of ferryman, river traffic, and rival Chicago. Along with the famous Gateway Arch nearby, it stands as a primary civic symbol of St. Louis.

The Eads Bridge represents a masterpiece of engineering for its time, notable for the following:

- ➤ First major bridge to cross the Mississippi River
- ➤ First to make extensive use of steel and span bracing
- ➤ First with arch spans of 500 ft
- ➤ First to use cantilevered construction, avoiding falsework that would hinder river traffic
- ➤ First in the U.S. to use the pneumatic caisson for deep underwater pier construction

The bridge connects St. Louis, on the Missouri side of the river, with East St. Louis, Ill. With its construction, St. Louis hoped to continue its role as the gateway to the west. The burgeoning growth of Chicago to the north jeopardized that role.

This mammoth project greatly advanced the science and art of bridge design and construction. When completed, the bridge was the longest arch bridge in the world with three spans of 502 ft, 520 ft, and 502 ft. Four massive stone piers anchored to bedrock support the spans. The total bridge length with approaches stretches to 6,442 ft. The Eads Bridge provides an 88-ft clearance to the river below.


Wikipedian Kbh3rd

▲ The Eads Bridge across the Mississippi River at St. Louis, 2009.

▼ The Eads Bridge was the first to use cantilevered construction, avoiding falsework in the river.


Linda Hall Library of Science, Engineering & Technology

Vision Becomes Reality

Pier construction began in 1867, shortly after the Civil War. The west pier was completed with a cofferdam, despite massive difficulties. Workers had to cut through a veritable junkyard of sunken steamboats and debris. For the east pier, Eads switched to a pneumatic caisson, having observed its use on a smaller bridge project while traveling in Europe for health reasons. He greatly improved the design of the caissons and while he was at it, invented the sand pump to remove gravel, sand, and silt from them to expedite progress. The east abutment reached a record 103 ft below mean water level. At these depths and air pressures, caisson disease, which was not well understood at the time, overtook some of the workers, resulting in 14 deaths and more than 100 cases of severe disability.

Once the piers were in place, early in 1871, Eads turned his attention to the steel superstructure. Each of the three arches consists of four tubular ribs—two on each side of the bridge—connected by steel bracing. The tube sections are 18 in. in diameter and 10 ft to 12 ft long. Couplings join the straight tube sections at a slight angle to form the arch. Altogether the bridge has 1,036 tubes, 1,024 main braces, and 112 huge anchor bolts, plus tension rods, nuts and bolts.

Perfecting the Steel Alloy

The contract called for testing of every part with rigid specifications regarding "elastic limits" and "modulus of elasticity," which at the time were unfamiliar terms to the steelmakers and fabricators. Six months went by before they fashioned a single cylindrical tube stave worth testing, of which six were needed to form each arch tube. Eventually a rival steel firm, with the aid of a metallurgist imported from Europe, found an acceptable formula that solved the steel tube problem.

Jim Talbot is a freelance technical writer living in Ambler, Pa.

A Mississippi River Man

James Eads is one of history's most interesting engineers. His whole life revolved around the Mississippi River. This self-taught engineer initially made his fortune in salvage, walking the river bottom under a diving bell to find sunken ship cargoes.

Eads designed, built, and financed the iron-clad river gunboats that had devastated Confederate river fortifications and did much to ensure Union victories in the western campaigns of the Civil War. Following that he managed against all odds (with more government hindrance than help) to build the bridge that today bears his name across the Mississippi River.

Eads also fought for legislation and financed the building of narrow jetties at the mouth of the Mississippi to open up commerce on the river. Often the channels through the delta were not deep enough for ships to pass, and many would be stuck for long periods waiting to get in or out. With his jetty design, the river's velocity did the job of scouring and creating depth.

The anchor bolts that secured the iron skewbacks to the piers, most of which were steel, also proved troublesome. Each was 34 ft long and weighed more than 3,000 lb. Initially, the testing machine was breaking 80% of them. Eads would not relax his standards. By mid-summer the steelmakers managed to make bolts that survived testing in sufficient quantities.

Much of 1872 was spent finding ways to create the couplings that would join the arch tubes. Few were surviving the testing machines. Eventually trial and error plus the greasing of palms solved this particular problem. But only half the couplings needed were produced over a two-year period.

Closing the Arches

By the spring of 1873 work began on the cantilevered construction of the arches. That was none too soon, as a loan of a half million dollars from the House of Morgan in London depended on the arches being closed by September 19, 1873.Work crews first erected temporary wooden towers atop the piers. The towers supported "cables" to hold the arch halves and bracing in place as they crept in space towards each other to meet in midstream between piers. The cables themselves consisted of sections of steel bars about 1 in. thick, 6 in. to 7 in. wide, and 27 ft long.

Eads specified the arch tube lengths slightly longer than the actual distance required because the arches would compress once the cables were removed. Originally Eads figured the arches would lap each other by about 2¼ in. But the estimate of the steel's modulus of elasticity proved too low. Later he estimated the arch tubes would lap by 3¼ in.

Eads wasn't worried. He had already devised a solution to close the arches if needed. His idea was to cut duplicates of the final arch tubes in half, take 5 in. off their length, and cut opposing screw threads inside two ends. He would have ready wrought iron plugs with corresponding screw threads on each end. These "extensible links" would close the arches, using the threads to adjust the distances as needed. Steel bands would later cover the exposed threads.

It turned out that this solution was necessary. Unseasonably hot weather offset the action of cable jacking and 60 tons of ice to shorten the final tubes sufficiently. Finally giving up, the crews used Eads' extensible links to close the arches two days ahead of the loan deadline.

When the bridge was finally completed, Eads assembled 14 large locomotives, as many as were available to him, to test the structure ahead of the grand opening. Their tenders filled with coal and water, the locomotives crisscrossed the bridge several times in various configurations. Designed to carry 3,000 lbs per linear ft, the bridge currently can carry 5,000.

The bridge opened to great fanfare on July 4, 1874. In attendance were President Ulysses S. Grant, who had been elected shortly after the pier construction for the bridge began, as well as governors, mayors, legislators, financiers, and more than 150,000 onlookers. A 14-mile parade, a fireworks display, and saluting guns on each side of the river contributed to the festivities.

Adapting to the Times

The bridge has two decks. The original top deck carried horse-driven vehicles and offered two lanes for pedestrians. The bottom deck originally served passenger and freight railroad traffic. Surprisingly, the railroads boycotted the bridge for more than a year after its opening. They preferred to continue the practice of unloading cargo, ferrying it across the river, and reloading it on the other side.

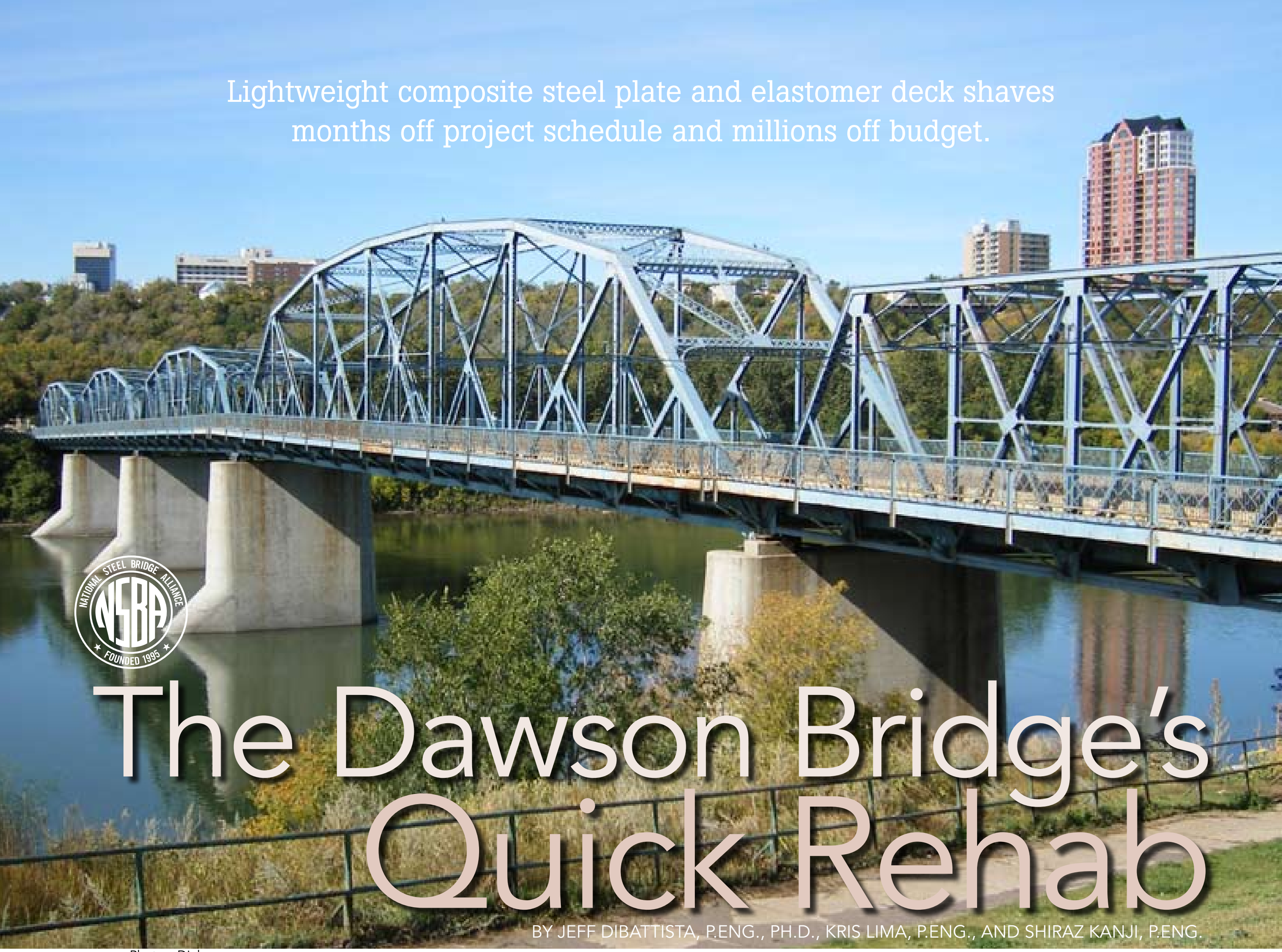
The year 1974, 100 years after its opening, marked the bridge's last regular train service across the lower deck. In 1991 deterioration and lack of traffic completely closed the bridge. But two years later Metro, the St. Louis region's public transportation agency, made use of the lower deck for its light-rail system MetroLink. And spearheaded by the city and regional TrailNet system, the widened upper deck reopened on July 4, 2003 with four lanes for automobile traffic and a refurbished south lane for walkers, runners, and cyclists.

Metro and the city of St. Louis currently share ownership of the bridge. The city maintains the top deck and Metro takes care of everything else. Reportedly, MetroLink runs roughly 290 trains daily across the bridge. Occasionally the top deck of the Eads Bridge is closed to automobile traffic while it serves as a site for festivals and celebrations. A new nearby bridge over the Mississippi will open in 2014, reducing automobile traffic demand. A design competition underway has the Eads Bridge playing an integral role in renewal of the St. Louis Gateway Arch grounds.

Metro recently acquired funding from the American Reinvestment and Recovery Act of 2009 to completely rehabilitate the bridge. The three-year project includes replacing aging support steel, sand blasting and painting the entire superstructure, and repairing the MetroLink track system. MetroLink will maintain service in both directions on one track while working on the other. The tracks interlock, meaning trains can cross from one to the other.

Now a National Historic Landmark and tourist attraction, this iconic and beautiful 137-year-old bridge continues to arouse the emotions and pride of the St. Louis populace. Additionally it functions as an effective intermodal form of transportation across the Mississippi River. The rehabilitation work under way will preserve this engineering masterpiece for many years to come. It's easy to imagine the Eads Bridge celebrating 200 years of service as a significant connection between America's east and west. Hail to this Steel Centurion. MSC

▲ The Eads Bridge in the 1920s, offering trolley service on the top deck.



Lightweight composite steel plate and elastomer deck shaves months off project schedule and millions off budget.

The Dawson Bridge's Quick Rehab

BY JEFF DIBATTISTA, P.ENG., PH.D., KRIS LIMA, P.ENG., AND SHIRAZ KANJI, P.ENG.

Photos: Dialog

CITY OFFICIALS RECENTLY were able to both save a historic Edmonton bridge and avoid massive structural repairs and upgrades by opting for a lightweight steel deck system overlaid with asphalt instead of the traditional concrete replacement deck. The system uses composite panels consisting of steel plates with a solid elastomeric core. Although the material has been used in shipbuilding for years, its use in bridge construction is relatively new. In addition to providing an effective and economical solution, using this steel deck system also cut construction time significantly.

Bridge History

The North Saskatchewan River winds its way from the Rocky Mountains, across Alberta, and through the heart of Edmonton on its way toward Lake Winnipeg. Its shores have been populated at Edmonton by aboriginal peoples for millennia, with the first European influence appearing in the late 18th century. During World War II, Edmonton acted as a staging area for construction of the Alaska Highway, and today is the capital of Alberta with a regional population of over one million.

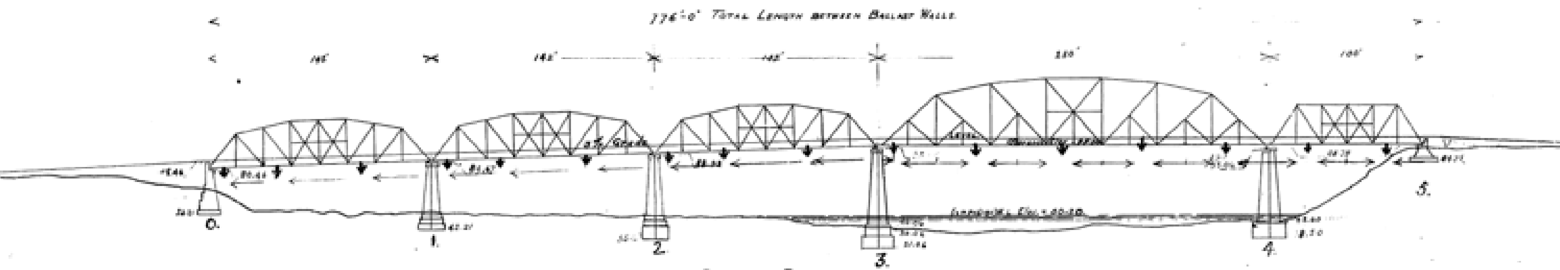
Historic Dawson Bridge has been a vital link for the people of Edmonton for generations, entering its 100th year of service in 2011. Originally known as the East End Bridge, it is a five-span riveted steel through-truss with a clear width of 26 ft, 8 in. and a total length of 776 ft: three spans of 142 ft, a navigation span of 250 ft, and an east approach span of 100 ft.

Originally constructed to carry horse-drawn wagons and electric trains to the Dawson Coal Company mine located on the east bank, the bridge opened on October 8, 1912 with a construction cost of $145,000. Only the second bridge to cross the North Saskatchewan River at Edmonton, Dawson Bridge quickly became a vital link for the city's growth, allowing coal to be transported quickly into the heart of the city for industry and home heating.

After closure of the Dawson Mine in 1944, the bridge was converted to carry only highway vehicles. Today, the bridge has one lane of traffic in each direction and accommodates about 17,000 vehicles each weekday. As a link to Edmonton's extensive multi-use river valley trail system, the two sidewalks on Dawson Bridge serve many pedestrians and cyclists.

Condition Assessment

In 2007 the city of Edmonton commissioned Dialog to conduct a condition assessment for Dawson Bridge. Field inspection revealed the nearly 100-year-old superstructure in need of significant repair, including total replacement of the bridge deck and complete recoating of all steelwork. Structural analysis also identified numerous truss members requiring strengthening or



City of Edmonton

General plan from 1913 of the East End Bridge, now known as the Dawson Bridge, in Edmonton, Alberta, Canada.

With an overall length of 776 ft, the Dawson Bridge consists of five simply supported trusses that cross the North Saskatchewan River on the east side of Edmonton.

replacement in order to increase the service life of the bridge and meet the target reliability indices of the *Canadian Highway Bridge Design Code 2006*. In addition, the original narrow sidewalks—only 5 ft wide—caused safety problems due to mixed use by pedestrians and cyclists.

Especially problematic was the existing 6½-in. steel-fiber reinforced semi-lightweight concrete deck, cast in 1986 on top of old timber subdecking from the 1940s. Though its relative light weight was beneficial for limiting dead loads, the thin concrete deck was too flexible to resist cracking. In particular, the city had continual maintenance problems with the methyl methacrylate membrane wearing surface at details where the concrete deck passed over the transverse floor beams. The concrete deck section was reduced to only 2½ in. thick to clear the top flange of the floor beams, making it nearly impossible to control cracking.

As part of the assessment, a load rating of Dawson Bridge was conducted using a 4-axle, 63.5 ton Alberta CS3 rating vehicle, the largest vehicle that might practically access the bridge considering its vertical clearance restrictions and location. That assessment concluded that numerous truss members required strengthening or replacement to meet the required level of safety and to extend the life of the bridge.

As options for rehabilitation were developed, it became clear that the bridge could be rehabilitated economically only if a lightweight deck replaced the existing deteriorated deck. A traditional concrete deck would require costly replacement or strengthening of many truss members along with difficult up-

The Dawson Bridge rehabilitation included upgrading critical connections by replacing the original rivets with high-strength bolts.

A hydraulic jacking system was used to relieve the load on truss members in need of strengthening or replacement as the work was performed.

Jeff DiBattista, P.Eng., Ph.D., is a principal and Kris Lima, P.Eng., is an associate with Dialog, an integrated design firm specializing in engineering and architecture. Shiraz Kanji, P.Eng., is chief bridge engineer for the City of Edmonton.

▲ The old, deteriorated concrete deck was sawcut and removed in March 2010.

◄ **Top left and inset:** All members were blast cleaned in preparation for applying a three-part zinc/epoxy/urethane coating system, providing protection well into the bridge's next century of service.

➤ Fabrication of the SPS components, which consist of two ⅜-in. steel plates connected with perimeter bars and continuous fillet welds then filled with a liquid elastomer that quickly solidifies.

grading of existing connections. Additionally, it might overload the piers, abutments, and foundations. The design team concluded that replacing the existing semi-lightweight concrete deck with a lightweight steel deck would allow the dead load savings to be applied to carrying additional live load and widening the sidewalks. Only steel offered viable lightweight deck options: grating, orthotropic deck, or an innovative composite steel plate and elastomer system called the Sandwich Plate System (SPS) developed by Intelligent Engineering (Canada) Ltd.

Grating was quickly eliminated as an option for the deck because increased road noise would be detrimental to the nearby Riverdale community. Orthotropic steel deck was judged a suitable option, but detailing would be challenging where the deck had to clear the tops of the floor beams without raising the grade line. There also were concerns about its susceptibility to fatigue cracking. After considerable research, the design team recommended the patented SPS solution, judging that SPS technology offered the best combination of light weight, thin profile, and ease of erection for the Dawson Bridge Rehabilitation project.

Innovation and Risk Control

The SPS composite steel plate and elastomer system was originally developed by UK-based firm Intelligent Engineering Ltd. for ship hulls and decks in the marine industry. Application of this technology in the bridge industry began about a decade ago. After its use on several bridges around the world, SPS technology is gradually gaining acceptance by bridge engineers.

SPS makes use of two relatively thin steel face plates connected by an injected thermosetting elastomer core. The final product is a composite panel with high stiffness and strength, but relatively low weight.

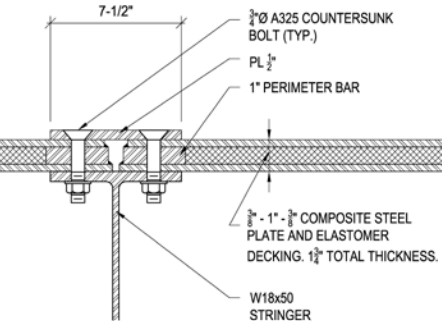
Deck panels are fabricated in the shop using conventional steel fabrication techniques. First, solid "perimeter bars" are welded along each edge of the bottom plate using a continuous fillet weld. The top plate is then lowered onto the perimeter bars and fillet welded all around forming a panel with a sealed void. The liquid elastomer, which cures into solid form within an hour, is injected through a port to form the core. For Dawson Bridge, the ⅜-in. steel face plates sandwich a 1-in. elastomer core, forming a composite deck panel with a total thickness of only 1¾ in. These prefabricated panels are typically 6 ft, 1 in. wide and 28 ft long.

Risk is inherent in the application of all new technologies in all industries. Perceived risk and its associated liability often dissuade engineers from trying innovations that might advance the state of the art in their area of practice. Potential liability places a constriction on the pace of innovation that, in the long run, is most often a disservice to society. Striking the right balance between innovation and risk control is the key to success. Thus, when Dialog recommended SPS—a relatively new technology—to the City of Edmonton, that recommendation came with the proviso that an intensive risk control program must be implemented, especially because Dawson Bridge is an important and expensive asset. As a progressive bridge owner, the city welcomed that innovation and directed the design team to proceed with SPS as the basis of design for the deck.

The risk control plan developed for the deck comprised six key elements:

- Extensive background research in the available literature;
- Site visits by the design team to other bridges with SPS decks, and interviews with the bridge authority managing those structures;
- Development of improved connection details in consultation with Intelligent Engineering;
- Fatigue testing of full-scale sample connections in the laboratory;
- Enhanced quality control and quality assurance programs during deck fabrication and erection; and,
- Monitoring of deck performance over the lifetime of the bridge as part of the Edmonton's bridge maintenance program.

Dialog judged the most important aspect of the risk control



Deck connection detail, showing A325 bolts countersunk into the top connection plate while the beam flange serves as the lower connection plate.

Laboratory sample of a typical steel plate and elastomer connection detail for the Sandwich Plate System.

SPS deck construction sequence: A) Steel deck in place; B) The surface is grit blasted; C) The steel is covered with a waterproof membrane; D) The asphalt wearing course is placed.

Placement of one of the SPS 6 ft by 28 ft deck pieces on the Dawson Bridge in August 2010.

plan to be the development of new connection details between adjacent SPS deck panels. Of the handful of bridges around the world built using SPS technology, all have involved significant field welding—a method that is costly and makes quality control difficult. Risks associated with field welding include fit-up out-of-tolerance, the potential for excessive heat input that might debond the elastomer from the steel, and undesirable weld flaws that might inadvertently result in premature fatigue cracking.

Taking to heart the golden rule "shop weld and field bolt," the Dialog design team developed unique bolted details for connecting the SPS deck panels that completely eliminate the need for field welding. Bolted connections drastically increase speed of erection, significantly reduce cost, and improve fatigue performance from Detail Category D (depending on the specifics of the weld geometry) to Detail Category B when using slip-critical connections.

To connect adjacent SPS deck panels, a top splice plate is fastened by a single row of countersunk pretensioned ¾-in. ASTM A325 bolts. Countersunk bolts provide a flat surface for the finished deck, except for the thickness of the splice plate itself. This surface, once grit blasted, is prepared to receive a waterproof membrane and asphalt.

Longitudinal deck splices are designed to align with floor stringers below. This arrangement enables the top flange of the stringers to act as the bottom splice plate for the connection, saving both weight and complexity. The new stringers chosen—W18×50—are larger than required for flexural strength but offer a flange wide enough to accept a row of bolts on each side of the web. At transverse deck joints, located away from floor beams to avoid clashes, bolted splice plates are used both top and bottom. In all cases enough bolts are used so that sealing requirements are met and negative moments in the deck can be transferred across the supporting stringers. This very simple approach to connections makes the deck very easy to fabricate and simple to erect. Using similar bolting details, the traffic barriers along the length of the bridge are also bolted down through the deck to the edge stringer.

Also as part of the risk control plan, three small 1:1-scale samples of the longitudinal bolted deck connection detail were built and tested under fatigue loading at the University of Alberta with the assistance of professor Gilbert Grondin, P.Eng., Ph.D. Those tests demonstrated that the new connection detail can withstand fatigue loads nearly double in magnitude to those expected in actual in-service conditions.

Reaping the Benefits of Innovation

Because the composite steel deck panels could be fabricated entirely in the shop and bolted quickly into position on the bridge, erection of the deck was completed in only six weeks during July and August 2010. This speed allowed the $17 million rehabilitation to be finished in only 12 months: the bridge closed to traffic on January 4, 2010, and reopened on December 20, 2010. A traditional concrete deck would have extended the project schedule to at least 18 months, added millions of dollars of extra truss strengthening work, and caused numerous other technical issues.

The Dawson Bridge project has successfully advanced the state of the art in bridge technology and has achieved cost savings for the City of Edmonton, while allowing the rehabilitation work to be completed within a single construction season. Today, Dawson Bridge is fully rehabilitated with the world's largest SPS deck—the only installation built entirely without field welding—and it stands prepared to serve Edmontonians for many generations to come. MSC

Owner
City of Edmonton, Alberta, Canada

Structural Engineer
Dialog, Edmonton, Alberta, Canada

Steel Detailing
Empire Iron Works Ltd., Edmonton, Alberta, Canada
(NISD Member)

General Contractor
ConCreate USL Ltd., Crossfield, Alberta, Canada

One Question / Three Answers

Bridges: Sustainability

ANSWERED BY M. MYINT LWIN, RAY MCCABE, AND MALCOM THOMAS KERLEY, P.E.

Question: How do you see sustainability impacting the bridge industry five years from now?

SOME IMPORTANT QUESTIONS have complex answers and benefit from reflection and discussion. In this series designed to reflect that understanding, NSBA asks leading minds in the bridge community to weigh in on some of life's imponderables.

Answer: M. Myint Lwin
Director of the Office of Bridge Technology, Federal Highway Administration

In the design and construction of bridge projects, bridge engineers have been and are paying attention to (1) strength, durability and reliability; (2) compliance with environmental and preservation laws and regulations; (3) community involvement; (4) use of recycled and high-performance materials; and (5) minimizing negative impact to the environment. However, there are opportunities to do more with specific, targeted and measurable goals to contribute toward sustainable bridge projects.

In the next five years, we will see general acceptance and implementation of green designs and rating systems by bridge owners for reducing life-cycle costs, energy use, greenhouse gas emissions, pollution emissions, waste, and the use of non-renewable resources to sustainable levels. Bridge engineers will be integrating structural, durability and environmental considerations in their designs. There will be increased demand on the industry to supply construction materials, equipment, and methods in support of the sustainability performance goals of the bridge owners.

In 1987, the Brundtland Commission defined sustainable development as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. The past generations had done their shares in creating marvelous and long-lasting structures that met their needs. They had not comprised our ability to meet our needs. It is now our responsibility to meet the environmental, economic and social needs of our generation and future generations.

For Lwin's additional commentary on the five points listed above, go to **www.steelbridges.org/onequestion**.

Answer: Ray McCabe
National Director of Bridges and Tunnels, HNTB Corporation

There is a change under way in America's transportation industry and it is clear that sustainability in infrastructure planning, design, construction and maintenance has grown in importance in the last few years. One factor driving that change is the implementation of a sustainability rating system for transportation.

With that in mind, I don't envision sustainability having any game-changing impacts to the bridge industry in the next five years. However, I do believe that continued/new emphasis on sustainability will focus in the following areas:

- **Increased service life for major bridges,** meaning those with large capital investment and high traffic volumes. For new designs of major bridges that target 100- to 150-year service life, emphasis will be placed on more durable components and materials, better corrosion-resisting steels, use of fiber reinforced composites etc.
- **Rapid bridge construction.** More efficient and faster construction methods will lead to less energy consumption, less traffic disruption and associated pollutants creating smaller environmental impacts.
- **Preservation of existing bridge infrastructure.** First, we must evaluate existing bridges with preservation in mind. Rehabilitation design must incorporate better materials and rapid construction while guarding against unnecessary replacement and rehabilitation by using modern structural health monitoring techniques.
- **Improved methodology to evaluate sustainability effectiveness.** More research and better evaluation tools need to be developed to assist in determining what sustainability solutions are most effective. For example, while concrete may require less energy consumption in manufacturing than steel at its use stage, steel offers an energy benefit in its ability to be recycled at is end stage.

One Question / Three Answers

Bridges: Sustainability

Answer: Malcom Thomas Kerley, P.E.
Chief Engineer, Virginia Department of Transportation

Sustainability is not the first thing I think about when I think about impacts to the bridge industry in five years. Resources in the areas of both staffing and funding will continue to be the main concern for bridge engineers as they look to maintain our aging bridge population. However, the impact of sustainability on the bridge industry will depend on the ongoing discussions about that subject.

On its Sustainable Highways Self-Evaluation Tool website (**www.sustainablehighways.org**), the Federal Highway Administration defines sustainability and its goal in this way:

> *"Sustainability is the capacity to endure. The goal of sustainability can be described with the Triple Bottom Line concept, which includes equity, ecology, and economy."*

Sustainability, like climate change, will be a topic for discussion for several years. What does it mean? How does it impact what we do? What changes do we need to make? Obviously, the bridge industry will be impacted by these discussions.

Bridge engineers in both the private and public sector should be involved in these discussions as project selection, materials, manufacturing and construction techniques may/will be impacted. Bridge engineers should continue to look for new processes and systems that reduce project delivery costs and delivery time and protect the environment. MSC

PROJECT MILESTONE

Two-Span UDOT Bridge Rolled into Place Overnight

The Utah Department of Transportation and contractor Provo River Constructors (PRC) made history overnight on March 26-27 with the successful move of the Sam White Bridge over Interstate 15 in American Fork, Utah. Working with the longest two-span bridge ever moved by Self-Propelled Modular Transporters (SPMTs) in the Western Hemisphere, crews set the new bridge into place at approximately 4 a.m. Sunday and reopened the freeway at 7 a.m., three hours ahead of schedule. The move was part of UDOT's $1.725 billion Utah County I-15 Corridor Expansion (I-15 CORE) freeway reconstruction project.

"The Sam White Bridge move demonstrates our commitment to employing the latest technology to minimize delays to the traveling public and delivering our projects as fast as possible," said John Njord, executive director of UDOT. Utah includes the cost of traffic delays and other inconveniences to the public as part of its project estimating and bidding process. Using the bridge transport technology reduced delays from months to days to meet the project's aggressive three-year timeline.

"Building the bridge using Accelerated Bridge Construction (ABC) eliminated the need for as many as 10 full freeway closures," said Dal Hawks, I-15 CORE project director. "This reduced traffic delays and benefited the state's economy by keeping people, goods and services moving while the bridge was being constructed."

PRC, the consortium of expert local, regional and national contractors and engineers acting as the project's design-build contractor, constructed the 354-ft, 1,900-ton structure on falsework in a "bridge farm" along the east side of I-15. A steel-plate girder design was chosen for the Sam White Bridge due to its relatively light weight and its ability to follow the profile grade line. AISC and NSBA member Utah Pacific Bridge & Steel Corporation, Lindon, Utah, fabricated the steel for the bridge, which was designed by the Moon Township, Pa.-based Michael Baker Jr., a member of the PRC consortium.

Moving the bridge perched 21 ft in the air involved precise coordination. The two-span structure was raised off the falsework, then moved simultaneously using four lines of SPMTs, which are hydraulic jacks on wheels, controlled by a single joystick.

To accommodate the bridge move, I-15 was closed in both directions between the American Fork Main Street and Pleasant Grove Boulevard interchanges on Saturday, March 26, starting at 11 p.m. until Sunday, March 27, at 10 a.m. Approximately 1,000 people came out to witness the operation. In addition, state elected officials, more than 100 delegates from other Departments of Transportation and the Federal Highway Administration (FHWA), and transportation industry professionals from as far away as China also watched the move.

After raising the structure off its falsework, crews moved the bridge approximately 500 ft across eight freeway lanes—which included rotating it to the crossing's final 48° skew—and lowered into place. To see a two-minute preview and animated simulation of the move sequence, go to **http://bit.ly/euZizx**. UDOT's five-minute time lapse video of the actual move is also available at **http://bit.ly/eAvSaP**.

Located 30 miles south of Salt Lake City, the Sam White Bridge is one of 59 new, modified or rebuilt structures on the 24-mile Interstate reconstruction project. The state-funded project is reconstructing the highway from Lehi to Spanish Fork which connects the northern and southern halves of the state. The I-15 CORE project is scheduled for completion by December 2012. To learn more about the bridge-related aspects of the project, visit **http://bit.ly/fcHc8c**.

The state has been using SPMT technology for nearly four years. Its first move was on October 28, 2007, when the 172-ft-long 4500 South Bridge was moved over I-215. The Sam White Bridge is UDOT's 23rd ABC bridge move—nearly double the number moved by all other states combined. The FHWA designated UDOT's move as a "Showcase" event for leaders to learn more about ABC technology and how it can be applied to other transportation systems in the country.

Utah DOT

Bridges: Life Cycle Costing

ANSWERED BY MALCOM THOMAS KERLEY, P.E., AND M. MYINT LWIN

Question: Do you incorporate life cycle costing into your decision-making process? If so, how?

SOME IMPORTANT QUESTIONS have complex answers and benefit from reflection and discussion. In this series designed to reflect that understanding, NSBA asks leading minds in the bridge community to weigh in on some of life's imponderables.

Answer: Malcom Thomas Kerley, P.E.
Chief Engineer, Virginia Department of Transportation

A simple answer to your question is yes. The how part of the answer is more complicated. Most states, if not all, use some form of life cycle costing philosophy in developing their projects. The American Association of State Highway and Transportation Officials (AASHTO) and the Federal Highway Administration (FHWA) support the use of life cycle costing in the development of projects. Both AASHTO and FHWA have sponsored research to identify best practices in life cycle cost analysis.

For example, the National Cooperative Highway Research Program's (NCHRP) Project 12-43, "Life-Cycle Cost Analysis for Bridges," produced NCHRP Report 483 and CRP-CD-26, which established guidelines and standardized procedures for conducting life cycle costing. Part II of the report is a Guidance Manual for use in either replacing existing bridges or evaluating new bridge alternatives. The FHWA website on Asset Management also provides guidance for improving investment decisions through life cycle cost analysis.

The AASHTO Highway Subcommittee on Bridges and Structures' "Grand Challenges: A Strategic Plan for Bridge Engineering" also addresses life cycle costing. Two of its challenges, Extending Service Life and Optimizing Structural Systems, address this subject. The use of new high-performance materials also impacts decisions in project selections.

States, all states, are interested in economical, long-lasting structures that are procured in a competitive environment. States look to minimize their future maintenance costs. In their decision-making processes, states consider life cycle costing philosophy and the assumptions they make impact their decisions.

Answer: M. Myint Lwin

Director of the Office of Bridge Technology, Federal Highway Administration

The Intermodal Surface Transportation Equity Act of 1991 (ISTEA) suggested the use of life cycle costing or life cycle cost analysis (LCCA) in the design and engineering of bridges, tunnels, and pavements. It was not until the National Highway System (NHS) Designation Act of 1995 that states were required to conduct an LCCA for each usable project on the NHS with a cost of $25 million or more. In support of the requirement, the FHWA issued a policy statement on LCCA in the September 18, 1996 Federal Register. The policy statement established LCCA principles to be applied by FHWA in infrastructure investment analysis, and provided a framework that states might use in conducting LCCA investment decisions. The importance of considering LCCA in various phases of project development, construction, maintenance, and operation was emphasized.

The Transportation Equity Act for the 21st Century of 1998 (TEA-21) rescinded the LCCA mandate of the NHS Designation Act of 1995. States were no longer required to perform LCCA. The Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users of 2005 (SAFETEA-LU) requires that states provide value engineering (VE) analysis or other cost-reduction analysis for a bridge project with an estimated total cost of $20 million or more; and any other project as appropriate. For major projects, more than one analysis may be required. The analyses for a bridge project must be evaluated on engineering and economic bases, taking into consideration acceptable designs for bridges, and using an analysis of life-cycle costs and duration of project construction.

The FHWA continues to develop LCCA practical tools and training materials in support of decision making in alternate design studies, construction costing, investments in inspection, maintenance, operation, preservation and management activities. The FHWA encourages the use of LCCA in all significant highway investment decisions. The short- and long-term benefits can be immense. MSC

Constructed against great adversity over a 14-year period, this 128-year-old landmark continues to serve the people of New York and America.

The Brooklyn Bridge: First Steel-Wire Suspension Bridge

BY JIM TALBOT

STEEL CENTURIONS
SPANNING 100 YEARS

Our nation's rich past was built on immovable determination and innovation that found a highly visible expression in the construction of steel bridges. The Steel Centurions series offers a testament to notable accomplishments of prior generations and celebrates the durability and strength of steel by showcasing bridges more than 100 years old that are still in service today.

NEW YORK'S FAMOUS suspension bridge over the East River linking Manhattan with Brooklyn—the Brooklyn Bridge—was a mammoth civil engineering project for the late 1800s. Its two massive granite piers, standing 276.5 ft above mean high water, were designed to provide clearance below its suspended deck for the masts of sailing ships. The piers towered over the existing skylines on either side of the river and extended down 44 and 76 ft below the water on the Brooklyn and Manhattan sides. The main span reaches 1,595.5 ft across the river and the bridge's total length, including approaches is more than 6,000 ft.

A contemporary with the steel-arch Eads Bridge over the Mississippi at St. Louis, the Brooklyn Bridge was the world's first major steel suspension bridge: the main cables, the suspenders, and the truss deck were all steel. The four 15.75-in.-diameter main cables, 3,578.5 ft in length, run from the anchorages on either side, over saddles on the pier tops, and swoop in a catenary to the level of the deck below. The deck is an 85-ft wide stiff steel truss suspended from the four cables by vertical and diagonal steel wire ropes.

A Roebling Bridge

The designer, John Augustus Roebling, was a German immigrant who, with his brother, came to America in the early 1830s. They founded a farming settlement called Saxonburg in Western Pennsylvania. Having been trained as an engineer in Berlin, Roebling soon grew impatient with farming. He returned to engineering with a series of jobs that included surveying rail lines and improving canals. At the time, canal boats were loaded onto railcars and pulled up and over mountains using long, expensive hemp ropes. Roebling started producing wire ropes for this purpose on his Saxonburg farm. He also designed several suspension bridges and aqueducts using wire rope. In the late 1840s

▲ The Brooklyn Bridge, which today carries an estimated 145,000 vehicles per day, was built at a time when the tallest building in New York was only 5 ft taller than the bridge's 276.5-ft towers.

➤ The 85-ft-wide main deck of the Brooklyn Bridge had a pair of rail tracks for passenger trains down the center flanked by lanes for coaches and a pedestrian promenade. Pedestrians paid a 1 cent toll on opening day and 3 cents thereafter. The vehicle toll was 5 cents. By 1884, a year after the bridge opened, 37,000 people a day were using the Brooklyn Bridge to cross the East River.

he moved his successful bridge construction and iron wire rope business to Trenton, N.J.

By the time Roebling designed the Brooklyn Bridge in 1867, he was a highly respected engineer and prosperous businessman. His plans called for suspension cables made from steel, which he considered "...the metal of the future." City and federal approval of the bridge design took two years until June of 1869. Later that month, while on a ferry pier sighting a position for the bridge, Roebling's toes were caught and crushed between pier piles and beams by an incoming boat as it bumped against the dock. Directing his own medical treatment after amputation of his toes, he died 24 days later of a tetanus infection and seizures.

Roebling's son, Washington, took over as chief engineer when construction began in early 1870. He had assisted his father on other suspension projects, and was familiar with European experiences with caissons, which would be needed to complete the piers. He served as chief engineer for the next 13 years, taking the bridge to completion. During much of that time he was suffering from a severe physical disability resulting from his supervisory work inside the pneumatic caissons. Little was understood at the time about caisson disease or "the bends."

Jim Talbot is a freelance technical writer living in Ambler, Pa.

This 1881 drawing shows how, with the main suspension cables in place, crews worked from both sides of the river to advance the deck over the water. As steel cross beams were added, planks were placed for the workers to stand on.

Building the Piers

Completion of the bridge piers took three years. Work began on the Brooklyn side pier where the caisson sank slowly toward bedrock because workers often had to cut or blast through huge boulders. Conditions were miserable and turnover was high. The final depth was about 45 ft and the maximum air pressure reached 21 psig. Only a few workers suffered leg paralysis.

Work on the Manhattan side pier began in September of 1871. This caisson met mostly sand, which could be sent up through a pipe propelled by the air pressure. The caisson sank relatively quickly but went to greater depths. At about 75 ft the required air pressure neared 35 psig. Three workers died from caisson disease shortly after leaving the air locks. Roebling, himself a victim of the disease, stopped the work before completely reaching bedrock. Helped greatly by his wife, Emily, he continued working as chief engineer, but was rarely on site.

Main Cable Preparations

By mid-1876 the towers were up, and it was time to add the four main steel cables. To begin, a boat towed a single wire across the river from Brooklyn. Crews hoisted the wire over the two towers, then used it to pull a heavier ¾-in. steel working rope over the piers between the two anchorages. The process was repeated to create a second working rope. Crews spliced the two working ropes together to form a continuous loop or "traveler." The first traveler served to haul steel rope across to create a second traveler. The length of one traveler loop was 6,800 ft or more than a mile.

The steel ropes for the two traveler loops stood about 27 ft apart at locations that approximated the position of the four main bridge cables. Their initial function was to haul more wire ropes to build a temporary footbridge and a series of platforms across the river for work crews. Later the travelers began their main function: to carry the steel wires for the main cables from anchorage to anchorage, two at a time. Because each main cable consisted of 5,434 parallel steel wires arranged in 19 strands, the travelers cycled back and forth many times to create a main cable. As one side of a traveler returned to Brooklyn, the other would be carrying a pair of wires to Manhattan.

Wire Fraud

The elder Roebling's specification for the main cable wire called for No. 8 Birmingham gauge galvanized steel wire (0.165 in. diameter) that could withstand 3,400 lb of tension before breaking. The wire had to lie straight when uncoiled from a reel. The project would need 6.8 million lb of the steel wire. Several firms in the U.S. and Europe, including the Roebling factory in Trenton, bid on the wire contract and submitted samples for testing. Some controversy developed over the quality of the newer, less expensive Bessemer steel versus the more traditional crucible steel. The contract went to J. Lloyd Haigh of South Brooklyn, N.Y., that submitted crucible steel.

Later, Washington Roebling discovered that the Haigh firm was sometimes delivering rejected wire rather than the good wire passed by inspectors. A good percentage of the steel wire deliveries were made by the Bessemer process as well. To compensate for the rejected steel wire already in the cables, Roebling required 150 more good steel wires per cable than originally planned. Additionally, the elder Roebling had calculated a safety factor of six for the main cables. His son figured the safety factor may have been reduced, but was far more than sufficient. Lastly, he learned that the original sample of wire submitted by Haigh was made by another firm.

Stringing the Steel Wire

As chief engineer, Roebling struggled in supervising the building of the superstructure because caisson disease had reduced him to an invalid. He and his wife, Emily, supervised the project with a telescope from their residence in a nearby building. With help from her husband, Emily Roebling learned math and engineering and served as a communication liaison with the engineers on site.

Work started on placing the main cable wires between the two anchorages in February 1877. Crews on the anchorages and platforms positioned or "regulated" the wires as they were hauled over by the travelers, lashing 286 wires into strands. One strand was at the center, surrounded by six strands, and surrounded again by 12 strands. The crews built the cables from the bottom up to form this arrangement. Sixteen machines wrapped the finished cables with iron wire to finish the job. Clamps moved ahead of the machines to bind the wires tightly to form a cylinder. Lastly the wires were oiled and painted. Crews completed the work on the main cables by October 1878.

Constructing the Deck

The deck consists of a steel truss suspended from the four main cables by 1,520 galvanized steel wire ropes and 400 diagonal stays. In designing the bridge, the elder Roebling believed that a heavy, stiff deck was the key to stabilizing suspension bridges under conditions of high winds. The Brooklyn Bridge deck arches slightly upward, enhancing its aesthetic qualities. Once the suspending cables were in place, crews added steel cross beams, working out from the anchorages. They stood on planks placed over the beams as the deck advanced over the water. After the suspending ropes and deck beams were in place, crews installed the diagonal stays.

Delays in steel deliveries plagued work on the deck and approaches and almost caused the removal of Roebling as chief engineer. Finishing touches included terminal buildings at each end and electric arc lamps along its length. The 85-ft wide deck accommodated a pair of rail tracks for passenger trains down the center flanked by lanes for coaches and a pedestrian promenade.

Opening ceremonies for the bridge finally took place on May 24, 1883, with president Chester Arthur and Governor Grover Cleveland attending. Washington Roebling was unable to attend the ceremonies, but his wife Emily held a reception at their nearby residence. Previously she had the honor of taking the first ride across the bridge. The trains started running in September, moved by an endless cable. A year after the bridge opened, 37,000 people a day were using it to cross the East River.

Washington Roebling, while partially crippled and hurting, lived on until 1926, dying at the age of 89. He actually ran his father's company, John A. Roebling's Sons, during his last years after the death of his son Karl. During that time he changed the mills over from steam to electric power, set up a department for electrolytic galvanizing of wire, and oversaw the cables for New York's Bear Mountain Bridge over the Hudson River. Himself a key part of the Roebling family legacy, he sometimes complained of being confused with his father. "Many people think I died in 1869."

During the years from 1944 to 1954, the trolley and elevated train tracks were removed and roadways were widened to three lanes in each direction. Work crews also strengthened the trusses and installed new horizontal stays between the four main cables. In 1964 the bridge became a National Historic landmark. In 1999 it received new decking to replace crumbling concrete. Currently the Brooklyn Bridge carries an estimated 145,000 vehicles a day, but is off limits to commercial traffic. Pedestrians and cyclists continue to share the raised promenade down the center of this celebrated, iconic American bridge. MSC

Much of the information for this article is from The Great Bridge, *by David G. McCullough, Simon & Schuster, New York, 1972.*

Poised for Innovative Rehabilitation

A structure as prestigious as the Brooklyn Bridge would not measure up to the public's expectations without its approach spans which, like the bridge itself, also require maintenance and repairs. One of these, the Franklin Square Bridge, is scheduled for rehabilitation in the near future. This medium-span structure forms part of the Manhattan approach to the Brooklyn Bridge at Pearl Street. The rehabilitation includes the replacement of the current bridge deck with an orthotropic steel deck, an innovative solution that reduces both overall weight as well as installation time.

The replacement of the bridge deck is a crucial element during rehabilitation activities, as it has a direct impact on road users on a daily basis. It is therefore essential to minimize this impact by selecting a rapid replacement solution. Orthotropic steel deck, which consists of long, shop-fabricated modular deck panels, fast-tracks the installation process by reducing field assembly time. The possibility of a shop-applied wearing surface has been analyzed and could minimize field work, thereby limiting traffic disruptions.

Increased traffic on the Brooklyn Bridge, which now handles 145,000 vehicles daily, has forced engineers to rethink the way certain operations are conducted and to propose solutions that will minimize the repercussions on traffic. At the same time, they must also consider costs, including the social costs of undertaking major road repairs in an urban setting. New York City-based Weidlinger Associates, Inc., designed the 12,000 sq. ft of orthotropic deck needed for the north and south Manhattan approaches with these considerations in mind. The firm's expertise pointed to the use of orthotropic deck, an ultralight concept that offers the distinct advantage of reducing the loads exerted on the structural elements of the existing bridge as well as the benefit of accelerated bridge construction. Structal-Bridges, a member of both AISC and NSBA, will fabricate a total of 24 orthotropic deck panels weighing some 450 tons for the project at its Claremont, N.H., plant.

The use of orthotropic deck on the Brooklyn Bridge, which will undoubtedly satisfy as well as greatly appease its users, marks a coming together of history and innovation. The rehabilitation also includes the modernization of drainage systems, deck joints and guardrails and will continue through 2012.

Information provided by Structal-Bridges.

Two Decades of National Steel Bridge Competition

BY THOMAS L. KLEMENS, P.E.

What began as friendly local intercollegiate rivalry has grown to be a highly educational and impressive program.

THIS YEAR MARKS the 20th anniversary of the National Student Steel Bridge Competition. Things have come a long way since the first national competition, in 1992, when Michigan State University hosted 13 teams. This year on May 20-21 a field of 48 teams competed in the 2011 finals held at Texas A&M University's Reed Center.

Historical Perspective

It all started in 1987 when Bob Shaw, then AISC director of university programs, arranged a student steel bridge competition for three Michigan universities: Lawrence Technological University, Southfield, Mich.; Michigan Technological University, Houghton, Mich.; and Wayne State University, Detroit. The resulting bridges included a deck truss that took more than three hours to build, a chain of heavy wide-flange girders bolted at the webs, and a half-ton replica of a 19th century railroad through truss.

Over the next four years additional schools joined the Michigan competition, and other local competitions developed throughout the country. Each of the local competitions claimed to have the best bridges in the country. To settle the issue, in 1992 Michigan State challenged all bridge teams to the first national competition in East Lansing, Mich. Fromy Rosenberg, AISC director of university programs from 1990 to 2008, provided organizational, moral and monetary support for the competition. Thirteen teams competed and Michigan State won.

With the educational and financial support of AISC, schools throughout the country were encouraged to develop their own student steel bridge teams and the competition steadily grew. From 1992 through 1995, when 31 teams competed, the national competition was open to all teams. In 1996 participation in the national competition became by invitation only. By then most bridge teams were organized by the ASCE student chapters, and the top two teams from each of the then 20 ASCE student chapters were invited. As the number of student chapters grew they were organized into the 18 regional conferences that now host the qualifying round.

Throughout the 25 years of the steel bridge competition AISC has provided financial support to every team that competes at the conference and national levels, financial support to the host schools and the required equipment, and staff and organizational support.

ASCE's involvement grew over the years, particularly at the local chapter level. In 2000 AISC and ASCE entered into a formal agreement and the competition was officially named the ASCE/AISC National Student Steel Bridge Competition.

➤ The Rules Committee conferring at the team captains' meeting May 20, 2011. Clockwise from lower left: Mike Engstrom, Ping Wei, Nancy Gavlin, John Parucki, Frank Hatfield, Jennifer Greer Steele, Bart Quimby, Jim Williams. Don Sepulveda and Renee Whittenberger are facing away from the camera.

➤ John Parucki (center, left) and Frank Hatfield fielding questions from team captions at the 2011 Nationals Student Steel Bridge Competition.

Today approximately 200 teams compete each year in the regional competitions. They come from nearly every state, as well as the District of Columbia, Puerto Rico, Canada, Mexico and China. And, in contrast to the early days of the competition, most of today's student bridges are light and quickly constructed. In 2011 the fastest construction time was 4.74 minutes and the lightest bridge weighed just 141 lb.

Playing by the Rules

The competition is based on a substantial set of rules, which include specific design criteria that are modified each year. The nine members of the Rules Committee develop each year's challenge and attend the regional and national competitions.

- **Frank Hatfield**, the committee chair, was faculty adviser for the first Michigan State team in 1988. His students hosted the first national competition in 1992 and he has been helping to write the rules and organize the competition ever since.
- **John Parucki** serves as national head judge. His fabrication company began supporting local university bridge teams after NSBA's Bill McEleney told Parucki and others attending a 1991 New York State Steel Fabricators Association meeting about the competition. He has been the national head judge since 1995.
- **Don Sepulveda** was a member of three student steel bridge teams from 1993 to 1995 and credits participation in this student program with saving his life. (See also page 66 of this issue.) He has been on the Rules Committee since 2001.
- **Jennifer Greer Steele** was on the Texas A&M student steel bridge team from 2001 to 2003. She was a judge from 2004 to 2006 and has been a member of the Rules Committee since 2007.
- **Bart Quimby** was the faculty adviser for the University of Alaska, Anchorage student team that competed in the first national competition in 1992. A member of the Rules Committee since 2000, he developed the scoring spreadsheet, provides technical support for scoring throughout the competitions, and maintains the website **www.nssbc.info**.
- **Mike Engestrom** has been on the Rules Committee since 1995. His employer, Nucor Yamato Steel, has been a sponsor of the competition since 1999.
- **Jim Williams** is on the faculty at the University of Texas, Arlington, and in 1994 helped organize the first Texas student steel bridge competition. He joined the Rules Committee in 2003.
- **Renee Whittenberger** was a member of a student steel bridge team for four years during her college career. After graduation, she served as a regional and national judge for four years and has been on the Rules Committee since 2007.
- **Ping Wei** is the ASCE director of educational activities and has been on the Rules Committee since 1998.

What It Takes to Compete

Although many teams begin planning as soon as the new rules are issued each August, this year's all-around winner from Lakehead University, Thunder Bay, Ontario, began in January with the start of the new semester. Although the school has been fielding steel bridge teams since 1989, this was the first time any of the five senior structural engineering students on this year's team had participated.

➤ The Lakehead University team's bridge components in the staging area.

The team first considered three different truss types using Bentley's STAAD analysis and design software. "We had a competition amongst ourselves to see who could get the lowest score with some approximated values," said team member Chris Kukkee.

"That's one of the things that pushed the team to do more than what was really required," said Damien Ch'ng. "We all have a competitive nature, and we just kept pushing until we were down to $500 or so between bridge designs." To put that level of nickel and diming into perspective, consider this: The competition rules include formulas that combine the scores in various categories to provide an overall cost for the structure. This year Lakehead's

Thomas L. Klemens, P.E., is senior editor of Modern Steel Construction.

The judges check the completed Lakehead University steel bridge.

Measuring the Lakehead University bridge's horizontal deflection.

bridge came in first with a "cost" of $2,024,822, so a theoretical $500 difference between possible bridge designs was not significant enough upon which to base a decision.

"At the point of the students deciding which design to go with, there's also the element of the roll of the die," said Antony Gillies, one of the team's faculty advisers. On the day of the competition, the position where the load will be placed in the backspan is decided by rolling a die. A table in the rules lists the six possible locations, which teams can consider in developing their designs.

"We knew we could make any of the designs work," said Dave Enns. "There were different elements to consider, like a double stack with fewer members would give us the speed advantage but we'd lose the stiffness. An undertruss would give us stiffness and less speed. Ultimately we went with the deeper truss system to minimize the effect of the roll of the die… it would give the best weight-to-deflection ratio overall."

"We also knew that once we built the bridge, we couldn't change the deflection," Ch'ng said. "But the build time was different—with practice we could get faster." So the team went with the option that gave them more control over the variables.

"We didn't focus on being the fastest bridge only," said Kukkee, "or the stiffest bridge only, or the lightest bridge only. We wanted to be all of those." To do that, the team knew, would require good connections that could be assembled quickly. Kukkee came up with a double stud system that would twist and lock in place. "It was a three-prong keyhole concept," he said. "But with 1¼-in. tube there wasn't enough space to make it work."

Next Enns drew up a twist lock with protruding L-shaped teeth, but that design also had clearance and fabrication issues.

"As soon as I saw Dave's design I realized it looked like the way you connect a lens to a camera body," Ch'ng said. "So I took what Dave had and modified it a little bit." After some additional analysis to work out the detailed design, he handed over his CAD drawings to team member Cory Goulet for machining.

"That's when the connection design once again got changed," Goulet said. The school had recently acquired a CNC metal working machine and was in the process of getting up to speed on its use. "Once we began to fabricate we realized we didn't have the proper tools to make many of the required cuts, so we decided to change tool diameters and cut sizes in the software. We had to figure it out on the fly because we had a very limited amount of time to make these parts." In the process Goulet became quite adept at CNC programming with Mastercam.

"There were some who thought the parts couldn't be cut using this equipment," said Timo Tikka, who with Gillies has been a Lakehead faculty adviser for many years. "Cory managed to figure out a way to fool the computer software to do anything he wanted."

Once the team started fabrication, there was a continual effort to improve various aspects of the bridge. However, maintaining balance—between lightness and stiffness, for example—was also a continual challenge. One such episode occurred shortly before the regional competition when the bridge's lateral deflection increased. The rules limit lateral deflection to ½ in., which this year was tested by sequentially applying a 75-lb side pull at two points on the structure.

2011 National Student Steel Bridge Competition Winners

The top three national winners overall are:

Overall Winners
1. Lakehead University
2. Michigan Technological University
3. SUNY College of Technology at Canton

The top three winners of the following six categories the students competed in are:

Construction Speed
1. Lakehead University
2. Michigan Technological University
3. SUNY College of Technology at Canton

Lightness
1. Lakehead University
2. University of Hawaii at Manoa
3. Georgia Institute of Technology

Display
1. Georgia Institute of Technology
2. University of Hawaii at Manoa
3. California State University, Long Beach

Stiffness
1. University of Hawaii at Manoa
2. Arkansas State University
3. SUNY College of Technology at Canton

Economy
1. University of Alaska Fairbanks
2. Lakehead University
3. Michigan Technological University

Efficiency
1. Lakehead University
2. University of Hawaii at Manoa
3. Michigan Technological University

"We had built a bridge that was working very well," Ch'ng said. "We ran multiple practices and filed some pieces down to make them connect more smoothly. Then, after running more practices, we did another lateral load test and because of putting everything together and the filing we did, everything had loosened up quite substantially and we failed lateral. And this was the night before leaving for the regional competition."

The team discovered that it wasn't the superstructure itself deflecting, but that the legs were rocking and causing too much sway. "We spent the night and most of the next day trying to stiffen up the legs," Ch'ng said."Chris came up with a unique sort of clamp system that would tighten everything up. So we fabricated it all up, put it together, and we managed to pass the lateral test. As soon as we had it working, we packed it up and drove down to the regional competition."

"I don't think I've ever made it to the welcoming ceremony at that regional conference," said adviser Gillies. "It's become a tradition for the team to have a last minute crisis."

After qualifying at the regional conference, the team continued with structural modifications and to improve their construction time. "We had removed three pieces from the bridge in our lateral system to make it faster and lighter, and we were just on the border line at ½ inch," Kukkee said, referring to the limit of lateral deflection. "On our final test just before we left we were really pushing the limit, and not comfortably below half an inch, so we ended up putting a small ⅜-in.-diameter tubing on one of the lateral braces on the cantilever. That gave us an extra 0.1 inch margin and we felt comfortable with that. That piece was welded on just before it went in the box."

At the national competition, Lakehead was one of five teams in the first heat, and it was clear they had practiced and were very much working as a team. "We decided to use two runners just so we wouldn't tire out too quickly," said Kristen Myles, "even though that extra 'builder' added to the construction cost." The cost figures heavily in the construction economy and overall categories, with the largest component being that each builder-minute adds $50,000 to the cost.

Faculty adviser Tikka said the team's performance also hinged on coordinated interaction. "Our team's communications were second to none. There was only one other team that was communicating in a similar manner." To see the Lakehead team in action and hear the two runners calling out part identifications and other information in an otherwise quiet arena, go to **http://bit.ly/jLQvFc**.

"The troubleshooting experiences on this project were really valuable," Enns said. "It's a prime example of showing up on a job site and site conditions aren't exactly what you anticipated and making corrections on the fly. The fabrication was also an eye opener, like how much movement there was on a thin piece of steel when you welded it."

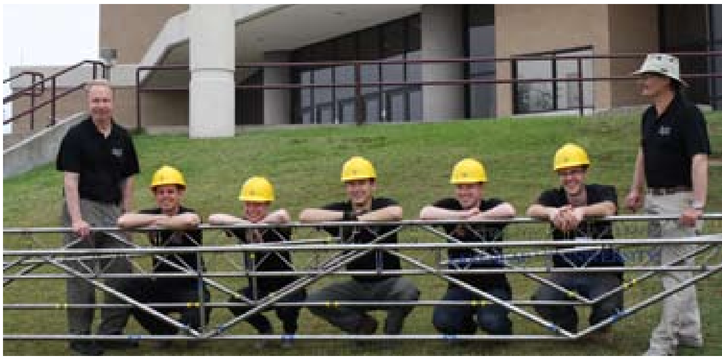
One additional benefit accruing from the student steel bridge competition, Gillies observed, is the connection it is building to the local community. "The students do the whole package, including the fundraising," Gillies said. "Almost all the money is raised from outside of the university. This program really opens up a relationship with the local community, from structural engineers down to parts suppliers—the company that gives us bolts, for example. You realize the power of communication from the day you are actually speaking to people and these people get as enthused as the students."

Of course, hosting the competition is also a substantial undertaking. Beyond the details of the competition itself, arrangements for this year's event included providing two lunches and a banquet for nearly 800 people; setting up blocks of rooms in nine area hotels; contracting with two facilities—one for the bridge construction and another for the display and banquet; and communicating with all involved. Jenna Kromann, a junior civil engineering student at Texas A&M, was this year's host committee director.

The biggest hurdle they faced, Kromann said, was taping off the floor for the competition. The taping group could only get access after a Friday evening event. "We had people there until three in the morning," Kromann said.

The spring semester was a busy one for Kromann. "I would get so many emails in my inbox—sometimes eight in an hour!" But the pace obviously suited her, because she ended the semester with a 4.0 grade average. "I guess when you're busiest is when you do your best," she said. MSC

The "camera connection" developed by the Lakehead University steel bridge team was both very efficient in transferring loads and quick to assemble.



The 2011 Lakehead University student steel bridge team, in hardhats from left: Chris Kukkee, Kristen Myles, Damien Ch'ng, Dave Enns, Cory Goulet. Faculty advisers Timo Tikka (left) and Antony Gillies stand at either end. Machinist adviser Kailash Bhatia is not in the photo but was an important part of the team.

Down by the River

BY GEOFF WEISENBERGER, LEED GA

An Italian steel bridge project keeps the fabrication as close as possible.

THERE ARE MANY WAYS a steel fabricator can reduce its environmental footprint—optimizing cut lengths, installing more energy-efficient lighting, reducing the idle time of the shot-blaster, building a temporary facility right next to a project.

Wait, what? A temporary steel fabrication facility? Building a temporary mix plant next to a large concrete project is nothing new, but a temporary fabrication shop isn't something you see everyday.

But it happened—in Italy. Following a flood of the Po River in April 2009, an historic bridge collapsed and needed to be replaced quickly. The bridge spanned the Po between the regions of Lombardy and Emilia-Romagna at Piacenza, Italy. The replacement bridge, just over 0.7 miles long, consists of 11 sections made of approximately 8,200 tons of steel. Structural engineer MCA Engineering, which has offices in Rome and Milan, wanted to reduce the transportation impact of bridge components from a remote fabrication facility (thus incurring hundreds of truck trips) and so decided to construct a temporary fabrication shop at the Lombardy end of the bridge. The shop employed 160 workers who were able to build the bridge assemblies in 18 months.

The on-site construction facility not only had a positive impact from an environmental standpoint—it contributed to the project reducing its carbon footprint by 10% in comparison to a traditional project—but it also facilitated efficiency and timing. The bridge was the first large project in Italy to encompass a complete and preliminary calculation of the carbon footprint of each and every phase, as well as the first project in Italy to go through a life-cycle assessment (LCA).

Is such a practice suitable for every building or bridge project? Of course not. But it's a great example of how certain innovative ideas can be appropriate under the right circumstances. Not only that, but it also demonstrates how opportunities for lowering the environmental impact of a project can vary depending on the project itself.

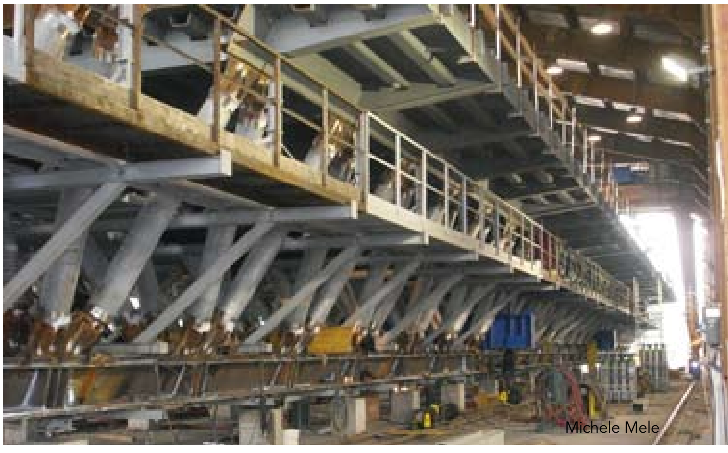
And in the grand scheme of things, whether it's practical and widespread or not, this project pushed the boundaries of normal practice and did something completely different. That's impressive from any standpoint, especially sustainability, where raising the bar is pretty much the name of the game. In this case, the reduced environmental impact came from cutting a link out of the transportation chain. In another project, a different tactic might lead to environmental and economic gains. It's a good reminder to always keep your eyes open for opportunities to do things differently when it makes sense.

If this short overview leaves you wanting to know more, don't despair. I'm using this column as a movie trailer to entice you without giving too much away. A full article on this project, which will include other environmentally friendly practices used in the construction, will appear in the August issue. MSC

Michele Mele

▲ The new Po River Bridge near Piacenza, Italy, features a reticular spacial structure supported on many of the original piers, which have been completely reinforced and restored.

▼ A view from inside the large fabrication facility that was built on site to reduce the transportation impact on the project.



Michele Mele

Geoff Weisenberger, LEED GA, is AISC's director of industry sustainability. You can reach him at weisenberger@aisc.org. Learn more about steel and sustainability at www.aisc.org/sustainability.

The Railroader and the Bridge

When he was a frustrated civil engineering student, the steel bridge contest turned Don Sepulveda's life around.

DON SEPULVEDA STEPPED INTO a new role in March when he became the Executive Officer – Regional Rail with Metro, the Los Angeles County Metropolitan Transportation Authority. He says the short explanation is that he is a "railroader," which in this case means his team is responsible for Metro's interest in everything in Los Angeles County that moves on steel wheels but is not operated by Metro. As such, he deals with federal, state and local governments as well as the railroads themselves, covering everything from rights of way to traffic and noise. And much of his ability to take on this wide ranging role he traces back to his participation in the steel bridge contest. In fact, he says, "Steel bridge saved my life."

It all started in 1987 when Sepulveda decided to go back to college. "I was a non-traditional student," he said, but that just begins to set the stage. He had been out of high school for nine years, working as a contractor, a structural inspector, and other similar things.

"I had a lot of math in high school," Sepulveda recalled, "but when you don't use it for nine years, it goes away." So many of his early classes were simply getting him back up to speed. "I don't have a clue how many units I have, but there are a whole lot of math classes in there." But the story gets more interesting.

"I was married with one child when I went back to school," Sepulveda said, "and somewhere in the process we had another child. So I was a full-time student and the breadwinner for the household. I had a mortgage and a family. My wife didn't work—she stayed with the kids—and I was running a business for somebody."

Wanting to proceed as quickly as possible, he set himself a grueling schedule at California State University, Northridge. "I would go to the office in the morning and get the teams out, then go to class by eight o'clock" Sepulveda said. "After a couple hours there, I'd go do my appointments during the day. I'd go back into the office, do billing and invoicing and some of the team work, then go back to school for a seven o'clock class that ended at 10. That was my day to day existence."

By 1993, Sepulveda was burning out. "I didn't have any motivation—there was no reason for me to be in school. I didn't see what civil engineers did. I had never even heard of ASCE or AISC. So I was about done."

That spring Sepulveda decided to take a day off from work so he could go on a field trip to see a dam with the civil engineering senior design class. "So we're on the bus and all these guys are talking about a 'steel bridge' and a 'concrete canoe.' I was interested and started asking questions, and after the field trip I went back to the ASCE room."

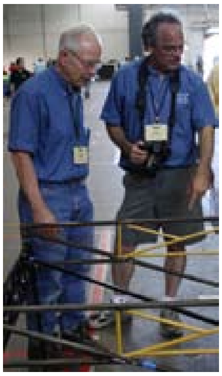
Looking over the bridge, he immediately had several ideas on improving and optimizing the design. It was just a month before the regional student steel bridge competition, and suddenly Sepulveda was involved. "I stayed there all night with them working on the bridge," he said, "and all of a sudden there was a reason for staying in school. It showed me there was a light at the end of the tunnel that was not a train. It was invaluable."

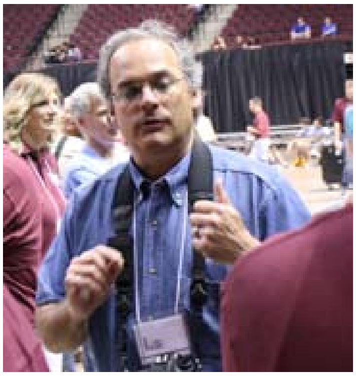
Sepulveda participated in two more steel bridge teams before finally getting his degree. Since then he says has done everything he can to help students, which among other things includes serving as an advisor to the Cal State Northridge student chapter. He also served as the steel bridge competition regional head judge for several years, and in the late 1990s as a national judge. He has been on the rules committee since 2001.

"When students come up to us and say, 'These rules are great,' or 'This was a challenge for us—we've learned so much,' that's what it's all about," Sepulveda said. "Let's face it, some of the stuff in the steel bridge competition few of them will ever use in real life. But they're getting experience in project management, leadership, and communication. And they're getting the idea of looking at the whole picture, not just one little aspect of it, and that's the value they take away from this."

"I can't say enough good about it. I figure that it basically saved me, and I know it's helping other students, too."

To learn more about the student steel bridge competition, go to **www.aisc.org/steelbridge**. MSC





Far left: Rules Committee members Frank Hatfield (left) and Don Sepulveda discussing one of the student bridges at the 2010 national competition in the Purdue University armory.

Left: Don Sepulveda at the 2011 National Student Steel Bridge Competition held at Texas A&M University in May.

A New Bridge Over the Po River

BY MARIO UBIALI

An 18-month replacement project showcases bridge construction innovation in Europe.

Michele Mele

▲ The temporary guiding steel frame extends in mid-air beyond the section of the bridge that has reached the pillar.

▼ The bridge seen from below during installation showing the lean structure together with the large top platform, which spans approximately 30 ft from one side to the other.

Michele Mele

ON APRIL 30, 2009, the largest river in Italy, the Po River, was at a frightening all-time high. Abundant rains had swollen the river to 23 ft above its usual level. While cars were still running over the historic bridge connecting the two shores at Piacenza, the structure suddenly collapsed and cars fell into the rubble. Luckily enough, nobody died. However, suddenly a large and very economically active part of the country was cut in two. The Milan division of ANAS, the state agency that presides over road and bridge administration, had to put together a plan to quickly rebuild a new, safer bridge. And do it in record time.

As often happens with stories that start with an unfortunate event, what followed turned out to be one of the most innovative steel bridge projects in Italy and one that is now regarded as a leading example in the entire European Community.

With a total cost of 42 million euros ($60 million), the bridge was designed by MCA Engineering, which has offices in Milan and Rome. Michele Mele, who besides being president of MCA is also professor of construction technique at Rome La Sapienza University, led the project and also served as project manager. Mele faced a number of challenges: ANAS wanted the project to be quickly designed and then swiftly executed. Time efficiency in the construction phase was center stage and concerns about the existing historical pillars needed to be somehow reconciled with the need for an exceptionally strong and seismically compliant structure.

From day one Mele had steel in mind, but the entire project had to be planned and performed with a lot of thinking outside of the box. The new bridge would be made of 11 sections spanning between the original pillars, each of them weighing 1.5 million pounds. The total came to more than 8,000 tons of steel, stretching over a bridge measuring just 0.7 miles of length. The original foundations and pillars had to be preserved for historical reasons, so they were reinforced and restored. New foundations were put in place on the two sides of the river.

The height of the bridge itself could not be kept at the level it had been in the old bridge. Giving close consideration to the

▲ Detail of the reticular spatial structure that successfully combines a lean look with solid seismic resistance.

highest river level in the last 200 years, Mele determined to build at a minimum level of 5 ft above the all-time highest water level. Visual lightness and a certain direct reference to the previous design was also taken into consideration: the bridge was therefore designed with an extensive use of multifunctional elements, all combined in a reticular spatial structure that is just 13 ft deep for 85% of the bridge length, reaching 26 ft at the pillars locations, where it extends to give full vertical support. The resulting structure has a modern and extremely lean silhouette that also is reminiscent of the old bridge profile.

In compliance with modern bridge standards, the new project includes two 11.5-ft-wide lanes for large trucks and high speed vehicular traffic, accommodating a 60-mph speed limit, and two side lanes each approximately 4 ft wide devoted to both bicycles and walking. Side barriers also were designed to exceed the requested specifications.

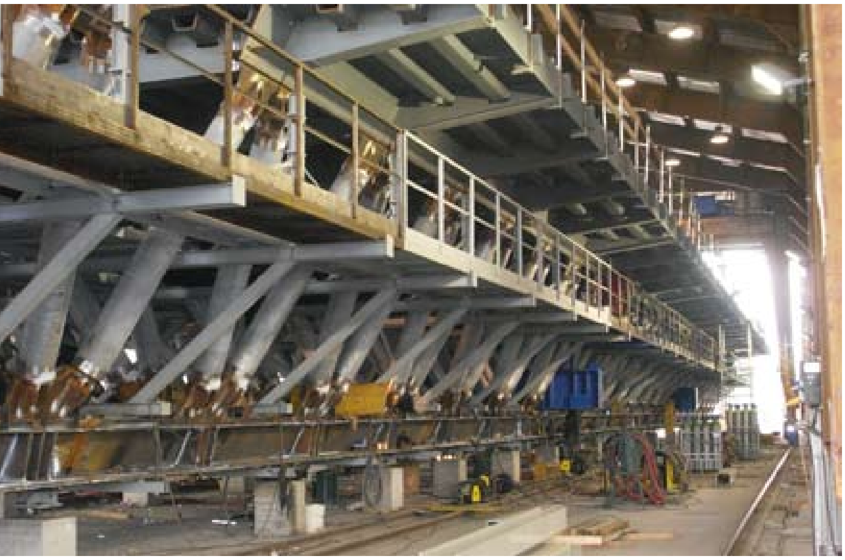
The only way to achieve all of the ambitious goals set forward by ANAS was to assemble an extremely competent work group, in which each player would coordinate with others to maximize results. FIP Industriale, one of the leading European companies in bridge building, partnered with Errezeta and created a building consortium called Consfer, which was in charge of the building and

Mario Ubiali is one of the founders and current CEO of Zinco Global, a multinational network of consulting and service companies specializing in steel protection and hot dip galvanizing. In 2010, he promoted the first Italian edition of SteelDay®.

Many of the old bridge's original pillars were completely restored and reinforced, allowing them to serve as supports for the new bridge.

The bridge viewed from one side of the Po River, with new pillars visible where the collapse of the old bridge damaged the original supports.

An internal view of the large fabrication facility that was specially built on site to reduce transport impact on the project.



Photos this page by Michele Mele

After completing the fabrication of a full section of the bridge in the on-site facility, it is pushed out and installed onto the support pillars.

erection. Tenaris, a large multinational group with more than 25,000 employees worldwide and an annual income of $7.7 billion, was elected to be the steel supplier through its mill in Dalmine, approximately 60 miles north of the bridge site. TenarisDalmine's steel-making expertise as well as pipe manufacturing for over a century would prove key in some of the most fundamental aspects of the project. However, ANAS didn't want just another steel project: it was going for durability and wanted to build something that would be both environmentally efficient and maintenance free. Mele brought in Nord Zinc Spa, a firm with more than 10 years experience on complex architectural and structural projects encompassing both hot dip galvanizing and powder coating, to provide steel coating and protection.

The intertwined aspects of the project lent themselves to an integrated approach to the entire operation: the project was not just for the building of a new bridge, but started with planning the demolition of the collapsed, original construction. Time and cost were issues, but the demolition procedure had to allow both preservation of the historic pillars for their subsequent use and reclamation of all the materials used for the construction of the top part of the original bridge. The procedure was so complex and well executed that it became the recipient of the Demolition Award in 2010 and the object of a "Mega-Demolition" documentary by the National Geographic Channel, aired in 2011.

In the meantime, the environmentally efficient approach was already in place: all of the reclaimed steel from the collapsed bridge was sent to TenarisDalmine to be recycled for the making of the new structural elements. Recycling the old steel was just a small part of the entire sustainable approach. In close cooperation with Nord Zinc, Mele wanted to achieve a slightly more ambitious goal: to guarantee ANAS that the bridge would not require maintenance for a period of time that would be at least three times longer than the current specifications in public sector projects. That would mean monetary savings as well as a prolonged life cycle for the bridge itself, which would in turn mean a lower environmental impact. But how would it be possible to achieve a maintenance-free period of 50 years? The answer was a completely customized approach to steel coating. Most of the structural elements and the outer railing was coated with a targeted combination of hot dip galvanizing and powder coating called Sistema Triplex, which Nord Zinc calibrated upon the life expectancy requirements and coordinated with TenarisDalmine in relation to steel properties.

Reclaiming the old steel and protecting the new bridge were certainly two very significant aspects of the environmental efficiency of the project. However, the team was worried that such benefits would be hindered by the great impact of fabricating elements somewhere far from the

➤ A new section of the bridge starts the slow journey from the on-site fabrication facility to its final destination.


Michele Mele

construction site and using hundreds of trucks to transport parts. Why not build the bridge where it was being erected? Mele had now another project within the project: he designed a temporary steel construction facility that was erected on the Lombardy end of the bridge. There 160 workers rushed through the record-breaking 18 months of frantic construction activities, for a total of 450,000 hours of work.

The on-site construction facility not only positively impacted the environment, helping the entire project to achieve a 10% CO_2 reduction over a 50-year life cycle in comparison to a traditional project, but also facilitated efficiency and timing. The Po River bridge was the first large project in Italy to include a complete and preliminary calculation of the carbon footprint of each and every phase, leading to key choices in structural, protective and construction matters. The result was not just environmentally friendly, but really environmentally efficient—and proven to be so by Italy's first complete Life Cycle Assessment.

Although the environmental aspects were of great importance to the customer, the project team had to overcome other engineering structural challenges. The old pillars that would support the bridge had to be relieved, as much as possible, from the load and strain coming from the steel structure. Using RM Bridge and Strauss 7, Mele and his engineering team ran parallel calculations to analyze loads and came up with another interesting and innovative solution. Rather than going for the traditional steel structure where some elements are considered structurally primary while others are secondary, Mele designed a reticular spatial structure, where all elements are equally important in load and stress distribution and bearing.

The resulting steel structure distributes the load through the entire length of the bridge and discharges on the two shores, minimizing the impact on the old original pillars. Large sections were assembled in the on-site construction facility, coated according to the targeted specs, and positioned in their final location across the river.

Today, the steel bridge on the Po River at Piacenza stands tall while hundreds of drivers cross the water for their daily tasks. At night, special lights help it stand out in the darkness, illuminating it as a symbol of unification, as the country celebrates the 150th anniversary of its independence. The choices made in the project should make this bridge stand firm for many other anniversaries to come. **MSC**

▲ A guiding steel structure extends beyond the leading section of the bridge, which cantilevers as the structure is advanced until it lands on the next pier.

▼ A night view of the walkway and adjoining automotive lanes, with a view of the double barrier protection at the lane and walkway boundaries.


Alessio Pesenti

steel quiz

LOOKING FOR A CHALLENGE? *Modern Steel Construction*'s monthly Steel Quiz tests your knowledge of steel design and construction. This month's questions highlight activities taking place with bridges and bridge construction. The answers can be found in resources available on the National Steel Bridge Alliance (NSBA) website, **www.steelbridges.org**, including the monthly NSBA Newsletter, NSBA White Papers, and the *Steel Bridge Design Handbook*; on the American Iron and Steel Institute (AISI) website, **www.steel.org**; in ASTM material standards available at **www.astm.org**; and on the SteelDay website at **www.steelday.org**.

1 True/False: SIMON is NSBA's steel plate and box girder bridge design and analysis program.

2 How many total units make up NSBA's *Steel Bridge Design Handbook*?
a) 9 units and 3 design examples
b) 3 units and 9 design examples
c) 19 units and 3 design examples
d) 13 units and 9 design examples

3 What is the relationship between AISC and NSBA?

4 How many steel highway bridges are currently in service in the United States?
a) About 415,000
b) About 850,000
c) About 75,000
d) About 185,000

5 Near which U.S. city is NSBA's flagship SteelDay event being held on September 23, 2011?
a) Chicago
b) Washington
c) New York
d) Pittsburgh

6 What was the first bridge in the United States to make extensive use of steel and cantilevered construction?
a) Smithfield Street Bridge, Pittsburgh
b) The original North Avenue Bridge, Chicago
c) Eads Bridge, St. Louis
d) Hell Gate Bridge, New York City

7 True/False: The color formula for the Golden Gate Bridge's "International Orange" is available to the public.

8 Where is the 2012 NSBA World Steel Bridge Symposium going to be held?
a) Phoenix
b) Toronto
c) Dallas, Texas
d) Pittsburgh

9 True/False: The American Association of State Highway and Transportation Officials (AASHTO) allows only heat cambering methods for rolled beams for bridges.

10 ASTM A709 Grades HPS 50W, HPS 70W and HPS 100W high-performance steels are available in which of the following form(s)?
a) Structural plate
b) Wide flange shapes
c) All rolled shapes
d) All of the above

1 True. Since the 1980s, SIMON has served hundreds of bridge engineers as a key tool to efficiently design and analyze steel bridges. It is intended to be used in the preliminary design phase to realize efficiencies and demonstrate the practicality of a steel bridge for a specific application. A popular legend has it that *Bridge Over Troubled Water* was the number one song at the time SIMON was written; "Garfunkel" would have been too obvious a name for it.

2 (a) The original *Highway Structures Design Handbook* was produced by US Steel in the 1970s. The renamed successor *Steel Bridge Design Handbook* is available as a free download on the NSBA website (**www.steelbridges.org**). This document is in the process of being updated with a plan for 23 units and seven design examples.

3 NSBA is a division of AISC dedicated to advancing the state-of-the-art of steel bridge design and construction. NSBA is a unified industry organization of businesses and agencies interested in the development, promotion, and construction of cost-effective steel bridges. The organization includes three regional directors who are the primary liaisons between the NSBA and bridge owners. They assist fabricators, designers, and owners in making the best bridge decisions and selections possible. In addition, the NSBA provides steel superstructure technical assistance at various stages of drawing completion.

4 (d) The Federal Highway Administration provides data on all U.S. bridges through its National Bridge Inventory (NBI) database. For more information about the NBI, visit **www.fhwa.dot.gov/bridge/nbi.htm**. As of the end of 2010, the NBI database listed 185,148 steel bridges in the U.S.

5 (b) NSBA in conjunction with the Ironworker Management Progressive Action Cooperative Trust (IMPACT) will host an interactive, hands-on event just outside Washington (in Upper Marlboro, Md.) on September 23, 2011. To learn more and attend this event, go to **www.steelday.org**.

6 (c) Named for its designer and builder, James B. Eads, the Eads Bridge in St. Louis was the first major bridge built using steel and cantilevered construction. At the time of its construction in 1874, the 6,442-ft-long by 46-ft-wide ribbed steel structure was the longest arch bridge in the world. An article about the Eads Bridge was published in the March 2011 issue of *MSC* and is available online at **www.modernsteel.com/backissues**.

7 True. Now you can find the exact paint mixture on the Golden Gate Bridge, Highway and Transportation District's website: **http://goldengatebridge.org/research/factsGGBIntOrngPaint.php**

8 (c) NSBA's 2012 World Steel Bridge Symposium will be held in conjunction with the NASCC: The Steel Conference in Dallas, Texas, April 18-21, 2012. The World Steel Bridge Symposium brings together design engineers, construction professionals, academicians, transportation officials, fabricators, erectors, and constructors to discuss and learn state-of-the-art practices for enhancing steel bridge design, fabrication, and construction techniques.

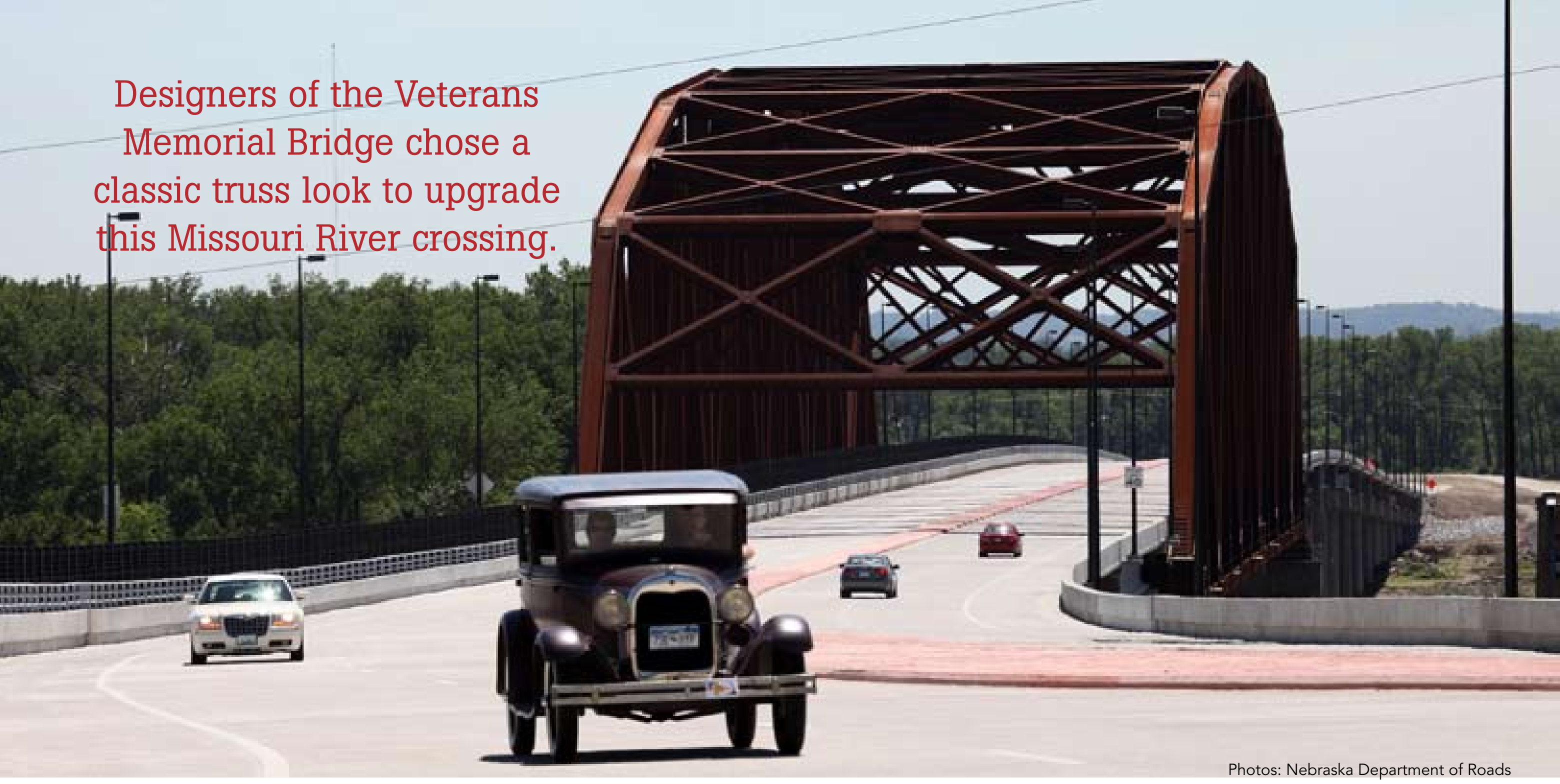
9 False. The 2010 Interim Revisions to the AASHTO LRFD Construction Specifications have added cold cambering as an allowed method. See "Cold Bending of Wide-Flange Shapes for Construction" by Reidar Bjorhovde in the 4th Quarter 2006 issue of AISC's *Engineering Journal* for further information.

10 (a) High-performance steel, which typically has higher toughness than other steels that could be used in bridges, is available only as structural plate.

Steel Solutions Center

Anyone is welcome to submit questions and answers for Steel Quiz. If you are interested in submitting one question or an entire quiz, contact AISC's Steel Solutions Center at 866.ASK.AISC or at **solutions@aisc.org**.

Designers of the Veterans Memorial Bridge chose a classic truss look to upgrade this Missouri River crossing.



Photos: Nebraska Department of Roads

Modern Design of a *Historical* Bridge Type

BY DOUG WALTEMATH, P.E., AND STEVE PELLEGRINO, P.E.

IT TOOK A WHILE, but when the opening day ribbon cutting for the new Veterans Memorial Bridge across the Missouri River finally arrived, dignitaries and citizens of Iowa and Nebraska turned out to celebrate the new link between Omaha, Neb., and Council Bluffs, Iowa. Fittingly, the ceremony took place on the Friday that ushered in the 2010 Memorial Day holiday weekend. Many veterans occupied front row seats as the governors of both states honored their past service to our country and spoke of the potential benefits of increased commerce between the two cities and how this bridge will contribute to that effort. To further celebrate the past, a parade of motorcycles and vintage cars took the first drive across the bridge.

The project had been in the works since 1996 when, due to the deteriorating condition of the existing bridge, preliminary studies for a replacement structure began. The existing bridge, a two-span continuous Warren Truss, was considered a landmark by many long-time residents of Omaha and in 1992 was listed on the National Register of Historic Places. However, its narrow 22.5-ft width disqualified it for restoration.

Harrington & Cortelyou (H&C) provided the design for the truss span piers, the truss span and the substructure for 17 of the 24 approach spans as a subconsultant to the project's prime consultant, TranSystems, Kansas City, Mo. H&C engineering services included coordination with the U.S. Coast Guard, the Nebraska Department of Environmental Quality and the Iowa Department of Natural Resources, all of which had to issue the permits and certifications needed for construction.

Contact was made with the Coast Guard very early in initial studies. The horizontal clearance requirement would determine structure types that were feasible for consideration. The preference of the owners was to use the normal minimum clearance required by the Coast Guard of 400 ft for the Missouri river when site conditions permit. With a navigation span of 425 ft to 450 ft, using economical parallel flange welded plate girders was a feasible option. Unfortunately site conditions did not permit use of the shorter span. The existing bridge has a horizontal clearance of 514 ft and is located at the immediate downstream end of a crossover in the navigation channel. The channel shifts from hugging the Iowa bank to hugging the Nebraska bank upstream of the bridge. The Coast Guard surveyed the barge operators and they indicated that often the barge tows are still skewed with respect to the bridge when they pass under it and the new bridge's navigation span should be as long as possible.

The preferred alignment of the new bridge was 110 ft upstream of the existing bridge. The Coast Guard required a 600 ft minimum horizontal clearance for the navigation span of the replacement structure. After setting back the Nebraska pier from the bank to minimize the chances of a barge collision, the truss span length needed was 624 ft.

The navigation span requirement eliminated consideration of a plate girder river unit. A brief cost comparison of cable-stayed, tied-arch and truss structure types showed that single-span tied-arch and truss were the most economical options with both having comparable costs. Early in the project a concern was expressed that highway truss bridges over the Missouri River were disappearing. In most cases new welded plate girder spans replaced old, often historical, truss bridges. With the mandate of a 624-ft span and the truss alternative being cost competitive with the other structure types considered, the decision was made to go with the truss span.

The new Veterans Memorial Bridge combines a dramatic visual presence with a historical feel.

(Top) Erection of the Veterans Memorial Bridge utilized temporary bents at L2' and L6.

(Bottom) The walkway/bikeway on the new Veterans Memorial Bridge connects trail systems in Omaha, Neb., and Council Bluffs, Iowa.

U.S. 275 crosses the Missouri River on the Veterans Memorial Bridge's 624-ft. center span, which provides the Coast Guard-required 600 ft minimum horizontal clearance for navigation.

The truss was designed using the 2005 AASHTO *LRFD Bridge Specifications*. The truss is a 12-panel, Warren-type truss with variable height verticals and measures 624 ft between bearings. Significant features include an 87-ft, 8-in. bridge deck width consisting of two 34-ft roadways, a 6-ft center median and a 10-ft sidewalk. The center-to-center of the truss chords measures 93 ft. The maximum vertical height is 90 ft. Nine stringers are spaced at 10 ft, 3 in. and designed to be continuous over the floor beams, which eliminated costly bolted stringer-to-floorbeam connections. The truss itself consists of welded plate H-sections for the chords and all secondary members for ease of fabrication and erection and reduced costs. Structural steel is primarily Grade 50 weathering steel. HPS Grade 70 steel was used for the lower chords.

The total steel weight for the truss was 4,508 tons and required 50,600 high-strength bolts for construction. ASTM A490 bolts, 1⅛ in. in diameter, were used in the primary truss joints.

The construction contract for the truss span and supporting piers was awarded to Jensen Construction Company. Construction began on the piers in late 2007. The massive truss piers are each founded on 10 drilled shafts each 7 ft in diameter and 70 ft deep. Typically, the design of Missouri River bridge piers in the river is controlled by barge impact loading. For this project, however, the wind loads on the truss controlled the foundation design.

The contractor opted to erect the truss in place. The design and truss erection sequence were developed by the contractor. Temporary bents were erected at L6 and L2'. Due to navigation requirements, falsework could not be placed between the Nebraska bank and L6. The columns of the bent were 8-ft-diameter steel shells founded on a concrete footing supported by four drilled shafts similar in size to the permanent construction. With the temporary reduction in navigation span width, the bent at L6 had exposure to being struck by a barge, but the cofferdam acted somewhat like fenders/collision protection.

Steel erection began between the Iowa pier and L2' and from there to L6 it was cantilever construction. To resist uplift at the Iowa pier, the end floor beam was locked down using anchorages consisting of bundles of post-tension strands cast in the columns of the pier. The Iowa end of the truss is the expansion end. The contractor developed and installed an elaborate restrainer device to lock the expansion bearings and prevent longitudinal movement during erection. After landing on the bent at L6, cantilevered construction continued until reaching the Nebraska bank pier.

The new Veterans Memorial Bridge features two 12-ft lanes of traffic with a 10-ft shoulder in each direction. A 10-ft clear bikeway/walkway runs along the north side of the bridge providing connectivity between the trail systems in Omaha and Council Bluffs. The finished bridge has a dramatic visual presence and provides a link to the past, when the truss was the only structure type spanning the Missouri River. The project also provides a safe, comfortable and welcome travelled way. MSC

Owners
Nebraska Department of Roads and the Iowa Department of Transportation

Structural Engineer (truss span)
Harrington & Cortelyou, Inc., a Burns & McDonnell Company, Kansas City, Mo.

Contractor
Jensen Construction Company, Des Moines, Iowa

Contractor's Engineer
Genesis Engineers, Kansas City, Mo.

Doug Waltemath, P.E., was project manager for the Veterans Memorial Bridge project, and Steve Pellegrino, P.E., was the lead designer and supervised the plan production. Both are senior bridge engineers with Harrington & Cortelyou, Inc., a Burns & McDonnell Company.

Completely removing and replacing the bridge carrying westbound I-44 over the Gasconade River required a closure of less than 20 days.

Sliding Bridge *Speeds* Delivery

BY STEVE HAINES, P.E., AND CHIP JONES, P.E.

HALFWAY BETWEEN ST. LOUIS and Springfield, Mo., I-44 crosses the scenic Gasconade River along the northern border of Mark Twain National Forest. Built in 1955, prior to even the earliest portions of the Interstate Highway System, the bridge carrying the westbound lanes experienced considerable deck deterioration in recent years. As a result, Missouri Department of Transportation (MoDOT) scheduled the bridge for replacement in early 2011. The project included total replacement of the superstructure and repairs to the existing bent caps. MoDOT let the project with a maximum of 60 days of closure time allowed.

The replacement contract was awarded to Emery Sapp & Sons, Inc. (ESS) based on an aggressive construction schedule that limited the total bridge closure days to 35 days. After award of the contract, ESS enlisted Parsons to assist in developing an innovative slide-in construction scheme to replace the bridge on a greatly accelerated schedule in order to further reduce the amount of time the road would be closed to traffic. The ultimate goal was to limit the closure to 20 days total, which would earn ESS a $600,000 early completion incentive ($40,000 per day, capped at 15 days).

Parsons worked with ESS to develop the construction scheme to build the proposed replacement bridge adjacent to the existing bridge while maintaining traffic on the existing bridge. Once the replacement bridge was constructed, traffic was shifted temporarily to the eastbound span, while the existing westbound bridge was demolished and repairs were performed on the existing substructure. Once the repairs were complete, the replacement bridge was slid laterally more than 40 ft, using a hydraulic skidding system, and positioned on the reconstructed bents in less than 12 hours.

Proposed Bridge Replacement

The proposed replacement bridge was designed by MoDOT Central Bridge Office with the assumption that conventional construction methods would be used to construct the bridge. The layout consisted of a six-span bridge with the middle four spans being a

▲ 64-ton push/pull hydraulic jack.

◄ Final bridge location on the repaired existing bents.

▼ Replacement bridge at approximately the half-way point, moving from right to left.

◄ Slide plate, shown after the bridge has been slid into place.

Photos in this spread by Steve Haines.

Steve Haines, P.E., is a project engineer with Parsons, Denver. He has 16 years experience with the latest knowledge in bridge-moving techniques to minimize the impact to the traveling public and has performed bridge moves using multiple accelerated construction methods, including slide-in methods and Self-Propelled Modular Transporters. Chip Jones, P.E., is a division manager for Emery Sapp & Sons, Columbia, Mo. With more than 22 years of heavy construction experience, he has overseen dozens of complex infrastructure projects. His innovative approach has led to the successful completion of these projects throughout his 12-year tenure with Emery Sapp & Sons.

continuous unit and both end spans being simple spans for a total bridge length of 670 ft. The 36-ft, 8-in.-wide bridge is a composite steel plate girder with an 8½-in.-thick reinforced concrete deck. The four-span continuous unit used a four-girder cross section with a girder web depth of 72 in. and girder spacing of 9 ft, 8 in. The end simple spans also used a four-girder cross section with a girder web depth of 42 in. and girder spacing of 9 ft, 8 in. All structural steel was ASTM A709 Grade 50W.

Temporary bents designed to handle the loads due to the construction of the replacement bridge and the loads applied during the sliding operation were constructed adjacent to the existing bents while traffic remained on the existing westbound bridge. The proposed replacement bridge was at the same elevation as the existing bridge to eliminate any required bridge approach work. Building at the same elevation also limited any vertical jacking of the bridge required for the sliding procedures or during placement of the permanent bearings.

The top of each temporary bent was cast at a constant elevation to facilitate sliding the replacement bridge into place. This constant elevation required a minor modification to the original design to accommodate the normal crown section of the bridge, which in the original design would be created by using a stepped bent cap. To create the crown with the constant elevation bent cap, each bearing sole plate was thickened the same amount as the removed step. This method placed all the bearings at the same elevation at the top of the bent cap.

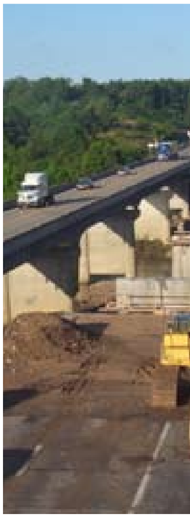
Sliding Setup and Procedure

The replacement bridge was built on top of sliding bearings under each girder at each bent location to eliminate any bearing transitions prior to performing the sliding operation. That allowed the contractor to slide the bridge into place using hydraulic jacks placed at each bent. The sliding interface between the top of the bent cap and the bearings was a standard stainless steel and Teflon interface. Stainless steel sheets were placed on top of both the temporary bents and the repaired permanent bent caps. The sliding pads placed under each girder were elastomeric pads with ⅛-in. Teflon sheets bonded to the bottom of each pad. The elastomeric pads attached to the Teflon sheets allowed for any minor rotations that occurred during the construction activities. The elastomeric pads also compensated for any minor variations in the bent cap during the sliding operation.

▼ Completion of steel erection.

▼ Deck reinforcing complete and ready for concrete placement.

▼ Demolition of the existing westbound bridge begins on May 6.



The sliding materials and slide-in procedure were performed by heavy lift contractor, Mammoet. The total weight of the bridge superstructure was 2,050 tons. The hydraulic jacks used to slide the bridge over into place were 70 ton hydraulic jacks, one at each bent location, and all jacks were interconnected to control the differential rate at which the bridge was pushed into place.

The jacks were connected to the steel superstructure using connection plates bolted to the bearing stiffeners. The bent diaphragms were redesigned to transfer the pushing loads more efficiently into the superstructure, which was the only modification to the structural steel required due to the slide-in procedure.

During the sliding operation, the jacks reacted against a steel slide plate that had been cast into the top of the temporary bents. Notches fabricated into each side of the slide plate spaced at approximately the stroke length of the jack provided the reaction points for the jacks. After each push cycle of the jacks, the jacks self-retracted and were pulled forward to the next adjacent notch. Pushing the bridge into place required a total of 12 cycles.

Transitioning to Permanent Bearings

Once in its final position, the bridge was transferred from the temporary sliding bearings to the permanent bearings. That required only minimal lifting because the slide-in procedure positioned the bridge very nearly at its final elevation.

The bearing transition was performed individually at each bent location. Due to limited space on top of the bent caps, the bent diaphragms were designed to handle the jacking loads required to transition the bearings. Six jacks were used to lift the bridge at each bent location. The jacks were controlled to extend at the same rate and raise the girders all at the same elevation.

The transition sequence began with raising the bridge slightly to unload the temporary sliding bearings and remove them along with the stainless steel plate and the shim-

Replacement bridge fully open to traffic on May 24.

8:30 a.m.: Final preparations before the bridge move on May 16.

3:30 p.m.: Half-way point of the bridge move.

7:00 p.m.: Final placement of the bridge.

Photos in this spread by MoDOT.

ming material. The permanent bearing was then placed at each girder and the bridge was lowered into place. Once the jacks were unloaded and removed, the stainless steel plate and shimming material that was supporting the jacks was removed. This operation was performed individually at each bent until all sliding material had been removed and the bridge had been transferred onto its permanent bearings.

The slide-in procedure ultimately provided a very efficient replacement method that reduced the impact to the traveling public. Westbound traffic was switched to the eastbound bridge on May 5, 2011, which was the first significant impact on the traveling public. On May 16, 2011, the replacement bridge was slid into place in less than 12 hours. On May 23, 2011, one lane of the replacement bridge was opened to traffic, and fully opened the next day, which beat the goal of limiting the closure to 20 days.

The slide-in procedure required only minor modifications to the MoDOT-designed steel superstructure. The inherent flexibility of the steel superstructure allowed the structure to be moved into place without any damage or cracking occurring to the superstructure. MSC

Owner
Missouri Department of Transportation

Design Engineer
Missouri Department of Transportation, Central Bridge Office

Specialty Move Engineer
Parsons, Pasadena, Calif.

Steel Detailer and Fabricator
DeLong's Inc., Jefferson City, Mo. (AISC and NSBA Member)

General Contractor
Emery Sapp & Sons, Inc., Columbia, Mo.

Specialty Move Contractor
Mammoet, Houston

Bridges: Innovation

ANSWERED BY M. MYINT LWIN, MALCOM THOMAS KERLEY, P.E., AND RAY MCCABE

Some important questions have complex answers and benefit from reflection and discussion. In this series designed to reflect that understanding, NSBA asks leading minds in the bridge community to weigh in on some of life's imponderables.

QUESTION: What innovations are needed to make steel bridges more competitive?

Answer: Malcom Thomas Kerley, P.E.
Chief Engineer, Virginia Department of Transportation

From a state perspective, state DOTs want strong, both technically and financially, industry partners. Strong steel industry partners create competition both within their industry and with other industries that states can benefit from. In a Design-Bid-Build environment, low bid is, of course, important. As states move to other delivery systems such as Design-Build and Public Private Partnerships, schedule may become more important in delivering a project.

In terms of past innovation related to steel bridges, weathering steels, high- performance steels, and new welding procedures ensure that the steel industry remains competitive with other industries. Continued improvements in materials and procedures are needed. The AASHTO Subcommittee on Bridges and Structures has an excellent relationship with the steel industry. The Subcommittee's "Grand Challenges: A Strategic Plan for Bridge Engineering" suggests innovative ways that the steel industry can optimize steel structural systems and how the industry can accelerate bridge construction.

Innovation is defined as "something newly introduced: new method, custom, device, etc., a change in the way we are doing things." The AASHTO/ National Steel Bridge Alliance (NBSA) Steel Bridge Collaboration has helped to define the needs of both partners and help achieve quality and value in steel bridges. Virginia, for example, participated for many years in the Federal Highway Administration's Mid-Atlantic Structural Committee for Economic Fabrication. Standardization of design, fabrication, and erection and the sharing of resources may not be considered innovative, but it provides for good engineering.

Answer: M. Myint Lwin

Director of the Office of Bridge Technology, Federal Highway Administration

Since the all-steel Eads Bridge in St. Louis, Mo. was completed in 1874, significant and progressive advancements in steels have been made through innovations in steelmaking and processing.

Today, there is a wide variety of structural steels with outstanding properties for modern bridge construction. These properties include a combination of strength, ductility, uniformity, fracture toughness, fabricability, repairability and recyclability. The bridge designers have a broad range of structural steels, such as, high-strength steels, weathering steels, high-performance steels, at their disposal in meeting the demands of their projects.

As we're learning from the aging interstate system, life cycle considerations are becoming more important as we replace bridges originally designed for a 50-year service life with more sustainable structures. It is of utmost importance that steel bridges (like all bridges) are protected from the corrosive effects of their service environment. Many materials and methods have been developed in the last 50 years for corrosion protection, such as, use of weathering steels, improved paint coatings, powder coatings, galvanizing, thermal spraying, etc.

Bridge designers will have to be innovative in meeting the challenge of providing cost-effective corrosion protection systems for further extending the service life of steel bridges. For complex bridges in a corrosive environment, designers may need to engage the service of corrosion specialists to work together in protecting bridges from the corrosive elements of the site.

FHWA, AASHTO and industry support research in the development of high-performing steels, cost-competitive high corrosion resistant steels, two-coat and one-coat paint systems, and other means to optimize the performance of steel bridges. In general, innovations need to focus on (1) selection of the right steels for the purpose, (2) design details and joints should be self-cleaning, self-draining, watertight and accessible for maintenance, (3) quality in fabrication and construction, (4) good workmanship in surface preparation and application of coatings, and (5) investment in preventive maintenance, such as, seasonal cleaning, debris removal, coating repair, leak control, to keep steel bridges in a state of good repair.

In summary, innovations must be directed to keep water and/or oxygen from steel components of bridges. The Eads Bridge is still in service. Many steel bridges in the National Bridge Inventory are 100 years or older. With proper care, steel bridges can have long service life!

Answer: Ray McCabe

National Director of Bridges and Tunnels, HNTB Corporation

Steel continues to bring the advantages of light weight, slenderness, flexibility, toughness and repairability to the bridge industry. For spans over 500 ft, steel continues to dominate and thus I will not focus my comments here except to say there are many areas of improvement or innovation here. But what about short and medium spans, accelerated bridge design and the upcoming need for efficient high-speed rail bridges? Here the choice is not so clear and needs to be the focus of the steel industry. More competitive steel bridges of the future will require improvements and innovations in the following areas: material, fabrication, design codes and design concepts.

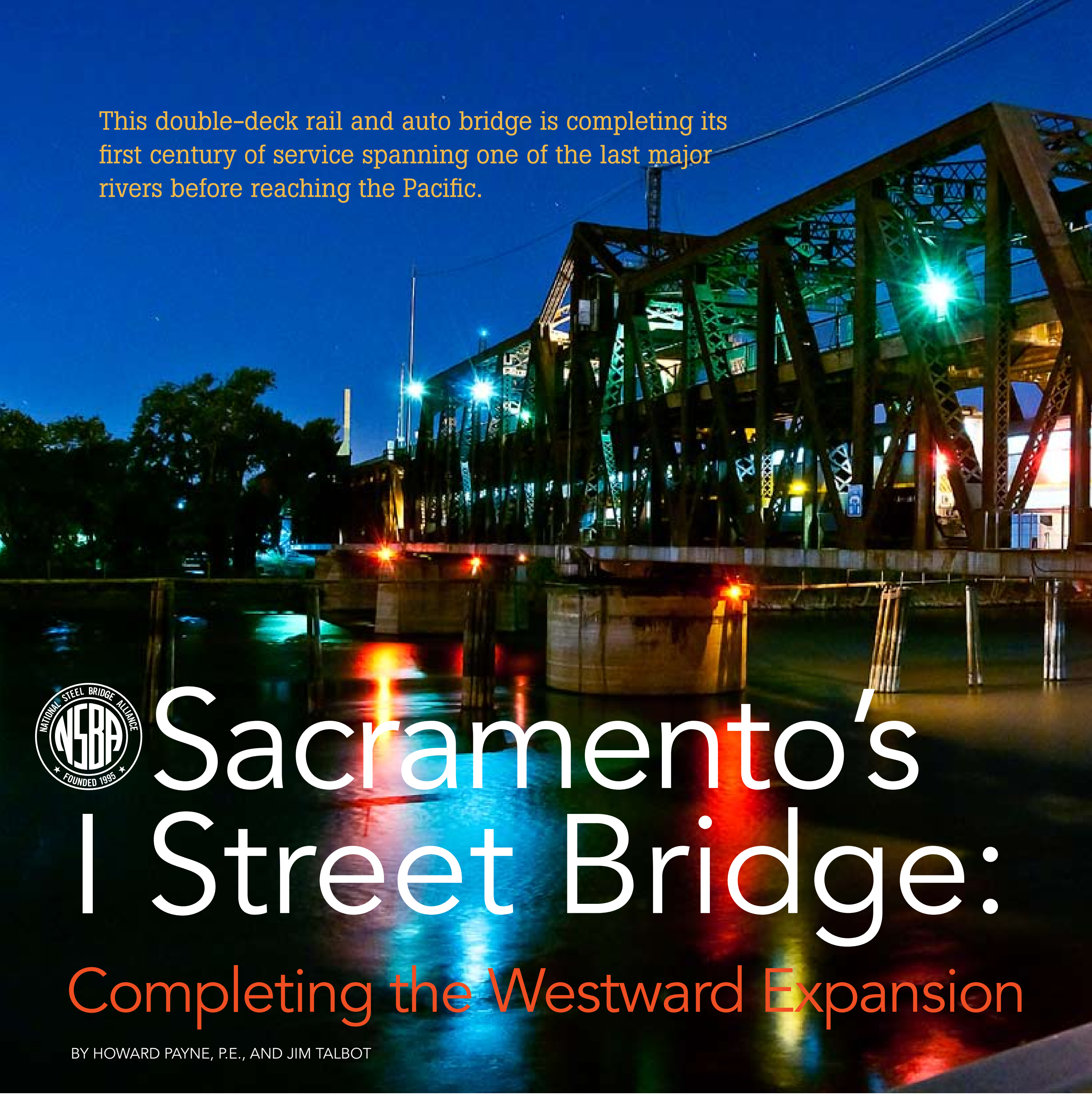
Material. While the development of high-performance steels has certainly boosted the competitiveness of steel, the industry needs to continue its research on toughness, weldability and corrosion resistance. Economical steel bridges of the future will undoubtedly incorporate fewer main load carrying elements to where redundancy becomes a concern. Owners await the day when they will no longer have to worry about crack growth and corrosion.

Fabrication. The steel industry needs to get on board with production of longitudinally profiled plates. This process is common in Europe and should be here in the U.S. These plates allow thickness to follow actual stress thereby reducing material and improving fatigue performance. I also believe we need to develop reliable, economical and rapid automated field welding techniques that would lead to the possibility of segmental steel construction.

Design Codes. Continued work with the LRFD steel specifications is necessary as new steel concepts come on board with details that have little or no design criteria. We need to continue toward more simplistic design specifications. In general, complicated specifications lead to conservatism and thus increased cost.

Design Concepts. Perhaps the biggest area for innovation comes in the area of design concepts, but only through innovations in the prior areas can better design concepts become reality. A book can be written on innovative design concepts but due to the need to keep this discussion short, I will only mention a few.

- Two-Girder Systems: Use of two-girder cross-sections with transversely prestressed concrete deck will provide more economical girder bridges. This system has been used extensively in Europe. It can be demonstrated that in most cases of continuous spans, these systems are redundant. For wide bridges, floor beams can be used.
- Double-Composite Systems: Providing composite action at the bottom flange of box girders (or I girders) by using cast-in-place concrete or precast slabs with closure pours will reduce steel and stiffen the bottom flange for buckling. For continuous bridges, the girders can be erected as simple spans and continuity achieved with the bottom flange concrete.
- Use of Cold-Formed Sections: Short-span bridges and other steel components will need to incorporate greater use of cold-formed sections. Improved steel toughness will be key to this advancement as the bending process will reduce toughness.
- Composite Space Trusses: These systems provide high stiffness/weight ratios, high strength/weight ratios and significant reliability due to their numerous alternate load paths. Only through fully modularized fabrication techniques will these systems become popular. MSC



This double-deck rail and auto bridge is completing its first century of service spanning one of the last major rivers before reaching the Pacific.

Sacramento's I Street Bridge:

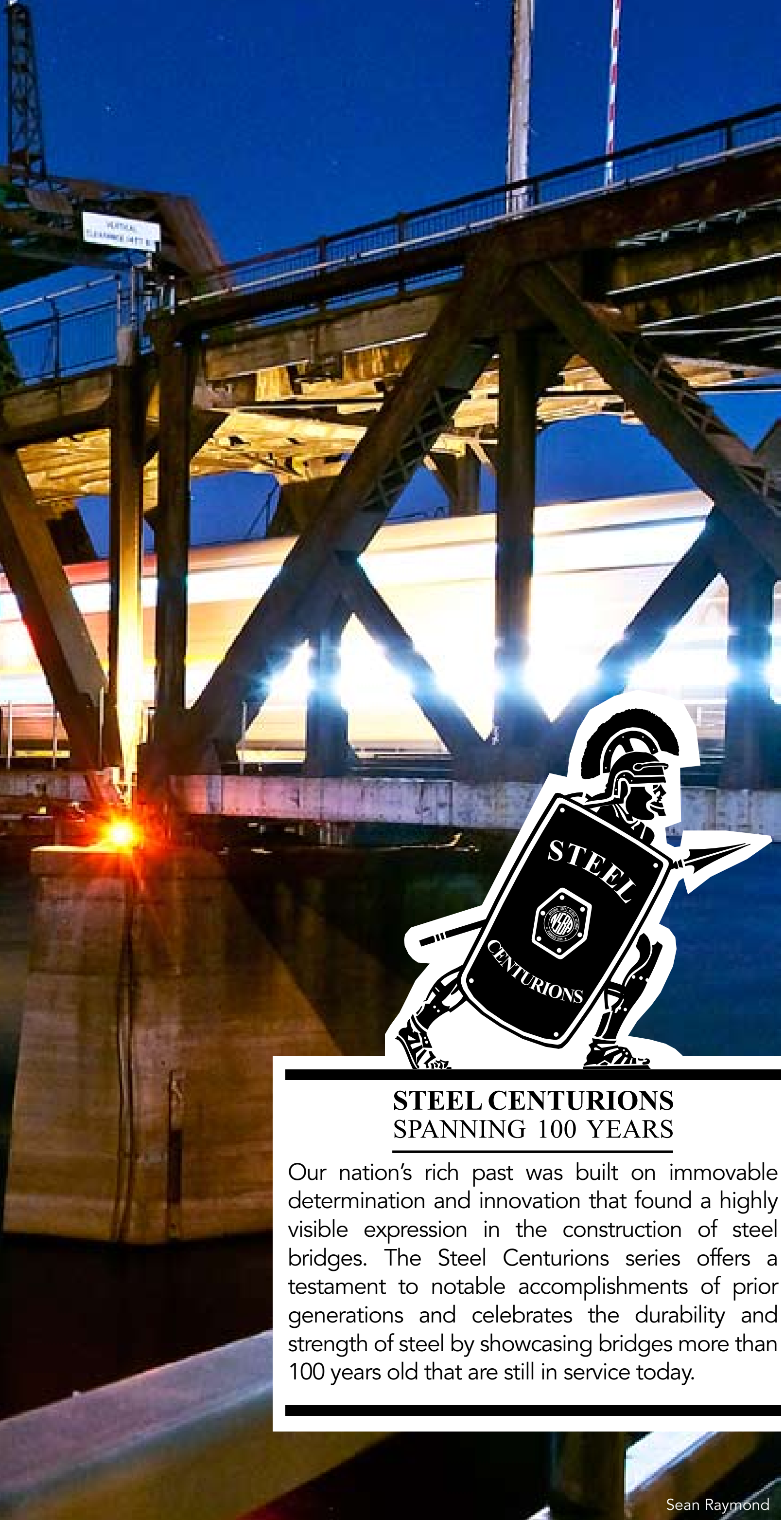
Completing the Westward Expansion

BY HOWARD PAYNE, P.E., AND JIM TALBOT

THE 100-YEAR-OLD, STEEL, I Street Bridge in Sacramento, Calif., carries rail, auto, and pedestrian traffic across the Sacramento River. A double-deck steel truss, the bridge consists of three fixed spans—two 167 ft and one 109.6 ft in length—plus a 394-ft span that swings open over a center pivot. The heaviest swing bridge in the U.S., its overall length is 2,194 ft, including approaches. The bridge has about 30 ft of clearance over low water and about 100 ft of clearance on each side of the pivot pier for barges and pleasure craft.

Railroad width clearances of 14 ft per track on the bottom deck originally determined the 30-ft width of the bridge. The upper deck provides 9-ft lanes for vehicle traffic bracketed by 5-ft sidewalks for pedestrians. To cope with the narrow passage, truckers and bus drivers sometimes turn in their rear view mirrors while on the bridge.

Today the bridge is on the main line of the Union Pacific Railroad. It carries about 40 trains a day, 32 of them being Amtrak transcontinental passenger trains and Caltrain commuters, and the remainder Union Pacific freights. It is busy enough that two trains at a time can be seen on the bridge. On the upper deck the I Street bridge carries about 10,000 vehicles a day, serving the north area of West Sacramento and downtown Sacramento. Openings for rivercraft today are minimal, but were frequent early in the 20th century when commerce was primarily waterborne.



Sean Raymond

STEEL CENTURIONS
SPANNING 100 YEARS

Our nation's rich past was built on immovable determination and innovation that found a highly visible expression in the construction of steel bridges. The Steel Centurions series offers a testament to notable accomplishments of prior generations and celebrates the durability and strength of steel by showcasing bridges more than 100 years old that are still in service today.

The bridge also serves rail traffic for the inland Port of West Sacramento. Situated 79 nautical miles from the Pacific Ocean, this barge and ship facility moves rice, wheat, corn, lumber, machinery, and containers. The ship canal is currently being dredged from 30 to 35 ft, which will accommodate 75% of the world's fleet.

Historical Background

Sacramento and West Sacramento were originally parts of large Mexican land grants. In 1848 John Sutter, Jr., made the city's first block plan, beginning development of the city's waterfront and ports. The California Steam Navigation Company, one of the first major businesses in the area, built docks and warehouses. Sacramento became the focus of the 1849 gold rush, and West Sacramento was its agricultural supplier. Farmers provided grain, corn, livestock, melons, and potatoes, and operated commercial salmon fishing. In 1856 the Sacramento Valley Railroad was built toward the east from Sacramento to Folsom.

The steel bridge sits on the site of multiple timber bridges constructed in the latter part of the 19th century. Earlier bridges resulted from efforts by railroad companies to push west to the San Francisco Bay Area. All of the railroad's metal work originated in the eastern United States and was shipped around Cape Horn. This led to the development of large railway shops in northwest Sacramento, which became the major industry in the west for many years.

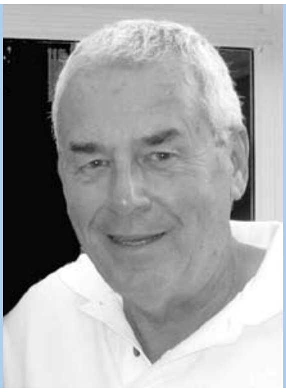
By 1869 the Central Pacific Railroad ran from the eastern side of the Sacramento River to Promontory Point, Utah. The Sacramento terminal served as a convenient off-loading point for railroad materials. But the railroad did not cross the Sacramento River, which meant passengers and goods had to be transferred to river boats.

Over a little more than 50 years, four timber bridges preceded the present structure.

- In 1858 a toll swing bridge carried pedestrians and loaded wagons across the river. It had distinctive, curved laminated truss chords and a swing span supported by a timber tower and cables.
- In 1869 the California Pacific Railroad Company bought the first bridge and replaced it with a new Howe truss timber bridge with a 200-ft draw span, a single railroad track and mixed traffic.

▲ The swing span design of Sacramento's I Street Bridge follows that of the Howe truss, with vertical members and diagonals that slope upward toward the center.

Howard Payne, P.E., was a bridge engineer with Caltrans for 18 years. Now retired, he also has served as a docent at the California State Railroad Museum, located next to the I Street Bridge in Sacramento. Jim Talbot is a freelance technical writer living in Ambler, Pa.



Peter Brungs

Supported by a 42-ft-diameter pivot pier in the Sacramento River, the 394-ft swing span of the I Street Bridge weighs in at 3,374 tons.

- The Central Pacific Railroad took over in 1876 and rebuilt the bridge. As the railroad yards and shops grew, this bridge became a one-track bottleneck within the two-track system.
- In 1893 the Central Pacific became the Southern Pacific railroad. It built a larger and stronger timber bridge that had the same configuration as the present bridge—two tracks on the lower deck and a wagon road on the upper deck.

Enter Steel

Construction of a new $786,000 steel bridge began in 1910 with John D. Isaacs as consulting engineer for the railroads. Design of the fixed spans incorporates vertical members with diagonals that slope downward toward the center. Additional bracing in the lower sections characterize these spans as Baltimore trusses, a subclass of the Pratt truss. The swing-span design follows that of the Howe truss, with vertical members and diagonals that slope upward toward the center. It also has additional bracing in the lower section.

Loading specifications for the lower deck followed the Harriman Lines common standard rail model. The design for highway traffic on the upper deck supports 100 lb/ft^2.

The Missouri Valley Bridge and Iron Company, supplemented with Southern Pacific workforces, built the pier foundations. The American Bridge Company, located in Western Pennsylvania, furnished the steel superstructure, totaling about 4,500 tons. Weight of the swing span topped out at 3,374 tons. The cities of Sacramento and West Sacramento shared in the cost and maintenance of the upper deck.

The piers extend down about 55 ft, penetrating a layer of boulders and gravel prevalent in the region. A principal structure is the 42-ft diameter center pier built on an octagonal-shaped caisson, 54 ft in diameter and 80 ft tall. This pier stood taller than any buildings in Sacramento at the time. Crews set the caissons for the remaining stream piers inside of cofferdams.

Workers constructed timber fender piers upstream and downstream from the center pier, completing it in August, 1911. They erected the swing-span truss on this pier in the open position, using a straddle leg traveler, with access from the west side. Slowed by the difficulties of winter construction in the stream, and the time it took to cast and cure the concrete deck, the bridge finally went into service in April 1912. But the date commonly accepted for bridge construction is 1911, which is cast on a steel plate on the diagonals over each truss portal frame.

The trusses consist of shop-fabricated and field-riveted built-up box sections made from web plates and angles, cover plates, and lattice bars. Canted eyebars over the center pier support the trusses in their cantilever position, and give the bridge its distinctive profile. An operator in the central control house opens and closes the bridge.

In the open position, the calculated deflection of the cantilevered ends was about 5 in. Designers shortened the supporting eyebars to raise the deflected bridge ends about 4 in. while open, making the bridge continuous over the center pier and keeping some tension in the eyebars. As the span closes, wedges lift the ends into place and locks provide stability.

The bridge design ensures that the swing span always achieves balance over the pivot pier. The original center bearing was a phosphor bronze crowned disk, having a 52-in. diameter and 6-in. thickness. It sat between two nickel-steel bearing plates 5.5 in. thick.

The swing span was designed to open in either direction and powered by two 75 HP direct current electric motors. The motors sat near the center of the span, driving a gear train. The span takes about five minutes to open, and another five to close and restore traffic. A set of balance wheels run about ⅛ in. above a steel perimeter track to keep the cantilevered ends from tilting. The wheels carry no weight except that to overcome forces such as wind. A powered automatic latch at each end of the span assists in centering the bridge.

Improvements

In 1993 the bridge's center bearing began to chatter. While the entire swing span was jacked up during bearing replacement, new hydraulic motors were installed in place of the original DC motors.

Originally the roadway at the west end of the bridge jogged abruptly as it moved away from the track alignment, a configuration that caused numerous accidents and fatalities. In 1937 and again in 1959 this roadway section was lengthened with modern, safer curves.

A white navigational stripe runs along the bottom chord in sharp visual contrast with the weathered, dark brown superstructure. Fortunately, the steel suffers minimal rusting in the dry Sacramento Valley climate.

What of the future? The I Street Bridge is listed in both the California Register of Historical Resources and the National Register of Historic Places. The bridge is well maintained mechanically, and its weathered look is simply evidence of a century of aging gracefully. Meanwhile, the nearby Tower Bridge on Capitol Avenue, or M Street, has become a city symbol that gets all of the publicity. A lift bridge with architectural towers, the Tower Bridge was built in 1935 and has since been painted gold. But it's the I Street Bridge that still carries the mainline load, a true Centurion. MSC

Steel Plate Availability for Highway Bridges

BY CHRISTOPHER GARRELL, P.E., LEED AP

An overview of plate sizes commonly produced by domestic mills.

THE LENGTH AVAILABILITY for the various plate widths and thicknesses is a very common question engineers have when designing highway structures. Understanding availability of plate material while performing design iterations will ensure that the material used can be sourced from all steel mills and result in better economy for the overall bridge superstructure.

The information listed below is not intended to be an all-encompassing summary of available plates that a mill may be able to produce. It is instead intended to provide a look at plate availability across the steel mills within the United States by width, thickness and length, as shown in Figure 1. Other widths, thicknesses and lengths may be available from one or more of these producers. In cases where a dimension is not shown, one should consult the steel mill or a local steel bridge fabricator. For specific contact information, please contact your local NSBA Regional Director (see sidebar). Alternatively, the AISC Steel Solutions Center can assist you by phone at 866.ASK.AISC and online at www.aisc.org/askaisc.

The tables that follow outline availability of A709-50 and A709-50W for non-fracture critical applications only. All units are in inches unless otherwise specified.

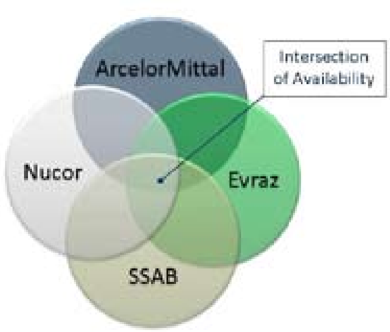


Fig. 1: The rationalization of plate availability.

Christopher M. Garrell, P.E., LEED, is southeast regional director with NSBA.

Availability and Relative Cost

Steel plate producers in the United States are ArcelorMittal, Evraz, Nucor and SSAB. Geographically, most steel plate mills are located within the eastern third of the United States as shown in Figure 2. Despite their location, many plate providers will choose to equalize on freight or meet a competitive price depending on their target markets.

Fig. 2: Plate mill locations in the United States.

Usable Area

The source plate from which each component of a steel plate girder is cut and fabricated is referred to as the "mother" plate. Given the variability of plate squareness and the thickness of each cut, the net usable area of a mother plate is reduced. For example, consider the haunched girder section shown in Figure 3.

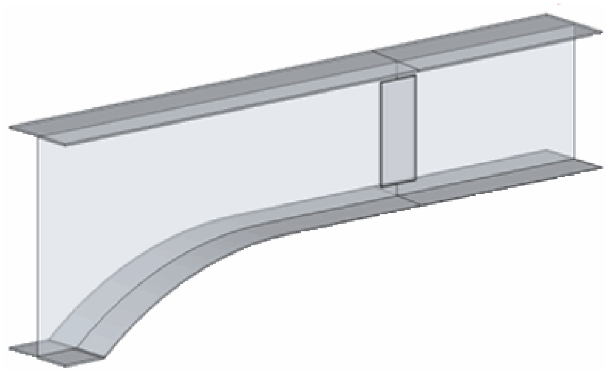
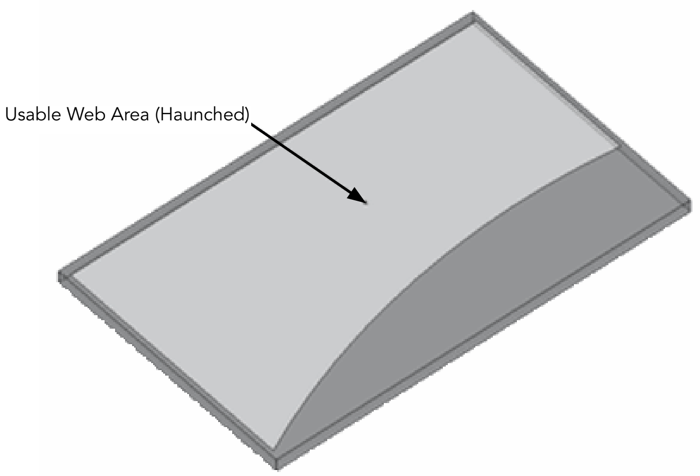


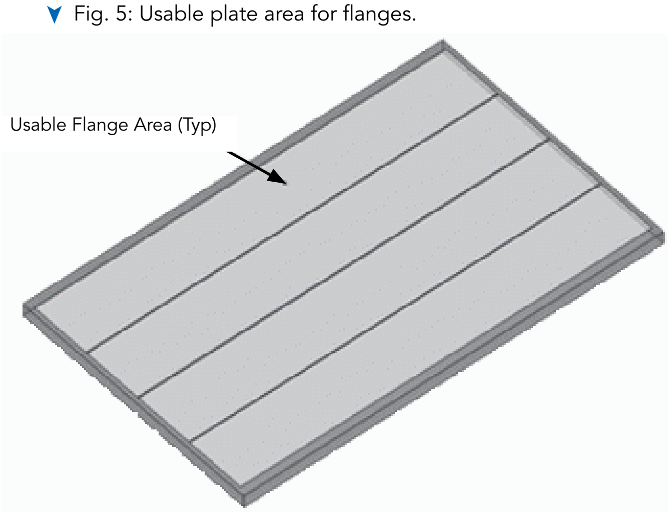
Fig. 3: Example Haunched Plate Girder.

The depth of the haunched web is controlled by the width availability of steel plate and also the material loss due to the cutting and squaring process (Figure 4). With respect to the flanges, a fabricator will optimize the layout of the flanges in order to maximize the number that can be obtained from a single width of plate (Figure 5). However, similar to the web, the net available area is reduced by the material lost to squaring the plate and *n*-1 cuts (where *n* represents the number of flange plates that can be cut from a single mother plate). Similar to a haunch, the amount of camber a girder has also affects the net usable area of a plate.



▲ Fig. 4: Usable plate area for haunched web.

▼ Fig. 5: Usable plate area for flanges.



While it is not entirely necessary for engineers to include optimization of plate usage into their design process, it is important to understand how design decisions may affect the size and number of plates purchased by a fabricator to accommodate the design. At a minimum, an engineer should be conscious of how chosen sizes compare to the length and width boundaries of available steel plate, as an inch may force a fabricator to the next larger available plate size. In turn, this may increase material waste and also limit availability. For reference, Table 1 summarizes approximate material loss due to the fabrication process. Note that this can vary from fabricator to fabricator, and can be dependent on their capabilities and equipment.

	Width	Length	Notes
Web Plate	1″– 4″	1″– 6″	Material loss will increase if web is haunched or cambered.
Flange Plate	1″– 4″ total plus an additional ¼″ per burn	1″– 6″	A fabricator may choose to increase flange widths specified by the engineer from ¼″– ⅜″.

Table 1
Approximate material loss due to squaring and cutting during fabrication.

A709-50 and A709-50W (Non-FC) Availability

The plate availability for ArcelorMittal, Evraz, Nucor and SSAB was compiled so that the common widths and thicknesses could be tabulatized. The goal of this process is to obtain steel plate thicknesses, widths and lengths that are available from all four steel plate mills. The following sections summarize the availability of A709-50 and A709-50W non-fracture critical materials, which are appropriate for the majority of the steel highway bridges being designed. As stated previously, while the capability of some steel mills exceeds what is shown, the purpose is to only summarize sizes that are available from four mills.

Thickness Availability

For the steel mills with information available at the time of printing, thicknesses range from 3/16 in. through 4 in.; note that the AASHTO LRFD *Bridge Design Specification* limits the thickness of material used for structural applications to 4 in. Available thicknesses are indicated by an "×" in a cell in Table 2.

	ArcelorMittal	Evraz	Nucor	SSAB
3/16	X			X
¼	X			X
5/16	X		X	X
⅜	X	X	X	X
7/16	X		X	X
½	X	X	X	X
9/16	X	X	X	X
⅝	X	X	X	X
11/16	X		X	X
¾	X	X	X	X
13/16	X		X	X
⅞	X	X	X	X
1	X	X	X	X
1⅛	X		X	X
1¼	X	X	X	X
1½	X	X	X	X
1¾	X	X	X	X
2	X	X	X	X
2¼	X	X	X	X
2½	X	X	X	X
2¾	X	X	X	X
3	X	X	X	X
3¼	X	X		
3½	X	X		
3¾	X	X		
4	X	X		

➤ **Table 2**
Plate thickness availability by steel mill (in inches).

Width Availability

Similarly, widths from all of the surveyed steel mills were tabulated to compare availability. A range from 48 in. through 138 in. is shown in Table 3. While wider plate is available, the number of steel mills that can produce it decreases to a single provider. Available widths are indicated by an "×" in a cell in Table 3 below.

	ArcelorMittal	Evraz	Nucor	SSAB
48	X	X		
54	X	X		
60	X	X		
66	X	X		
72	X	X	X	X
75	X		X	X
78	X	X	X	X
81	X		X	X
84	X	X	X	X
87	X			X
90	X	X	X	X
93	X		X	X
94	X		X	X
95	X		X	X
96	X	X	X	X
99	X		X	X
102	X	X	X	X
108	X	X	X	X
111	X		X	X
114	X	X	X	X
117	X		X	X
120	X	X	X	X
123	X		X	
126	X	X		
132	X	X		
138	X	X		

Table 3
Plate width availability by steel mill (in inches).

Standard industry widths are 72 in., 96 in. and 120 in. Outside these standard widths, the ability for a mill to supply the plate may become a consideration. When possible, consolidation will be performed to minimize the number of non-standard widths, which will make steel more economical. Otherwise, a special heat sequence, which can equate to a minimum order size, may be necessary to provide plate outside the standard industry widths.

Thickness, Width and Length Charts

The availability of different steel plate thicknesses and widths is important when making choices for plate girder cross sections; however the piece lengths and locations of splices will be affected by the length of plate that steel mills can provide. Maximum plate length from a steel mill is a function of both plate width and thickness (Table 4).

To ensure the maximum availability, the table below was developed around cases where the thicknesses and widths are available from all four steel mills. The associated lengths for each mill at each common thickness and width were then reviewed. The minimum length for the group was then used to create Table 4. While in some instances, mills can produce longer pieces, the length values shown below ensure that if one chooses from this table, a fabricator can obtain the plate from ArcelorMittal, Evraz, Nucor and SSAB.

Closing

This distillation of steel plate availability may help ease part of the process of designing steel plate girder highway bridges. Further information regarding best practices can be found in the AASHTO/NSBA Steel Bridge Collaboration document "Guidelines for Design for Constructability"; this and other similar documents can be found on the NSBA website, www.steelbridges.org, under AASHTO/NSBA Steel Bridge Collaboration Standards.

Special thanks to James Barber, regional sales and product development manager, SSAB Americas; Michael Engstrom, technical marketing director, Nucor-Yamato Steel; and Phil Bischof, plate product manager, Nucor, for their assistance in collecting plate availability. Additional thanks to Alex Wilson of ArcelorMittal for his assistance. MSC

	Plate Width								
	72	78	84	90	96	102	108	114	120
3⁄8	972	972	972	972	972	972	972	972	750
1⁄2	972	972	972	972	972	972	972	972	750
9⁄16	972	972	972	972	972	972	972	972	972
5⁄8	972	972	972	972	972	972	972	972	972
3⁄4	1,030	1,030	1,030	1,030	1,030	1,030	1,030	1,030	1,030
7⁄8	1,030	1,030	1,030	1,030	1,030	1,030	1,007	954	907
1	1,030	1,030	1,030	1,030	992	933	882	835	793
1¼	1,030	1,030	907	846	793	747	705	668	635
1½	1,030	1,030	756	705	661	622	588	557	529
1¾	1,030	1,030	648	604	567	533	504	477	453
2	937	937	567	529	496	467	441	418	397
2¼	833	833	504	470	441	415	392	371	353
2½	749	749	453	423	397	373	353	334	317
2¾	681	681	412	385	361	339	321	304	288
3	624	624	378	353	331	311	294	278	264

Table 4 Composite plate chart: Maximum length (in inches) for given plate thickness and width.

NSBA's Regional Resources

The National Steel Bridge Alliance's Regional Directors are the primary liaisons between NSBA and the bridge design and construction community. They assist fabricators, designers, and owners in making the best bridge design selections possible. In addition, NSBA regional directors provide steel superstructure technical assistance and technical reviews at various stages of drawing completion. To contact your NSBA regional director, please see the list to the right.

NSBA Director – Northeast
William F. McEleney
Cranston, R.I.
McEleney@steelbridges.org

Regional Director – West
Calvin R. Schrage
Lincoln, Neb.
Schrage@steelbridges.org

Regional Director – Southeast
Christopher M. Garrell, P.E., LEED
Cary, N.C.
Garrell@steelbridges.org

A Master Craftsman

Bridge engineer Ted Zoli creates structural beauty and efficiency in both construction and performance.

PEOPLE FREQUENTLY INHERIT MORE than names from earlier generations, which certainly has been the case for Ted Zoli, aka Theodore P. Zoli, III. "I was born on a road job," Zoli said. His grandfather had a road building business, which his father later took over. At the time, they were building the original Interstate 87 north of Lake George in the Adirondack Mountains of upstate New York.

It was a pretty remote area, Zoli recalls, and family business also was a big part of family life. "Being around heavy civil construction since my early years, I think I had this sense that that's what I was supposed to do," he said. The feeling was reinforced as he witnessed the generational transition of the family business. "I had the sensibility as I was growing up that I would be in some form or fashion involved with civil engineering. Then I got very interested in bridges in college."

Zoli studied at Princeton University, where he was exposed to bridge engineers "who were actively developing informed, new ideas in structural engineering. And bridges being as utilitarian and as pure a form of structure as anything, it was a wonderful place to get a sense of what structural engineering can be and how ideas in structural engineering are explored. That's all that you have in a bridge is structure."

A year after earning his undergraduate degree from Princeton, he completed a master's at California Institute of Technology. He then joined HNTB in New York and today heads the firm's bridge division. "Literally my entire career has been focused in bridge design," he said.

A leader in the field of long-span, cable-supported bridges, Zoli says he thinks of bridge building far more as a craft than as either science or art. "Craft for me has the right sensibility, where you are learning deeply from the people around you that you work and interact with and also from the people who went before you." The western sense of art, he explains, is creating something for the few by the few. On the other hand craft, or what might be called folk art, is somewhat the antithesis of that, he says. "Craft is work that's created for the many by the many, and bridge building is much more in that camp." That perspective continually reminds him that he is working in a team, he says. And because bridges are public projects, built with other people's money, he says "that requires a certain sense of austerity about what we do, a sense of efficiency, and that really is more like craft than it is like art." That also means there is less of a place for art and ego in this type of environment, he observes.

Ted Zoli, bridge engineer.

John D. & Catherine T. MacArthur Foundation

Zoli's record as a craftsman includes a number of acclaimed structures. They range from high-capacity spans like Boston's Leonard P. Zakim Bunker Hill Bridge to the recent award-winning S-shaped Bob Kerrey Pedestrian Bridge over the Missouri River. Sparse and understated, yet inspiring and fun, the Bob Kerrey bridge illustrates how masterfully Zoli pursues efficiencies in his designs. One option would have been to use curved members, but given the scale of the bridge, the potential additional cost of bending was significant. Instead it was built with all straight pieces. "Even though the bridge is curved, there's not a single bent piece in the superstructure," Zoli said, "and they're all fabricated from rolled sections with every steel section being the same." Although that meant extra conservatism in some members, the extra material use was balanced by efficiencies in fabrication.

"Tremendous cost efficiencies can be gained by designing a structure that's optimized from the perspective of how it's fabricated and how it's erected and rather than by minimizing sections," Zoli said.

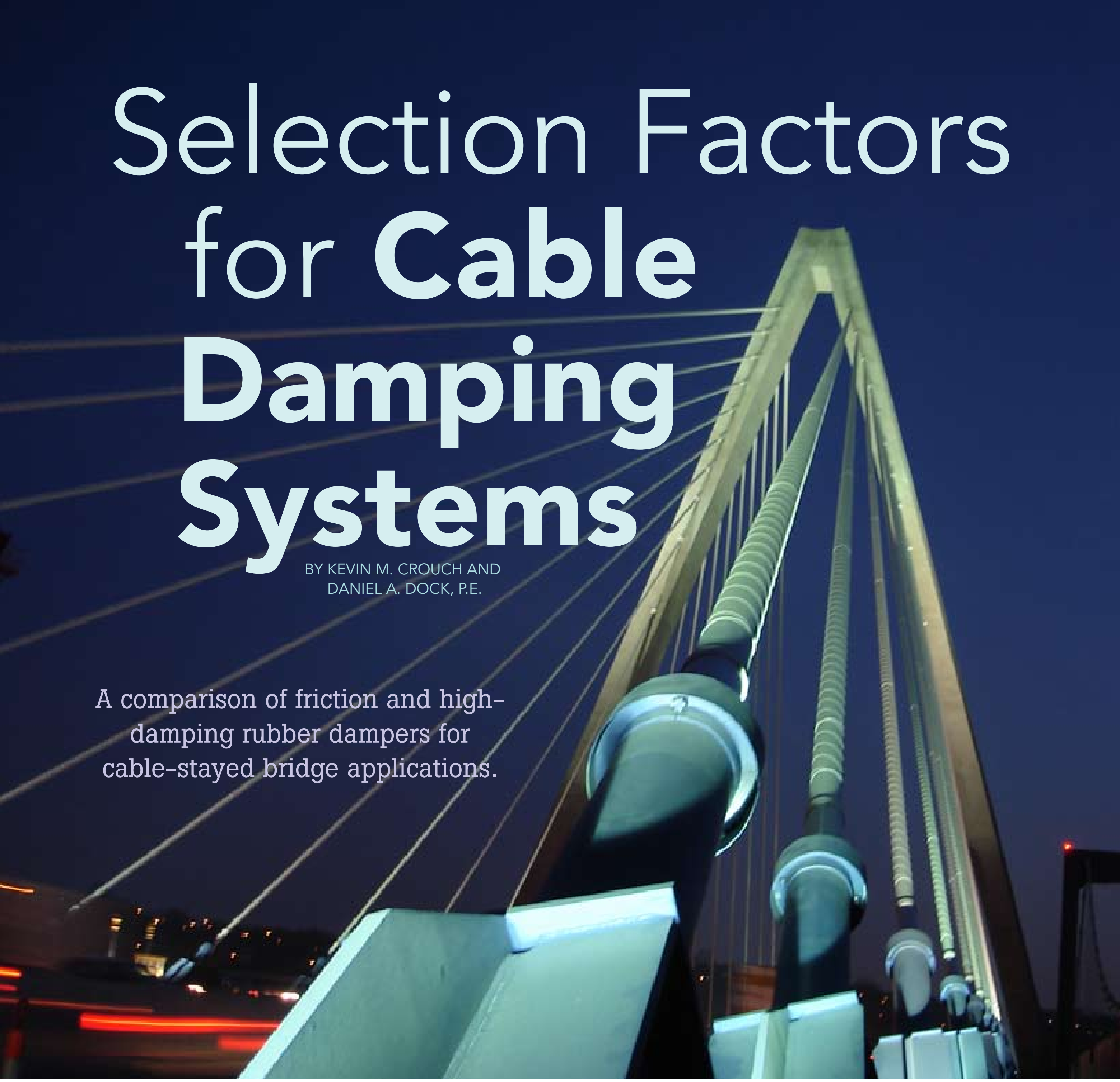
In 2009 Zoli was selected as a MacArthur Fellow by the John D. and Catherine T. MacArthur Foundation. The program awards a significant, unrestricted grant, distributed over a five-year period, "to encourage people of outstanding talent to pursue their own creative, intellectual, and professional inclinations," according to the foundation website.

For Zoli, that means the opportunity to further develop his concept of a lightweight rope bridge—an extension of the cat's cradle/Jacob's ladder string figure—that is inexpensive as well as structurally simple and efficient. "The 80-ft bridge I built with my Princeton students used 600 ft of synthetic rope, cost $250, and weighed 28 lb." And it fit in a backpack, he added, which makes it easily deployable in remote locations. Decking would be made from locally available materials.

With the MacArthur Foundation grant money he plans to fund construction of a prototype bridge in an appropriate location, quite likely in Vietnam. "My sense of engineering as craft is you have to build a few of these to get them right. They can be continuously improved."

Although it's not easy to switch topics once he starts talking about bridges, Zoli also says he is an avid biker and enjoys poetry. To learn more about his involvement in these areas and how these interests dovetail with his bridge-building expertise, listen to the complete interview at **www.modernsteel.com/tz**.

MSC



Selection Factors for **Cable Damping Systems**

BY KEVIN M. CROUCH AND DANIEL A. DOCK, P.E.

A comparison of friction and high-damping rubber dampers for cable-stayed bridge applications.

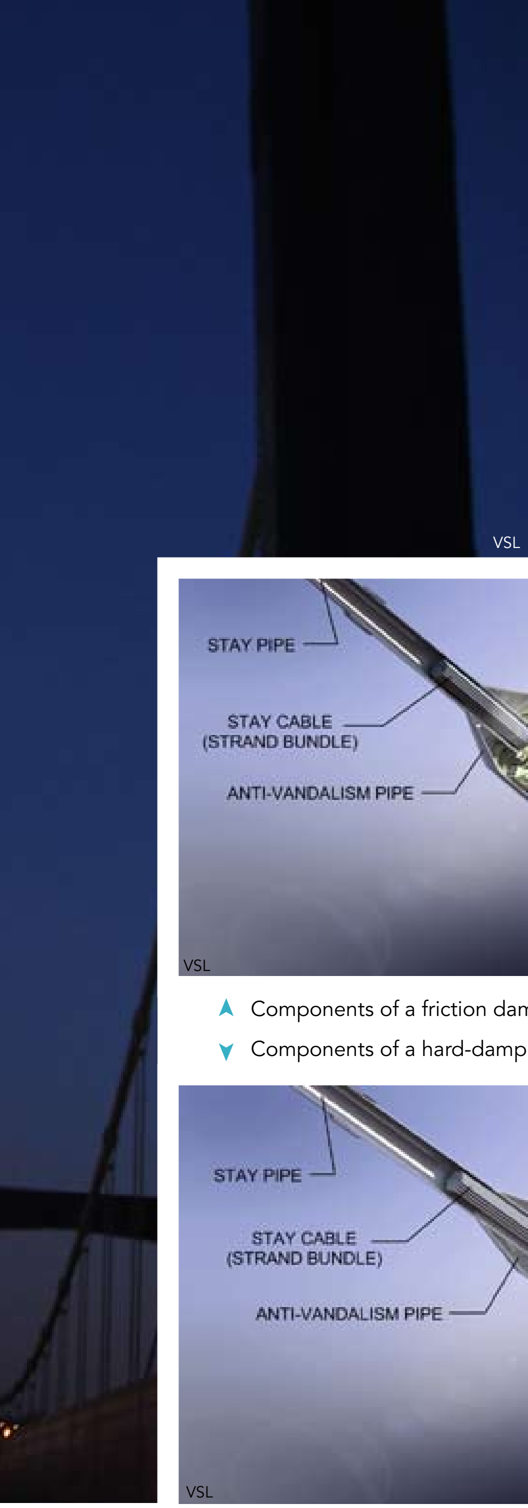
THE REQUIREMENTS FOR INCREASED DURABILITY of cable-stayed bridges now make the 100-year bridge the norm. A key factor in providing long-life is a strategy for controlling the complex problem of cable vibrations due to wind and aeroelastic instabilities.

This article examines the features of two vibration damping systems and factors to consider when choosing a damping system in the design of a cable-stayed bridge. Friction dampers typically are more suitable for longer cables and those with more demanding damping requirements. Once active, they protect the cable by providing damping across all modes of vibration and any axis. With no moving parts, high-damping rubber (HDR) dampers are ideal for cable-stayed bridges with short to medium cable lengths or cables with moderate damping requirements. The article concludes with three examples of recent installations.

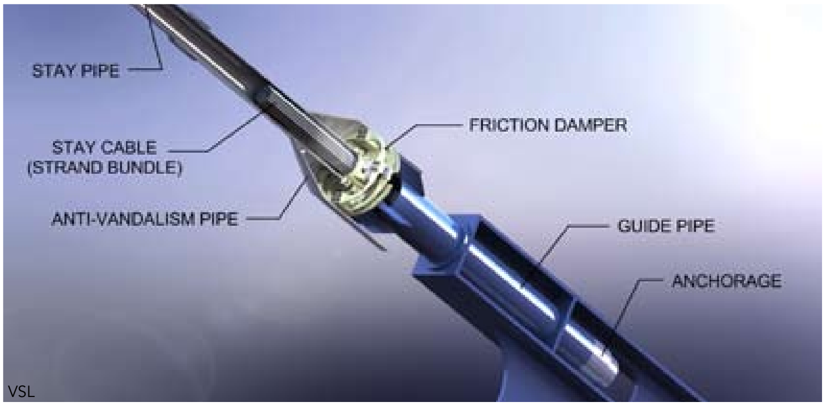
Increasing Popularity of Cable-Stayed Bridges

Cable-stayed bridges have been constructed all over the world in recent years. Combining a steel superstructure with current stay cable technology has enabled the construction of main spans in excess of 3,300 ft. Examples include the Stonecutters Bridge in Hong Kong and the Sutong Bridge in Jiangsu Province, China. The recently opened John James Audubon Bridge near Baton Rouge, La., currently is the longest cable-stayed main span in the western hemisphere at 1,583 ft. With many more planned projects on the horizon, the cable-stayed bridge appears to be well-positioned for future construction.

Given the up-front investment required to build a cable-stayed structure, it is understandable why owners want these bridges to provide a 100-year service. Many factors contribute to this extended life expectancy, including improved corrosion protection measures and the ability to replace individual strands or even entire cables without closing a bridge to traffic. Another important aspect of ensuring a long life involves improvements in controlling the complex problem of cable vibrations due to wind and aeroelastic instabilities. A number of different solutions have been developed to address this concern, most notably stay-cable dampers.

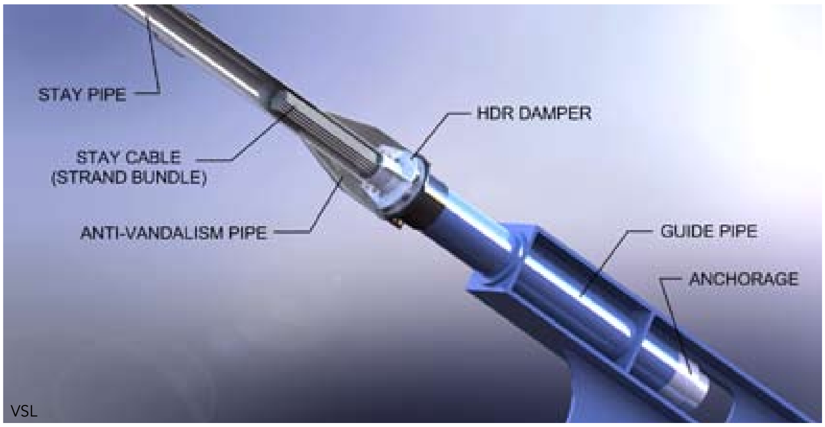


With its relatively short stay cables, the Christopher S. Bond Bridge spanning the Missouri River near Kansas City, Mo., was a good application for HDR dampers.



Components of a friction damper assembly.

Components of a hard-damping rubber (HDR) damper assembly.



Why Are Dampers Needed?

Stay cables are prone to a number of different types of vibration. The U.S. Federal Highway Administration's document *Wind-Induced Vibration of Stay Cables* (Publication No. FHWA-HRT-05-083) names at least eight different types of cable excitation. The most common one with the potential to generate large cable amplitudes is known as Rain-Wind Induced Vibration (RWIV), though other types of excitation can also affect particular bridges. RWIV typically occurs during a rain event with moderate wind speeds (in general 18 to 33 mph). Stay cables have a small amount of intrinsic damping, but in many situations this is not enough to control the excitation from various phenomena. A number of solutions have been developed to provide additional damping, including cross-ties, stay pipe surface treatments (such as helical ribs or dimples), external dampers (like piston-type viscous dampers), and internal dampers.

Though driver comfort is perhaps the most prominent reason for controlling stay cable vibration, durability is also a significant concern that dampers can address. Dampers contribute to long-term bridge life primarily through keeping steel protection elements, such as guide pipes and anchorage components, from experiencing repetitive large movements and loads. Large vibrations can damage the connections of these elements, as was observed on the Fred Hartman Bridge near Houston. Repeated cable excitation on that bridge led to broken welds at the base of the deck guide pipes.

On most cable-stayed bridge projects, a qualified engineering consultant performs a wind study to determine the level of additional damping recommended for each stay cable on the bridge. These recommendations

*Kevin Crouch is an engineer at Structural/VSL, Fort Worth, Texas, and previously worked as an engineer at Parsons Brinckerhoff. He can be reached at **kcrouch@structural.net**. Dan Dock, P.E., is vice president of engineering at Structural/VSL, Fort Worth, Texas. He has more than 30 years experience in structural engineering, having worked for major contractors and engineering consulting firms. He can be reached at **ddock@structural.net**.*

The long stay cables of the newly opened John J. Audubon Bridge in Louisiana are benefitting from the use of friction dampers.

are then used to develop project specifications, which in turn lead to the use of specific damping systems on a bridge. Certain types of dampers are more appropriate for specific applications, so it is important to understand a project's needs before proposing a solution.

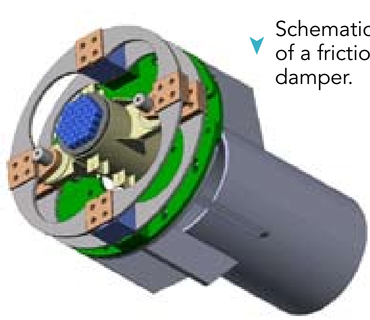
Two Distinct Damping Solutions

In the 1990s, two very effective damping solutions were developed to address the problem of stay cable vibration. The first, the friction damper, was created by Imre Kovacs and patented by VSL International. This solution was first applied in 1996 on the Puente Real (Badajoz) Bridge in Spain. In essence, the friction damper functions similarly to disc brakes on an automobile. Spring blades connected to a bridge's guide pipe provide a clamping force on a collar attached to an individual stay cable. At a particular amplitude, the force from the cable's vibration overcomes the friction between the contacting parts in the two assemblies, at which point the damper activates. The system then works quickly and efficiently, dissipating energy in order to return the cable to a low-vibration state. Because of their shape and non-linear behavior, friction dampers can provide damping across all modes of vibration and any axis. During periods of vibration with very small amplitudes, the damper remains inactive and functions like a guide deviator. This minimizes the wear on the damper and allows it to transfer the force from these small vibrations to the guide pipe rather than the cable anchorage.

Another damping system was developed in Japan by Sumitomo Rubber Industries. This solution, consisting of multiple HDR pads, was introduced on the Odawara Blueway Bridge in 1994. The rubber pads, which somewhat resemble a hockey puck, connect a stay cable to its corresponding guide pipe, dissipating energy and transferring vibration forces to the pipe rather than the cable anchorage. Unlike the friction damper, the HDR assembly is always active. However, because the system includes no moving parts, it is highly resistant to wear.

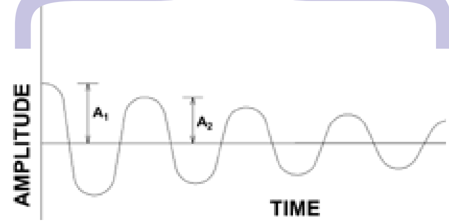
The unique features of each system make it important to evaluate which is more appropriate for a particular use. For instance, friction dampers are generally more suitable for longer cables, while HDR systems function best for shorter and medium-length stays.

In general terms, the further away a damper is from the anchorage, the more damping it can achieve. However, the flexibility of the damper support, which is usually the guide pipe, must also be considered, as a flexible support will reduce the effectiveness of a damper. Because of their higher effi-



Schematic view of a friction damper.

Close-up view of a friction damper.



Basics of Stay-Cable Damping

Stay-cable damping requirements are typically expressed with one of two values: percent of critical damping, or the percentage of logarithmic decrement. The percentage of logarithmic decrement (log dec) represents the natural logarithm of a ratio between two successive vibration amplitudes, expressed as a percentage. In the chart shown above, the percentage of log dec (δ) would be expressed as:

$$\delta = l_n \frac{A_1}{A_2}$$

Critical damping refers to the damping level needed to bring the cable to rest in one cycle without experiencing further vibration. The damping ratio (ξ) is typically expressed in terms of a percentage of this amount. The damping ratio can be related to the percentage of log dec with the following equation:

$$\xi \approx \frac{\delta}{2\pi}$$

Stay cables are long, flexible members and thus cannot achieve critical damping. Attempts at providing a completely rigid damper would simply create a node on the cable, while supplying an excessively soft damper would allow too much movement and thus forfeit the damper's effectiveness. Analysis confirmed by testing has been used to determine the highest damping level possible for a stay cable. For a cable with a passive damper attached at a particular point, the maximum achievable damping under free vibration can be expressed as:

$$\delta = \pi \frac{\Delta x}{L}$$

where δ is the damping expressed in the percentage of log dec, Δx is the damper position measured from the closest end of the cable, and L is the cable length.

The Luling Bridge, also known as the Hale Boggs Memorial Bridge, is getting new cable stays with a mix of both HDR and friction dampers.

ciency, friction dampers typically can provide the same level of damping as HDR dampers at a position closer to the cable anchorage. However, friction dampers usually require a larger diameter anti-vandalism cone than HDR dampers to allow for the larger movement associated with the system. The additional size of the components may need to be considered in situations with tight clearances. The two damping systems also can be mixed on a single bridge, with one system used on certain cables and the other on the remaining cables, or even combined on an individual cable, as is being done on the Luling project.

The Two Solutions Applied

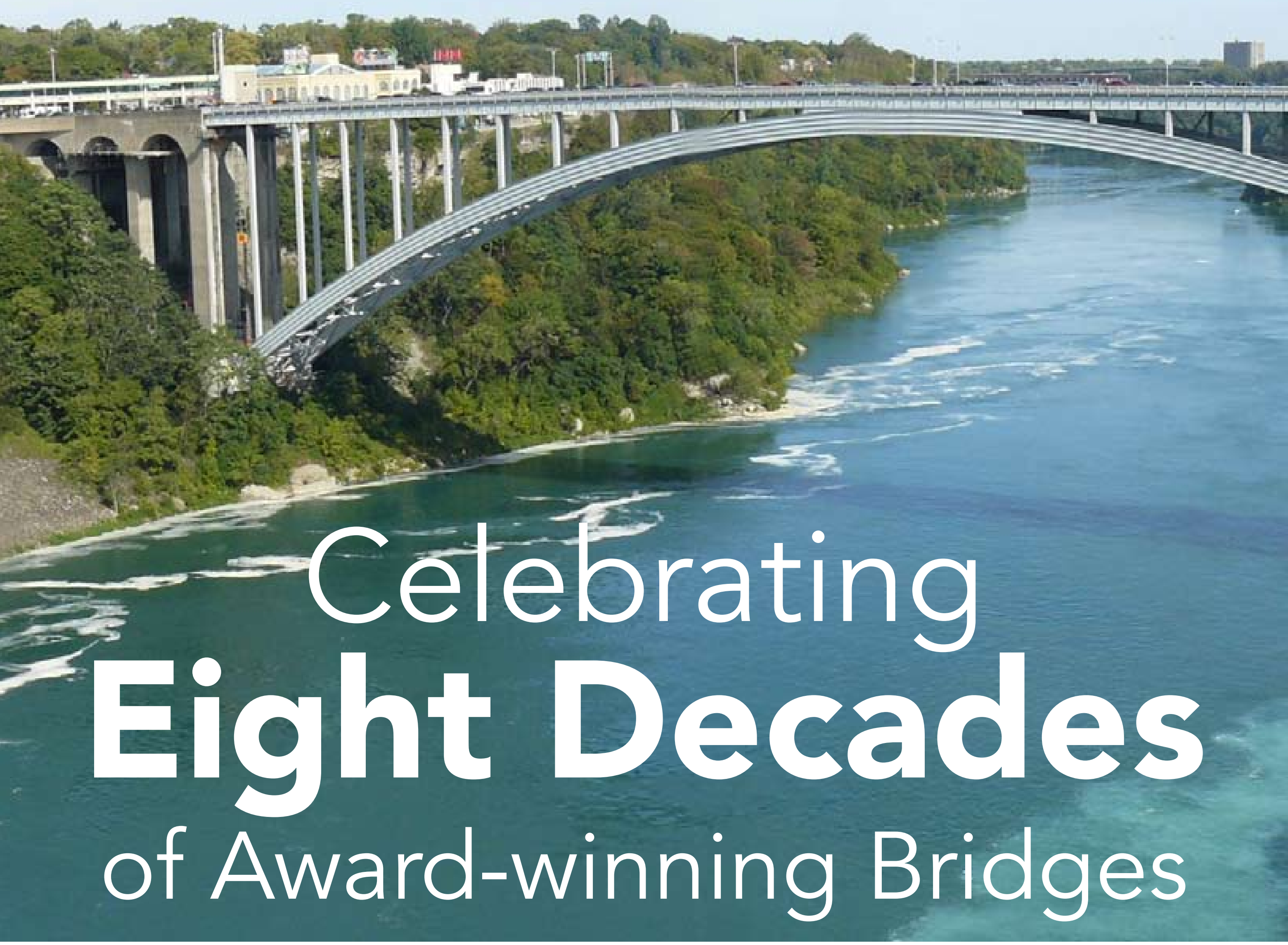
The John James Audubon Bridge spans the Mississippi River between New Roads and St. Francisville, La. Early in the design-build process, a wind engineering study indicated that varying levels of damping were needed for individual cables. The maximum was 0.59% critical damping. Given the cable lengths (maximum length of approximately 830 ft) and damping requirements, a friction damper was chosen for this application. At the present time, friction dampers have been installed successfully on all cables, and the bridge was opened to traffic in May 2011.

The Christopher S. Bond Bridge spanning the Missouri River is part of the kcICON project in Kansas City, Mo. As with the Audubon Bridge, a wind engineering study was performed early in the design-build process and the recommendations from the report became the basis for the required damping on the job. Two primary factors led to the selection of HDR dampers for the bridge. First, the shorter cable lengths, which had a maximum length of approximately 530 ft, and lower damping levels (the maximum cable required 0.38% critical damping) allowed the use of the rubber dampers. In addition, the diamond shape of the pylon combined with above-deck steel anchorage assemblies permitted smaller anti-vandalism cones in order to avoid possible clearance issues with truck traffic on the bridge. The bridge was opened to traffic in September 2010, complete with HDR damping systems in place.

The Luling Bridge, also known as the Hale Boggs Memorial Bridge, was originally constructed in the early 1980s near New Orleans. A lengthy investigation initiated by the Louisiana Department of Transportation and Development in the early 2000s uncovered concerns with the existing stay cables, leading to the first stay cable replacement project in the United States. As part of this project, the issue of cable vibration was addressed; the original cables had not been equipped with dampers. The project specifications required 0.95% critical damping for all cables. After much discussion, both friction and HDR dampers were selected for the project. The cable replacement is currently under way; dampers have been installed on one quadrant of the bridge, and the remaining systems will be installed as construction progresses. Project completion is anticipated for 2012.

These examples demonstrate the utility and flexibility of the friction damper and the HDR damper. Though different in many ways, both types of dampers function well under the appropriate circumstances. As the number of cable-stayed bridges continues to increase, these damping systems will certainly assist in maintaining the long-term durability of these bridges. MSC

A look back at some of steel's many contributions to America's growth and development.



Celebrating **Eight Decades** of Award-winning Bridges

FOR MORE THAN 80 YEARS, the National Steel Bridge Alliance Prize Bridge Competition has honored significant and innovative steel bridges constructed in the United States. The competition began in 1928 with first place awarded to the Sixth Street Bridge in Pittsburgh, coincidentally just a few blocks down the river from where the NASCC: The Steel Conference took place in May 2011. Since 1928, more than 300 bridges have been so honored in a variety of categories, which today include long span, medium span, short span, movable span, major span, reconstructed, and special purpose.

Recently, the Prize Bridge Competition has taken place in alternate years and the winners have been announced at NSBA's World Steel Bridge Symposium. Because the next WSBS will be co-located with The Steel Conference in 2012, we are taking this opportunity to look back at the award-winning bridges that have gone before, seeking to find the most popular as well as the most notable among them.

The bridges we recognize here as all-time favorites were selected in two concurrent levels of competition, resulting in two levels of awards. The People's Choice award winners were selected through an online public vote. The Industry Choice awards were chosen by the panel of esteemed judges noted in the inset.

All first place winning bridges in the various categories used since the competition began in 1928 were eligible for the 2011 competition. NSBA announced the 2011 Top Prize Bridge Award winners at the 2011 AASHTO Subcommittee on Bridges and Structures Annual Meeting in May in Norfolk, Va.

Read on for an appreciation, and a little history, of some of the most truly iconic and beautiful steel bridges our nation has to offer.

Vijaya Sanmukam

2011 "Favorite Bridge" Judges

- Ben Beerman – Federal Highway Administration
- Hormoz Seradj – Oregon Department of Transportation
- Robert Healy – Rummel, Klepper & Kahl
- Doug Waltemath – Harrington & Cortelyou
- Ray McCabe – HNTB
- David Hohmann – Texas Department of Transportation

People's Choice Award Winners

The goal of the online public voting was to determine the three favorite Prize Bridge Award winners of all time. The turnout was extremely enthusiastic, with nearly 3,000 votes submitted.

Rainbow Bridge
Niagara Falls, N.Y. (17.5% of votes)
1941 Prize Bridge Award, First Place — Class A

Built in 1941, just 1,000 ft down the Niagara River from the American Falls, the Rainbow Bridge was the largest hingeless arch bridge in the world from the time of its construction until surpassed by the Lewiston-Queenston Bridge in 1962. The total cost of the bridge was $4 million. The engineers were Waddell & Hardesty and the Edward P. Lupfer Corporation. Fabrication and erection was by the Bethlehem Steel Company.

The deck of the Rainbow Bridge is approximately 202 ft above the Niagara River. It is 1,450-ft long with a main span of 960 ft. Its two 22-ft-wide roadways provide two lanes in each direction. A $72 million transformation, completed in 2000, entailed the rebuilding of both plazas as well as widening the approaches.

Today the Rainbow Bridge continues to be a major tourism gateway between Canada and the United States, generating tens of millions of dollars of activity on both sides of the border. It is open 24 hours a day to passenger vehicles and buses; no commercial vehicles are allowed. Eighteen traffic lanes in New York and 16 in Ontario facilitate flow of traffic for governmental inspections.

—Lew Holloway, General Manager, Niagara Falls Bridge Commission

Paper Mill Road Bridge
Baltimore County, Md. (13.3% of votes)
2001 Prize Bridge Award Winner, Long Span

A new Paper Mill Road (MD 145) Bridge crossing of Gunpowder Falls and Loch Raven Reservoir opened to traffic in December 2000. Adjacent to the original crossing of a much earlier vintage, this aesthetically pleasing bridge designed by Johnson, Mirmiran & Thompson, Baltimore, consists of a rust-colored steel box arch with a span of 495 ft and an overall length of 670 ft that rises to a height of 99 ft above Gunpowder Falls. Innovative construction techniques were utilized to erect this modern arch structure. One such technique was the use of a causeway across the reservoir as a staging platform, but also designed to protect any submerged Native American artifacts and paper mill ruins.

Travelers using the new bridge benefit from the safer curves in the approach roadways, wider lanes and unrestricted load carrying capacity. The appearance of this structure is consistent with the park-like environment of the Loch Raven Reservoir, maintaining the pristine nature of this vital water supply for the Baltimore area. The arch structure provides a long center span to avoid impacts to the waterway, and complements the existing historic bridge, which was undisturbed by the construction.

This project in northern Baltimore County, Md., is a model for balancing future transportation needs, environmental considerations within a waterway, and preservation of a historical structure, all of which required intergovernmental cooperation. Fostering a partnership that resulted in that intergovernmental cooperation was vital to the success of the Paper Mill Road bridge project.

The existing historic bridge was owned by the city of Baltimore, although it is located outside the city's jurisdictional boundaries, but still within Baltimore County. The structure served to connect sections of Paper Mill Road, which was owned and maintained by the Maryland State Highway Administration. Negotiations among the three jurisdictions resulted in the state accepting the new bridge into the state highway system, thereby unifying ownership and maintenance of this vital link in this major commuter route serving traffic between Baltimore and Harford Counties.

Baltimore County agreed to take over the ownership and maintenance of the original bridge to preserve the historic structure for possible continued use, and the city divested itself of the operation and maintenance costs, as well as responsibilities associated with the existing bridge located outside of the city limits.


Sheridan Vincent

Colonel Patrick O'Rorke Bridge
Rochester, N.Y. (13.2% of votes)
2005 Prize Bridge Award Winner
Movable Span


Bergmann Associates

The true measure of success for a project is how the community views the facility long after opening day. During the planning and design of the Colonel Patrick O'Rorke Memorial Bridge, the Bergmann Associates team, the New York State Department of Transportation and Monroe County listened to a fully engaged stakeholder group and designed a structure that was consistent with the context of the community and an enhancement to its surroundings. More than seven years after the first vehicles crossed the newly constructed bridge, the success of this project is evident by observing the vibrancy of the surrounding communities and listening to locals, neighbors and users alike.

Thomas Hack, P.E., senior structural engineer with the City of Rochester, N.Y. recently said, "The Colonel Patrick O'Rorke Memorial Bridge resurrected not just another river crossing but it revitalized an entire neighborhood. Rochester's Charlotte neighborhood could not be more proud of this iconic structure. It has instilled pride and helped solidify the community's 'Port of Rochester' as a major destination point with a sense of place and a sense of activity. No longer is this crossing considered a monotonous utilitarian structure simply straddling a lifeless waterway. Rochester's waterfront is now thriving with activity, life and purpose."

"In every community there is usually a landmark structure that captures the spirit and imagination of its people," said Monroe County bridge engineer Bo Mansouri, P.E., "a structure that people can relate to, affectionately identify with, and come home to. The Colonel Patrick O'Rorke Memorial Bridge is one such structure within the historic community of Charlotte, Rochester, N.Y. It brings an immense sense of pride to the people of this harbor town community. Its dedicated name-sake memorializes a hometown hero who fought in the Civil War for independence and freedom of the entire country."

— Bergmann Associates, Rochester, N.Y.

Industry Choice Winners

Sixth Street Bridge

Pittsburgh, Pa.

1928 Prize Bridge Award Winner, Most Beautiful Steel Bridge

The Sixth Street Bridge, or the Roberto Clemente Bridge as it is now known by most non-engineers, is as unique a bridge as Clemente was as a baseball player. This beautiful and magnificent bridge, the first of Pittsburgh's three sister bridges, was a part of the street system when it first was built and now connects the central business district with the sports and entertainment section across the Allegheny River. After 83 years of service, this bridge remains an important part of the fabric of Pittsburgh.

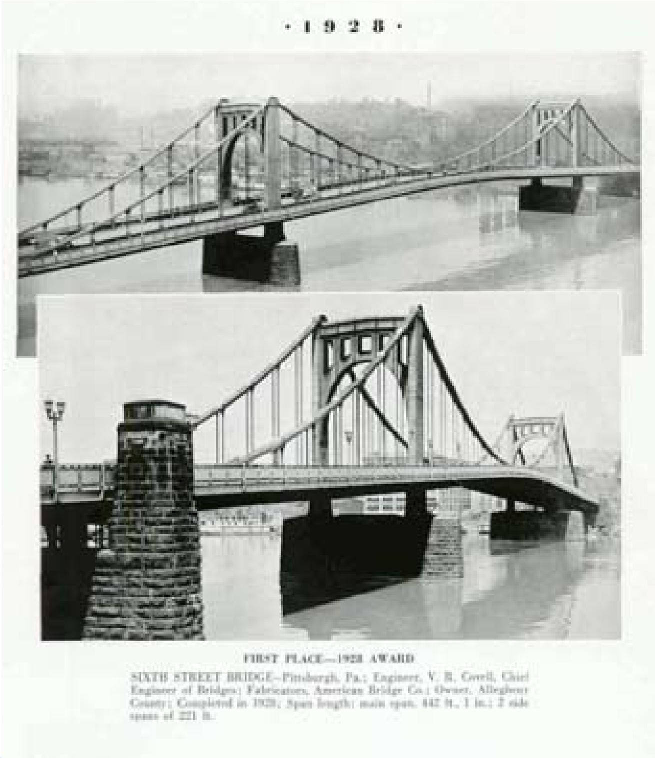
When constructed, the Sixth Street Bridge was the longest self-anchoring suspension bridge in this country and was quite a change from many previous slender-member bridges. It was designed by some of the Allegheny County Department of Public Works' 102 staff engineers. Rather than using cables, they used "links" of seven steel eyebars that alternate and mesh with eight-eyebar links to provide the suspension.

The reason for using the self-anchoring suspension was due to the lack of space. With a roadway on one side and railroad tracks on the other, there was no space for the massive anchoring rooms required. By connecting the eyebar suspension system to two large structural steel box girders that spanned the river, the engineers accomplished their mission. The two massive stiffening girders are tied down at the edge of the river piers by two long eye-bars placed deep into each pier. The heavy deck and the two structural stiffeners also are attached to the eyebar suspension by eyebars. As a testament to its design for strength, this bridge has never had a weight limit imposed on it.

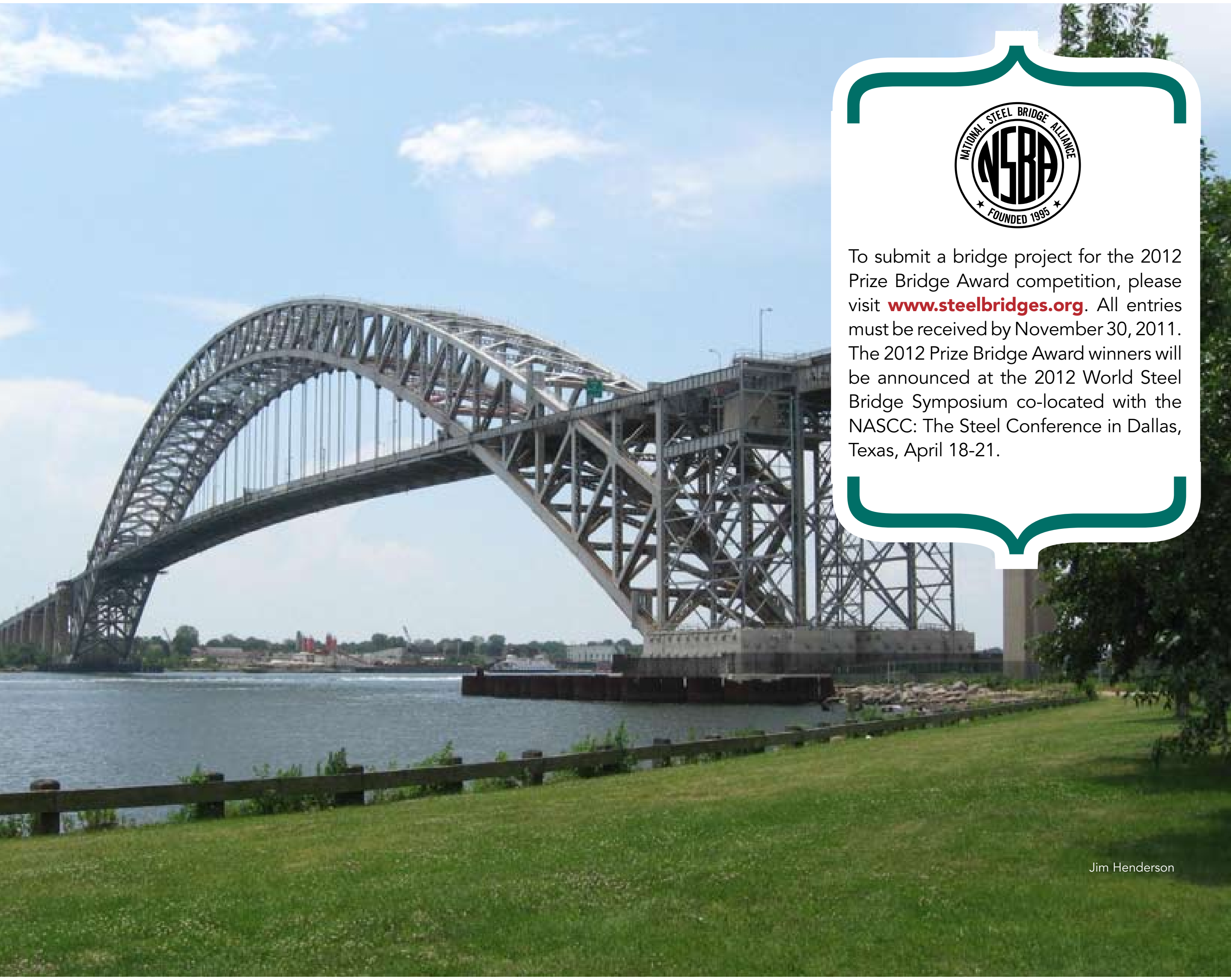
The use of the eyebar suspension medium makes this bridge a most attractive and appealing structure to both the engineer and the public. With two more sister bridges next to it, the effect is even more beautiful. This style of bridge has been used in other places in the world, but not often and not as dramatically as in Pittsburgh. Steel was used because it was constructed in the Steel Capital of the world. By far the best and most recognized icon of the many beautiful and unique steel bridges in the Pittsburgh area, it can also be seen from inside PNC Park, the home of the Pittsburgh Pirates.

This engineering wonder is even more important to Pittsburgh today than when it first opened on October 19, 1928. I am especially thrilled that AISC has again selected this beautiful and unique bridge that shows to the nation that steel bridges are spectacular, even in the eyes of the public.

—John. F. Graham, Jr., P.E., Graham Consulting, Inc., Pittsburgh, Pa., and former director of engineering and construction, Allegheny County, Pa.



John F. Graham, Jr.



Jim Henderson

To submit a bridge project for the 2012 Prize Bridge Award competition, please visit **www.steelbridges.org**. All entries must be received by November 30, 2011. The 2012 Prize Bridge Award winners will be announced at the 2012 World Steel Bridge Symposium co-located with the NASCC: The Steel Conference in Dallas, Texas, April 18-21.

Bayonne Bridge
Bayonne, N.J.
1931 Prize Bridge Award Winner,
First Place — Class A

With rail traffic in mind, the bridge's chief designer, Othmar H. Ammann, began developing a scheme that spanned the Kill Van Kull with a single, innovative, arch-shaped truss. As with the suspension bridge scheme, Ammann worked on the arch design in partnership with architect Cass Gilbert. The arch bridge that emerged promised to be a remarkably efficient solution, well suited to the site from both an engineering and aesthetic standpoint.

Construction of the Bayonne Bridge began in September 1928. The projected date of completion was early 1932. Thanks to thoughtful planning, careful management, and ingenious construction technology, the $13-million bridge was completed in November 1931—several months ahead of schedule, and $3 million under budget.

Once constructed, the truss was the world's longest. To this day the truss stands as one of the world's most elegant arches, made of a sleek and modulated form of high-strength alloy steel.

The American Institute of Steel Construction selected the Bayonne Bridge as the most beautiful steel bridge to open to traffic in 1931. As Ammann said at the opening ceremony, "The Port Authority recognized the fact that its structures must not only be useful, but they must also conform to the aesthetic sense. This was one of the motives for the selection of an arch spanning the entire river in one sweeping graceful curve."

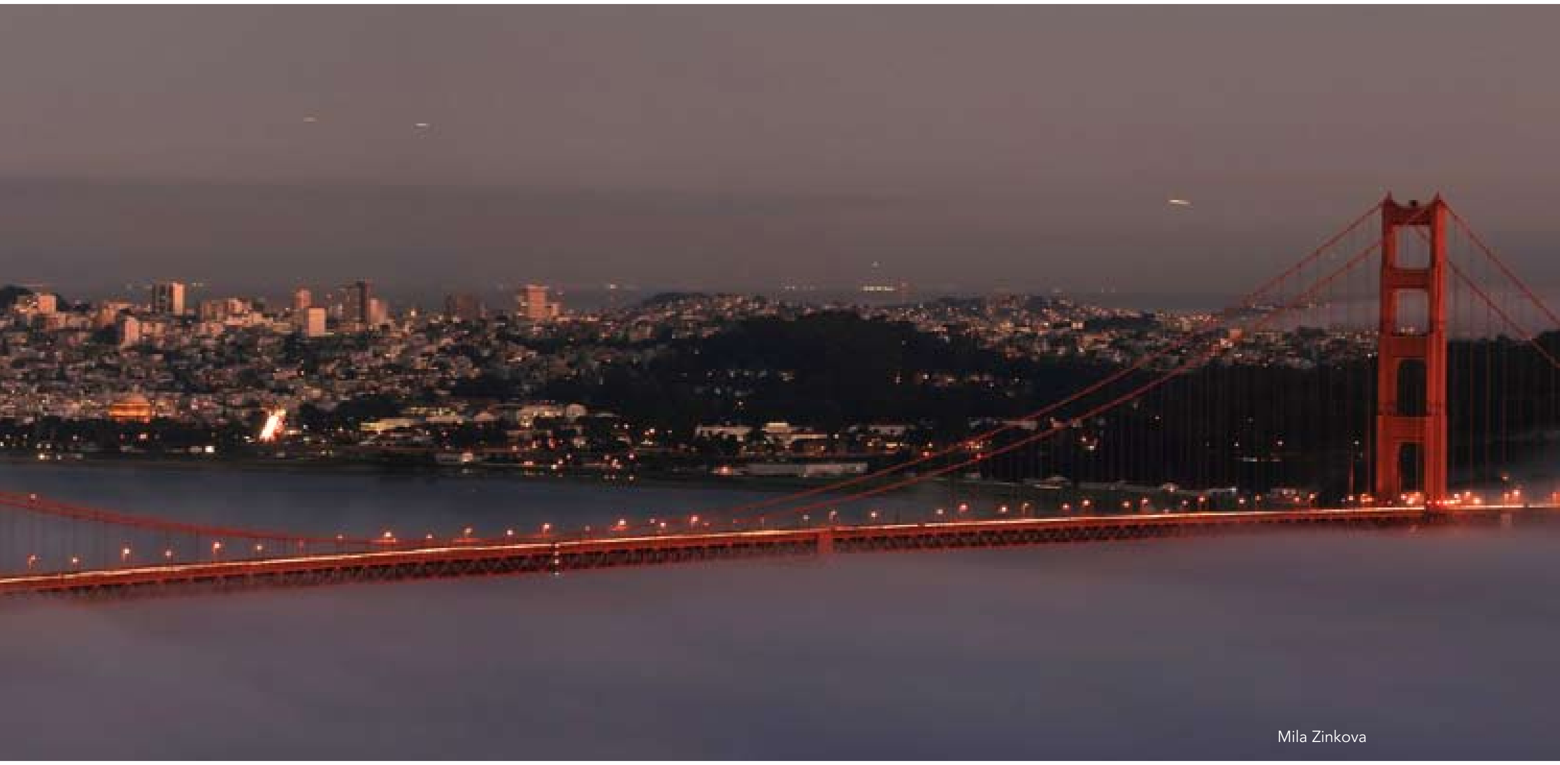
From "Bayonne Bridge: A Landmark by Land, Sea, and Air," by Darl Rastorfer, commissioned by the Port Authority of New York and New Jersey.

Larry Flynn

Golden Gate Bridge
San Francisco
1937 Prize Bridge Award Winner
First Place — Class A

The Golden Gate strait is the entrance to the San Francisco Bay from the Pacific Ocean. Approximately three-miles long by one-mile wide, it was named "Chrysopylae," or Golden Gate, by John C. Frémont circa 1846. An officer in the U.S. Army Corps of Topographical Engineers, Frémont later wrote that the strait reminded him of the harbor in Byzantium, which is now Istanbul, named Chrysoceras or Golden Horn.

In August 1919, city officials formally requested that San Francisco city engineer Michael M. O'Shaughnessy explore the possibility of building a bridge that crossed the Golden Gate Strait. O'Shaughnessy consulted with a number of engineers across the country about feasibility and cost of building a bridge across the strait. Most speculated that a bridge would cost more than $100 million and that one could not be built. But it was Joseph Baermann Strauss that came forward and said such a bridge was not only feasible, but convinced civic leaders that the bridge could be built for $25 to $30 million and could be paid for by toll revenues alone.



Mila Zinkova

The bridge ultimately was built out of necessity as population centers were growing and traffic congestion at the existing ferry docks was becoming intolerable. Upon its completion in 1937, the Golden Gate Bridge provided passage across the bay, on average, for 9,073 automobiles per day. After almost 75 years of service, its average daily traffic has increased almost 12 times, to nearly 107,000 daily users.

At 4,200-ft long, and with a vertical clearance of 220-ft at mid-span, the Golden Gate Bridge suspension span was considered the longest span in the world for 27 years until New York City's Verrazano Narrows Bridge took that title in 1964. The Golden Gate Bridge's main towers, suspended structure, anchorages, and approaches accounted for the 83,000 tons of structural steel used on the project.

Consulting architect Irving F. Morrow championed the art deco styling of the bridge by simplifying the pedestrian railings to modest, uniform posts placed far enough apart to allow motorists an unobstructed view. The light posts took on a lean, angled form. Wide, vertical ribbing was added on the horizontal tower bracing to accent the sun's light on the structure. The rectangular tower portals themselves decrease on ascent, further emphasizing the tower height. These architectural enhancements define the Golden Gate Bridge's art deco form, which is known and admired the world over. The Golden Gate Bridge has always been painted orange vermilion, dubbed "International Orange." Rejecting carbon black and steel gray, Morrow selected the color to blend well with the span's natural setting and also stand out in contrast to its frequently foggy atmospheric conditions. If the U.S. Navy had its way, the bridge might have been painted black with yellow stripes to assure greater visibility for passing ships.

The University of California Berkeley Library eloquently states, "The Golden Gate Bridge continues to astound and inspire. Some believe its soaring grace and sublime elegance enhance the beauty of its site as few man-made structures do. Considered an Art Deco sculpture and a symphony in steel, the bridge has always inspired artists, poets, writers, and filmmakers. It has also become a symbol for communication, for the portal to the Pacific—uniting America and Asia—and for San Francisco, its magical city by the bay."


Idaho Transportation Department

White Bird Canyon Bridge
White Bird, Idaho
1976 Prize Bridge Award Winner
Medium Span High Clearance

The graceful lines of the White Bird Canyon Bridge on Idaho's U.S. 95 belie the challenge presented in its construction. Begun in 1974, the bridge was the last link in a 10-year improvement effort to widen Idaho's primary north-south highway. When this section was opened, it eliminated 23 switchbacks in a seven-mile stretch that previously dropped the highway 3,000 ft from Camas Prairie into the Salmon River canyon.

Passing 205 ft above White Bird Creek, the bridge is 810-ft long and includes an imperceptible arch that is included more to compensate for thermal expansion than to impart strength. The steel structure consists of two parallel sets of 11 girder sections. The knee braces are fully boxed while the horizontal sections are open topped "bathtub" girders.

The steel was shipped cross country by rail, then trucked to the southern end of the project, which provided more working space than the canyon-enveloped north end.

—Will Hawkins and Mike Huntington. Huntington worked on the bridge and has documented its construction online at ***http://bit.ly/qRQX5n****.*

William Vann/EduPic

Roosevelt Lake Bridge
Roosevelt Lake, Ariz.
1991 Prize Bridge Award Winner, Long Span

The $21.3 million Roosevelt Lake Bridge was built to take traffic off the top of Roosevelt Dam. The longest two-lane, single-span, steel-arch bridge in North America, it spans 1,080 ft across Roosevelt Lake.

Prior to completion of the bridge in October 1990, traffic drove over the top of the dam on a roadway designed to allow two Model-T Fords to pass abreast. Today's recreational vehicles and full-size automobiles are too wide to permit two-way traffic on the dam, but the bridge provides that capability.

The Roosevelt Lake Bridge earned rare distinction when in November 1995 it was named one of the top 12 bridges in the nation. The American Consulting Engineers Council cited the bridge for overall design, size, eye-appeal and design challenge. Other bridges cited were the Golden Gate Bridge and Brooklyn Bridge.

Source: U.S. Department of the Interior, Bureau of Reclamation.

MSC Archives

Andrew Bossi

Woodrow Wilson Memorial Bridge
Washington, D.C.
2009 Prize Bridge Award Winner,
Special Award

The Woodrow Wilson Bridge is a project of national importance, located at a critical point on I-95 over the Potomac River connecting Maryland and Virginia just south of the nation's capital. The bridge is an integral part of a $2.6 billion corridor project that has eased congestion and shortened travel times for the more than 70 million travelers who use it every year and has allowed hundreds of billions in commerce to travel economically throughout the region. The bridge itself is a 1.1-mile-long, $650-million structure capable of carrying 12 lanes of traffic plus a hiker/biker facility. The bridge is also capable of carrying rail traffic if needed. The centerpiece of the bridge is its unique movable span which allows unrestricted maritime commerce on the river.

The Woodrow Wilson Bridge is one of the most significant achievements in bridge engineering in this country. As co-owners of the bridge, Maryland and Virginia are very proud of the technical achievements that the bridge represents, especially regarding its modern, state-of-the-art use of structural steel. Many of the challenges that the project faced were solved through the thoughtful and innovative application of modern steel technology. MSC

—Robert Healy, Rummel, Klepper & Kahl, Baltimore, and former deputy director, Maryland State Highway Authority.

Potomac Crossing Consultants

Funding for Steel Bridges

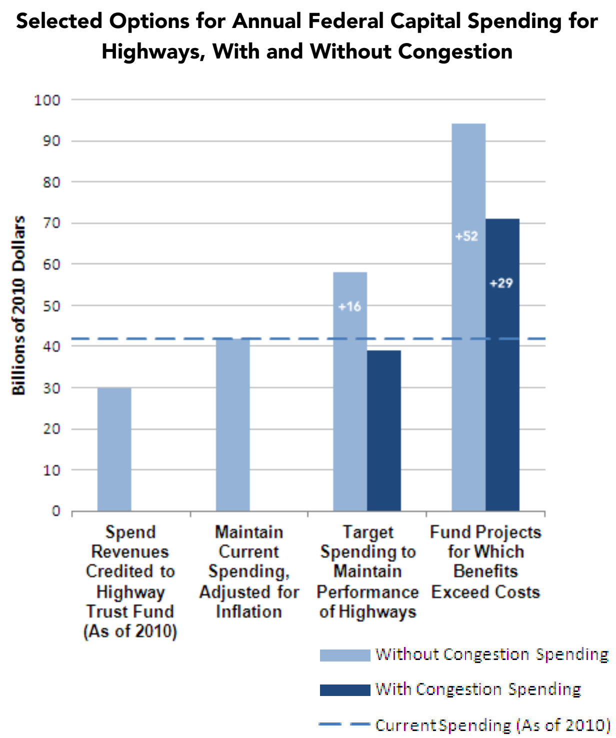
BY BRIAN RAFF

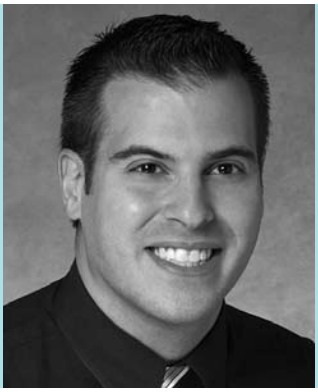
Although current infrastructure trends appear bleak, now is the time we all should be contacting our federal, state and local leaders.

IT IS ABUNDANTLY OBVIOUS to even the most casual observer that all of us in the United States have a mess on our hands regarding the deteriorating quality of the transportation infrastructure. Why are we in this mess to begin with? I wish we could blame the poor state of our nation's infrastructure on the current economy. Unfortunately, we're looking at a much longer-term, systemic problem. It has taken more than a few years to rack up a 25% share of structurally deficient and functionally obsolete bridges among our inventory of more than 604,000.

The majority of bridges in this country were built in the 1950s and 1960s, such that the average bridge in our current inventory is 43 years old. While material and coating technologies today suggest a bridge lifespan of almost 100 years, that wasn't the case 60 years ago. The majority of our nation's bridges are now reaching the end of their service lives at a time when money isn't available to repair or replace them.

Surprisingly, the percentage of deficient bridges (both structurally deficient and/or functionally obsolete) has decreased from 35% in 1992 to 25% in 2010. That figure, on the surface, makes it seem like we're headed in the right direction. In recent years, states like Oklahoma and Missouri have made tremendous strides to improve their inventories. However, while states have maintenance and rehabilitation programs to ensure their assets remain safe and remain in service, they constantly battle funding shortages, preventing them from addressing any critical infrastructure issues that may arise. Under better economic circumstances, funding was available, and states removed or replaced deficient bridges with new ones, automatically improving their deficiency percentages. With uncertainty looming over the details of the next transportation bill, one thing *is* certain: transportation investment levels will decrease, and some predict up to a 35% reduction in transportation-related investment in the first year under the new bill. This means it will be difficult, if not impossible, for federal, state, and local agencies to plan ahead. If states have no projects in their pipelines, designers, contractors, manufacturers, and construction workers as well as their local communities will all feel the negative impact of unemployment.





Brian Raff is the marketing director for the National Steel Bridge Alliance, Chicago. He can be contacted by sending email to raff@steelbridges.org.

How do we get ourselves out of this mess? The main solution to our transportation predicament boils down to funding. Congress passed a six-month extension to the nation's surface transportation program on September 15, 2011—the eighth such extension—authorizing $24.78 billion in spending from the Highway Trust Fund (at current funding levels) until March 31, 2012. While this Band-Aid solution keeps government employees working and allows the Highway Trust Fund to continue collecting revenues, we still find ourselves facing a significant funding shortfall to keep our roads and bridges in safe, working order.

How Much Should the Federal Government Spend on Highways?

On May 11, 2011, Joseph Kile, Assistant Director for Microeconomics for the Congressional Budget Office, submitted testimony before the Senate Committee on Finance about funding for highways and bridges. His testimony systematically lays out four options for future spending.

- ➤ Limit spending to the amount that is collected in current taxes on fuel and other transportation activities; doing so would result in spending that would be about $13 billion per year below the current amount.
- ➤ Maintain current capital spending, adjusted for inflation.
- ➤ Spend enough to maintain the current performance of the highway system; doing so would require about $14 billion per year more than current spending.
- ➤ Fund projects whose benefits exceed their costs; doing so would require even more spending than maintaining current services, up to about $50 billion more than current spending, depending on the degree to which benefits would be expected to exceed costs.

To put things into context, total federal spending on capital highway infrastructure projects in 2010 was $43 billion. Therefore, the federal government would need to spend $57 billion a year to maintain the current performance of the highway system, and would need to spend more than $93 billion a year to make significant improvements to our bridge inventory, more than doubling current federal spending.

To read Joseph Kile's full testimony, download it from the Congressional Budget Office at **http://1.usa.gov/p6tDrW**.

It is important to remember that only a portion of the federal surface transportation funding goes toward bridge work. Although the spending levels enabled by the current funding extension will keep the doors open, it won't even be enough to maintain the current inventory let alone improve it. As mentioned above, current proposals for a new highway bill are not looking to maintain current funding levels, but actually cut investment levels by up to 35%. That's why this is a critical time for action.

It's Time to Speak Up

From this point in time, we only have six months to give our representatives in Congress our most compelling and personal reasons why passing a robust, multiyear, surface transportation reauthorization bill is the best thing for our country and our industry.

Our industry must act immediately, presenting a unified, resounding voice to elected officials, educating them on the risks associated with inaction and under-investment in transportation and infrastructure. Perhaps the most telling analogy is the television commercial for oil filters—"Pay me now or pay me later." Delaying investment in bridge infrastructure today will result in significantly greater costs down the road in terms of both actual infrastructure costs and economic disruption.

AISC's Legislative Action page (**www.aisc.org/action**) is set up to help you and your colleagues reach out to elected officials with a tailored message, stressing the importance of a long-term, fully funded transportation bill. When you contact your Congressmen, they will also want to know how bridge construction will affect jobs, to which the response is both simple and compelling. You can tell them that a comprehensive 2010 report by ARTBA's economics and research team has quantified the enormous impacts of the transportation construction industry on the national and state economies. The study, "The U.S. Transportation Construction Industry Profile," shows that each year money invested in transportation construction industry employment and purchases generates more than $380 billion in U.S. economic activity—nearly 3% of the nation's Gross Domestic Product (GDP). That's larger than the annual GDP of 160 nations ranked by the International Monetary Fund, including oil-rich Saudi Arabia ($370 billion) and Kuwait ($111 billion). Clearly reauthorization of a strong transportation bill is a good investment in America.

We only have six months to influence the most important legislation affecting our industry and our lives. Don't wait; take action!

MSC

Breakdown of the U.S. National Bridge Inventory

	1992		2010		1992–2010
	Count	Percentage	Count	Percentage	Change
Structurally Deficient	118,736	20.7%	69,223	11.4%	–9.3%
Functionally Obsolete	80,436	14.0%	77,395	12.8%	–1.2%
Total Deficient	199,172	34.7%	146,618	24.2%	–10.5%
Total Inventory	**572,524**	**100%**	**604,426**	**100%**	**+5.6%**

The number of deficient bridges in the National Bridge Inventory actually has gone down since 1992. However, the problem is still significant, with 24.2% of the nation's bridges—146,618 of them—either structurally deficient or functionally obsolete.

How Massachusetts' I-93 Fast 14 accelerated bridge construction project used unitized construction to raise the bar for efficiency.

A Production Line Approach to Bridge Replacement

BY MICHAEL P. CULMO, P.E., JOSEPH GILL, P.E., SHOUKRY ELNAHAL, P.E., AND ALEXANDER K. BARDOW, P.E.

IN AUGUST 2010, the Massachusetts Department of Transportation (MassDOT) was in the process of performing remedial repairs to all of the bridge decks along I-93 in the City of Medford, Mass., when the seriousness of the project suddenly changed dramatically. A contractor had removed the wearing surface on several of the bridges in order to make the necessary deck repairs. One evening, a large pothole developed on the bridge over Route 28. The ensuing repair required the removal of significant amounts of deteriorated concrete, which resulted in a patch that grew to encompass a large portion of several lanes of the bridge. The repair took several days and the resulting traffic impacts affected the entire Metro Boston area.

Prior to the deck failure, MassDOT had already begun a feasibility study for the replacement of the bridge decks using accelerated bridge construction techniques. The plan was to replace the bridge decks in the summer of 2012 using prefabricated deck panels. The pothole that formed on the Route 28 overpass underscored the need to expedite the replacement project before similar potholes developed on other bridges.

The scope of the project involved all I-93 overpass bridges in the City of Medford, which totaled 14 bridges with 41 spans. The poor condition of the decks led MassDOT to decide to accelerate the design of the project and complete the construction in 2011. The goal was to complete the major portions of construction between June 1 and September 4, 2011. This decision was made in August 2010; therefore the design and construction had to be completed in approximately 12 months. The design/build (DB) method of contracting was chosen to expedite the process. A preliminary design was undertaken at the same time as the procurement process for the DB contract.

Project Approach and Traffic Management

CME Associates was selected to develop the project concept and 30% of the design plans, due in part to its experience with accelerated bridge construction techniques. CME worked very closely with the in-house design and construction staff at MassDOT in a collaborative effort to expedite the preliminary design.




Michael P. Culmo, P.E., is vice president for structures and transportation, CME Associates, Inc., East Hartford, Conn. Joseph Gill, P.E., is president and CEO of Gill Engineering Associates, Needham, Mass. Shoukry Elnahal, P.E., is MassDOT's deputy chief engineer for bridges and tunnels and Alexander K. Bardow, P.E., is MassDOT's director of bridges and structures.

➤ Rapid and efficient demolition was the first step in each bridge replacement.

➤ **Center:** The prefabricated bridge units (PBUs) developed by MassDOT can accommodate skews in both end-to-end and side-to-side applications.

Photos this page by CME Associates

The goal was to give the DB teams a workable set of drawings that could be used for the development of their proposals. This was necessary since the time frame from contractor selection to replacement of the first bridge was only four months.

I-93 is an eight-lane elevated expressway in Medford and carries approximately 180,000 vehicles per day. All but one of the bridges on I-93 carries the highway over local features such as city streets, state highways and the Mystic River. All of the bridges are steel stringer spans with concrete decks, and all but one are multiple-span structures. Early in the feasibility study process, a decision was made to replace the entire superstructures. This was due to a number of factors including the advanced deterioration of beam ends brought on by years of leaking deck joints.

Traffic management is always a major factor in accelerated bridge construction (ABC) projects. Additionally, the amount of time and space that can be provided to the contractor affects the potential options for ABC methods. Vanasse Hangen Brustlin (VHB) was brought in to develop the traffic management plan for the project due to their significant knowledge of the traffic patterns in the area. The company also worked in collaboration with the department's traffic engineering office to expedite the design.

The team investigated the possibility of an aggressive traffic management strategy that involved the full closure of one side of I-93 for an entire weekend, thereby giving a contractor full access to each bridge. The plan was to close two lanes of traffic in each direction and re-route the traffic to one side of the interstate via two crossovers. The counter-flow traffic would be separated by a movable temporary concrete barrier that

➤ From a design standpoint, parapet walls easily could have been included on the PBUs; however an alternate temporary barrier system allowed transporting the PBUs without the extra weight of the parapet wall concrete, since they could be cast later after the bridge was in place and open to traffic.

Designing the PBUs with Grade 50 weathering steel beams and an integral concrete deck, all assembled off site, kept the structure depth to a minimum and the weight low.

would be put into place on Friday night. In order for this plan to work, a significant portion of the weekend traffic would need to be detoured around the project site. Fortunately, the Boston metropolitan area has several belt highways (I-495 and Route 128) that could accommodate long-haul detour traffic. Local detours also were available that could accommodate overflow traffic.

MassDOT undertook an unprecedented public involvement program during the build-up to the start of construction. The department's goal was to inform every citizen in the Boston area prior to the start of construction. MassDOT named the project the "Fast 14" to simply and clearly describe the intent of the project to the traveling public and used all forms of media to get the word out. During construction, up-to-the-minute traffic message boards were used to provide accurate delay times that allowed travelers to make informed decisions on detours.

Bridge Design

One goal of the project was to salvage the bridge abutments and piers. An analysis of the substructures indicated that there was sufficient capacity to replace the existing steel stringer superstructures with structures of equal weight, but significant increases in structure weight were not possible. The vertical clearance was limited on many of the existing bridges, so a thin superstructure was required in order to increase the clearance as much as possible. Following a structure type study, the design team selected a modular steel bridge system—the ideal solution to these two constraints—consisting of Grade 50 weathering steel beams combined with a concrete deck that would be cast off site.

The units, which MassDOT named Prefabricated Bridge Units (PBU), were

Center: A 2-ft, 8-in. width was chosen for the closure pours connecting adjacent PBUs to reduce the width and weight of the units.

The 2-ft, 8-in.-wide closure pour between PBUs was made with high-early-strength concrete that achieved a compressive strength of 2,000 psi in four hours.

Photos this page by CME Associates

designed to allow side-to-side construction or end-to-end construction using conventional cranes. Similar techniques had been used by other state agencies on similar projects, which meant that the system was feasible. Through a detailed construction timeline analysis, the design team determined that using PBUs it was feasible to replace the largest bridge on the project, the four-span structure over Route 16, in 55 hours. In fact, the team determined that it was feasible to replace two multi-span structures in the same time frame.

The beams were designed as simple spans to eliminate the need for continuity connections in the field; however, the decks were designed as jointless using "link slab" technology, which involves casting a continuous deck over interior supports. The decks are purposely debonded from the beams near the support, which allows for end rotation of the beams without significant cracking in the deck. This technique has been used effectively in several states, including Massachusetts. The connection between the PBUs was a simple 2-ft, 8-in.-wide cast-in-place concrete closure pour made with high-early-strength concrete. The mix design required a compressive strength of 2,000 psi within four hours. The connection was designed with simple lapped reinforcing bars. The width of the pour was selected to reduce the width (and weight) of the units, which aided in the shipping and handling of the units during construction. Casting of the parapets prior to installation was allowed; however the weight of the parapets would most likely have exceeded the capacity of the cranes. In lieu of that, temporary barriers were designed to be placed in the shoulders of the roadway allowing for installation of the parapets after opening the bridges to traffic.

Construction

On January 19, 2011, the DB joint venture team of J.F. White and Kiewit Construction were identified as the best value team. MassDOT issued a Notice to Proceed on February 8, 2011. The team included the design firms of Tetratech, Gill Engineering, Dewberry and Lin Associates. With only four months to build the first bridge, the DB team decided to hold weekly meetings with MassDOT, FHWA and the preliminary design team to work through the final design and detailing. These collaborative meetings continued through the final design phase and into construction and proved vital in the successful deployment of this aggressive project. By having key decision makers involved, "over the shoulder" reviews were completed that helped keep the project on track.

Although the project includes 504 steel girders, the design team kept the detailing simple by using prismatic sections. Welded plate girders were used to minimize the structure thicknesses. Shop drawings were delivered to MassDOT in electronic format within days of the notice to proceed. Once fabricated, the steel was shipped to Jersey Precast Corporation, near Trenton, N.J., to have the decks cast on top of the PBUs.

Construction of the first bridge commenced on June 4, 2011. The contract documents provided a construction window of 13 weekends for the majority of the work. No construction was allowed on the July 4 holiday weekend and two weekends were set aside for inclement weather; therefore, the 14 superstructures had to be completed in only 10 of the 13 weekends. This required the replacement of multiple bridges on several of the weekends.

The first bridge, a three-span structure over Riverside Avenue, was completed ahead of schedule. The second weekend involved the replacement of two bridges—a total of six spans—at the Salem Street interchange. Those bridges were also completed ahead of schedule. The White/Kiewit team worked tirelessly throughout the summer, completing the 14 bridges in the first 10 available weekends. The last bridge was completed on August 14, 2011, three weeks ahead of the Labor Day holiday. All bridges were completed ahead of schedule, opening up the roadway for Monday morning commuter rush hour.

The Fast 14 program is an example of how steel girders can be used in accelerated bridge construction projects. The reduced weight and minimal structure thickness was advantageous for construction of bridges in an urban environment. The use of modular prefabricated bridge units allowed the contractor options for installation of the units based on the space available at each site. The system is adaptable for various span configurations and skews. MassDOT is looking to expand the use of PBUs on other projects throughout the state as part of its Accelerated Bridge Program.

One of the most significant aspects of the Fast 14 project was the collaboration and teamwork used to expedite the design and construction of this ambitious project in just 12 months. MassDOT made this project a priority and applied the personnel to make it happen. MSC

"Fast 14" Project Numbers

Bridges	14
Spans	41
Girders	504
Tons of steel	2,600
Replacement time	10 weekends

Additional information about this accelerated bridge construction project is available at **http://93fast14.dot.state.ma.us/**.

Owner
Massachusetts Department of Transportation

Concept and Preliminary Design Team
CME Associates, East Hartford, Conn.
Vanasse Hangen Brustlin, Inc., Watertown, Mass.
Nobis Engineering, Lowell, Mass.

Design/Build Team
J.F. White/Kiewit Joint Venture
Tetratech Corporation, Framingham, Mass.
Gill Engineering Associates, Inc., Needham, Mass.
Dewberry – Goodkind, Inc., Boston
Lin Associates, Inc., Brighton, Mass.

Steel Detailer
Structal – Bridges, Claremont, N.H. (AISC and NSBA Member)
Tensor Engineering Co., Indian Harbor Beach, Fla. (AISC Member)
Tenca Steel Detailing, Inc., Quebec City (AISC and NISD Member)
Candraft, Inc., New Westminster, British Columbia (AISC and NISD Member)

Steel Fabricators
Structal – Bridges, Claremont, N.H. (AISC and NSBA Member)
Griener Industries Inc., Mount Joy, Pa. (AISC and NSBA Member)
Michelman-Cancelliere IronWorks, Inc., Lehigh Valley, Pa. (AISC and NSBA Member)

One Question / Three Answers

Bridges: Design–Bid–Build?

ANSWERED BY M. MYINT LWIN, RAY MCCABE, P.E., AND MALCOLM THOMAS KERLEY, P.E.

Some important questions have complex answers and benefit from reflection and discussion. In this series designed to reflect that understanding, NSBA asks leading minds in the bridge community to weigh in on some of life's imponderables.

QUESTION: What is the fate of design-bid-build?

Answer: M. Myint Lwin
Director of the Office of Bridge Technology, Federal Highway Administration

Design-Bid-Build (DBB) has been the project delivery method used by state and local transportation agencies for highway construction projects for more than 50 years. The owner's design team, which includes in-house designers and consultants, prepares the plans and specifications in meeting the owner's design requirements. The construction methods are fully prescribed and described in detail. The plans and specifications for the project are prepared in such a complete way that any contractor could follow them and complete the project with a high degree of success.

Competitive bidding, with award typically made to the lowest responsive and responsible bidder, ensures that the owner is getting the lowest cost for the project. The owner assigns a construction project team to provide quality and quantity control and inspection of the contractor's work. The owner and contractor work together to comply with the provisions of the contract documents, and in accordance with the negotiated cost and time, with regard to changes in design and constructability. This is a major disadvantage of the DBB method, because changes during construction generally result in significant increase in the final cost and time of the project. The causes for the changes might be traced back to the design process that did not involve the knowledge and experience of the contractors or construction personnel. Based on the costly lessons learned, an owner now integrates the expertise of construction, inspection and maintenance personnel into the design process to ensure constructability, inspectability, and maintainability of the project.

Because of the deliberative process of the DBB method, a major project using this method generally takes longer than with other methods, such as Design-Build (DB) and Construction Manager/General Contractor. However, many key advantages remain in the DBB method, especially for smaller and medium-sized projects. A few of these advantages are:

1. The design is completely defined before the project is advertised for bids. The bidders submit bids based on a complete set of plans and specifications, and other exploratory and preliminary information the owner may have in support of the design.
2. DBB is a low-risk method for both the owner and the contractor.
3. The owner is provided opportunities to develop and maintain the technical expertise of the in-house professionals. Additionally, the owner may prepare plans and specifications for projects in anticipation of needs, and put them "on the shelf" ready for bidding.
4. New contractors and smaller, less-experienced firms will have opportunities to gain experience and prepare themselves for other methods of bidding.
5. Through construction partnering and working together instead of against each other, the owner, designers, inspectors, fabricators and contractor are improving communications toward shared project success in overcoming the disadvantages of DBB.

Building on the many years of progressive improvement of DBB based on experience and lessons learned, I expect the DBB method will be in use for another 50 years or more, especially for small and medium-sized projects. For major and complex projects, owner agencies will be exploring many alternate methods for shortening project delivery, incorporating innovative materials and techniques, improving quality, and achieving best values for the projects.

Answer: Ray McCabe, P.E.

National Director of Bridges and Tunnels, HNTB Corporation

Perhaps the best way to answer this question is to review the current trend of Design-Build (DB), which for this discussion includes P3's—Public Private Partnerships, which generally use design-build delivery. DB is clearly becoming an increasing share of the civil and building market. Over the last few years almost all of the large transportation projects have been, or are going to be, design-build and this trend is expected to continue and branch into medium and even small projects, although to a much smaller degree. The following factors support the trend toward design-build:

- DB has proven its ability to deliver even the most complex projects efficiently (ahead of schedule and below budget).
- More and more states are passing legislation allowing DB. I believe there are approximately 45 states that have some form of DB legislation.
- Owner organizations are diminishing in size and depth due to budget pressures on government. DB allows owners to manage large programs with fewer people by shifting responsibility (and risk) to the private sector.
- Contractors are more comfortable today in competing in a process where qualifications and project approach matter in addition to price.
- Contractors and engineers are gaining experience working together effectively and are producing increasingly positive results within their individual organizations and for owners.
- The large European firms coming to the U.S. bring extensive DB experience. This is how projects get delivered in the rest of the world.

Does this all mean the eventual end of design-bid-build? Definitely not. Design-bid-build has been a very successful delivery method and will continue to be the choice for small projects and for unusually complex/high-risk projects where the owner has a strong interest in remaining in control of the design and construction.

Answer: Malcolm Thomas Kerley, P.E.

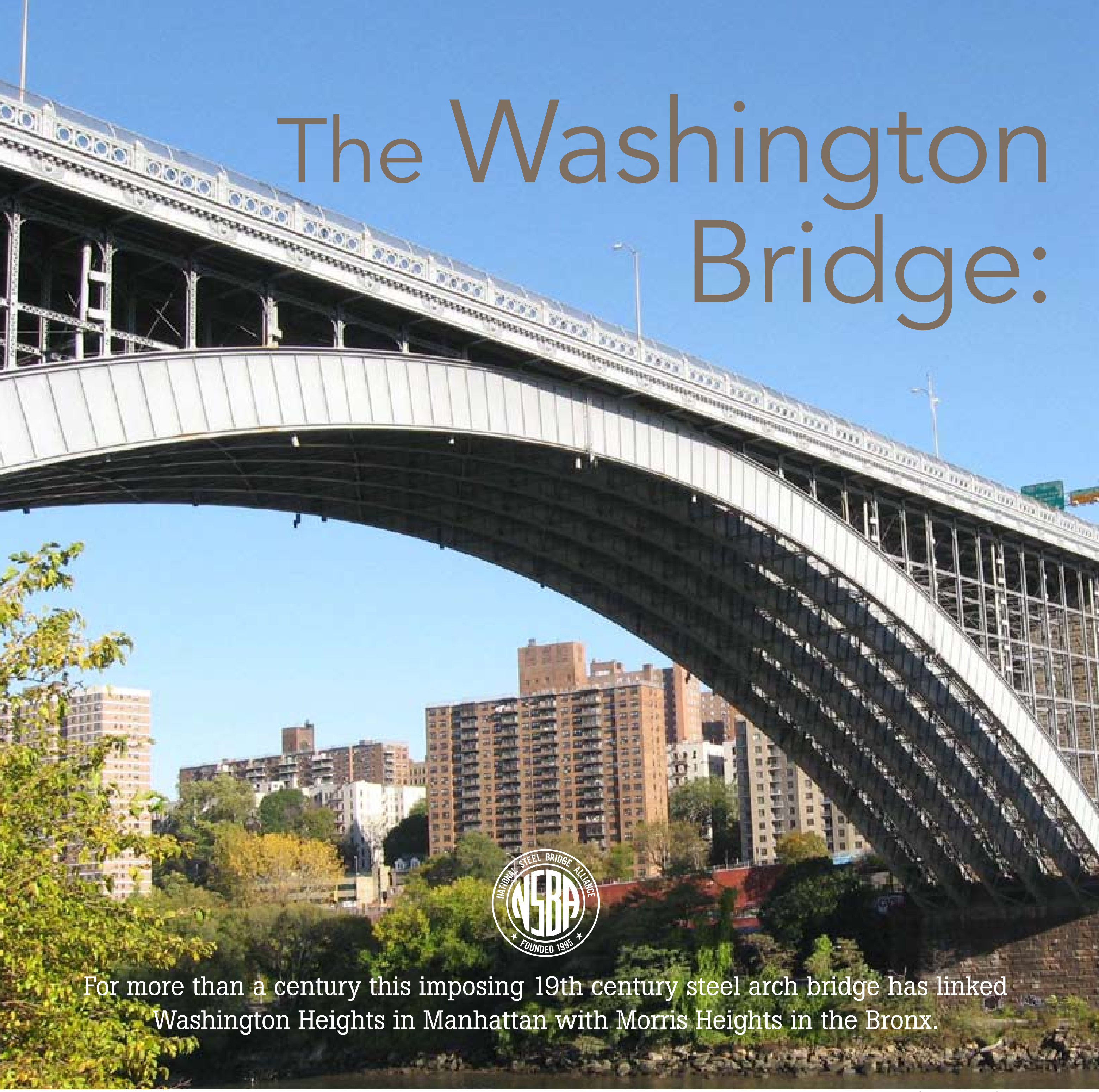
Chief Engineer, Virginia Department of Transportation

State DOTs have successfully used the Design-Bid-Build (DBB) procurement method for many years. With state DOTs downsizing, funding declining and transportation needs continuing to rise, they are looking for new ways to deliver projects faster and cheaper. As a result, the use of the Design Build (DB) procurement method as well as Public Private Partnerships (PPP) has increased. Most states need legislative action to allow these methods of procurement. Several states have passed legislation while others are still considering this change. For example, Virginia passed its Public Private Transportation Act to allow PPP in 1995 and DB legislation in the 2001.

What are the benefits of procuring projects using DB and PPP? These procurement methods provide states with fixed completion dates and costs based on the scope of the project, contract documents and risk transfer. Project risks are assigned to the party that can best manage them during project negotiations. PPP projects also allow for states to leverage their funds working with the private sector to bring non-traditional funding to finance projects.

So what is the fate of DBB? My crystal ball tells me that for the foreseeable future DBB will remain the main procurement method for state DOTs in terms of the number of projects. Many of the projects that state DOTs deal with are small improvement projects or rehabilitation projects to maintain their current systems. DBB projects allow state DOTs to maintain and train the staffs they need to manage their programs. Larger, more complex and financially challenging projects, where state DOTs are looking to reduce their risks and financial commitments, will use DB and PPP. Of course, there will be some large projects where DBB is used and some smaller projects using DB. The challenge for state DOTs is to ensure they deliver their projects effectively using the most appropriate procurement method allowed—DBB, BD or PPP. MSC

The Washington Bridge:



For more than a century this imposing 19th century steel arch bridge has linked Washington Heights in Manhattan with Morris Heights in the Bronx.

Photo: Jim Henderson

THE WASHINGTON BRIDGE is an imposing, beautiful structure, and especially interesting as a perfect example of the arched style of bridge architecture. Completed in 1889, it currently carries six lanes of traffic (plus 6-ft sidewalks on both sides) over the deep valley of the Harlem River. Sometimes confused with the George Washington Bridge on the west side of Manhattan, it connects the Washington Heights section of upper Manhattan to the Morris Heights section of the Bronx. Despite its Centurion status, about 50,000 vehicles a day cross the 2,375-ft-long Washington Bridge.

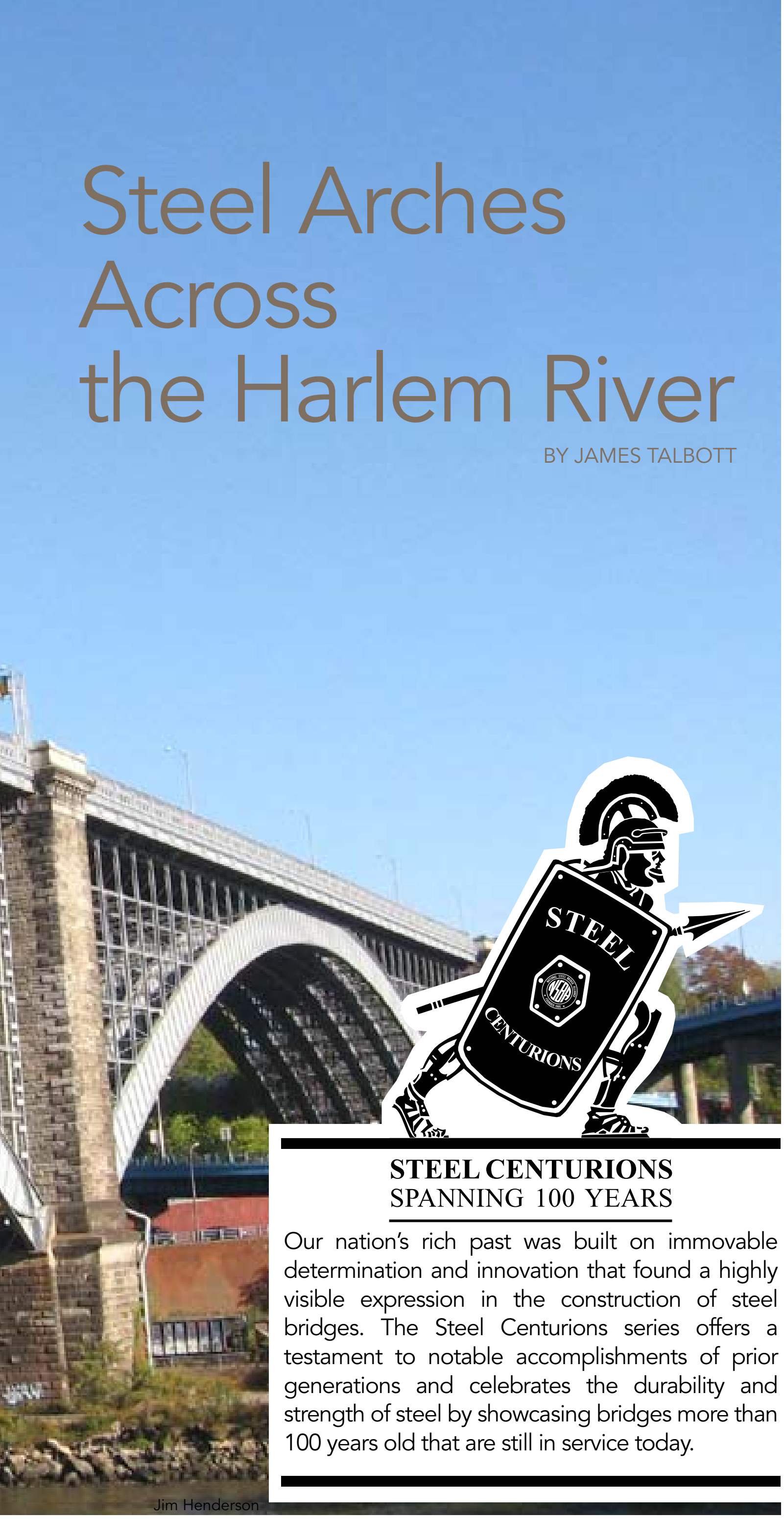
Manhattan Expansion

In the latter part of the 19th century, Manhattan's population was rapidly advancing northward. The city of New York absorbed the towns of Harlem, Yorkville, Manhattanville, Carmansville and others further up the island. The city then annexed a portion of Westchester County, beyond of its island limits.

New York City parks commissioner Andrew H. Green, an advocate of Greater New York, conceived of the idea for the Washington Bridge, originally called the Harlem River Bridge. Green believed that once housing and streets were laid out in Washington Heights, pressure would build for a link to carry traffic across the river between Manhattan and what later became known as

Steel Arches Across the Harlem River

BY JAMES TALBOTT



Jim Henderson

Looking up and across Harlem River Drive from near water level at the Washington Bridge.

STEEL CENTURIONS
SPANNING 100 YEARS

Our nation's rich past was built on immovable determination and innovation that found a highly visible expression in the construction of steel bridges. The Steel Centurions series offers a testament to notable accomplishments of prior generations and celebrates the durability and strength of steel by showcasing bridges more than 100 years old that are still in service today.

the Bronx. The Washington Bridge, along with the first subway connection across the river in 1904, persuaded many thousands of immigrants in Manhattan tenements to move to spacious new apartments in the Bronx.

Settling on a Design

The Board of Commissioners of Central Park conducted studies about the possibility of building a bridge across the Harlem River as early as 1868. In 1870 the city purchased land for this purpose at a site about 2,000 ft north of High Bridge, which is part of the Croton aqueduct across the river.

While several designs were considered, nothing further happened until 1885. That year, to kick-start the project, the mayor, comptroller and the president of the Board of Aldermen of New York City appointed three commissioners as the authority for bridge design and construction. They required that the new authority complete the bridge within three years. The authority organized a design contest for the new bridge.

The winning design for the arches by Charles Conrad Schneider was modified by William Rich Hutton and Edward H. Kendall to reduce costs. The main spans consist of two steel arches that each have 510 ft of clearance between piers. The main arch stretches over the river while the secondary arch crosses over railroad tracks and an expressway. The layout called for two 15-ft-wide walkways flanking the main roadway, bringing the total bridge width to 80 ft. A grassed mall graced the center of the carriage roadway between the opposing lanes.

Heavy balustrades of iron and bronze framed the sidewalks. An iron cornice and frieze covers the ends of the main floor-beams. The arches provided 134 ft of vertical clearance and 354 ft of horizontal clearance for marine navigation. The bridge opened to pedestrians in December of 1888 and to vehicles, which is to say carriages, about a year later. In 1906 it was opened to automobile traffic.

In April of 1886, the commissioners opened 10 proposals for earth and masonry work and five for metal work. All were rejected because the commissioners wanted the entire project let in one contract. After much wrangling, the commissioners in July signed a contract with the Passaic Rolling Mill Company and Myles Tierney to construct and complete the bridge according to preliminary plans for $2,055,000, of which $845,000 was for the metal work.

While the designs for the metal spans were relatively complete and acceptable, the commissioners considered those for the masonry and approaches only partly satisfactory. But 13 months of the three-year requirement for completion of the bridge had

Jim Talbot is a freelance technical writer living in Ambler, Pa.

The north side of the Washington Bridge with Manhattan in the background circa 1970.

elapsed, and the commission planned to modify them during construction. Work on the substructure commenced immediately.

Substructure

Excavations for the end piers began quickly in the summer of 1886. Solid rock occurred at or near the surface on both sides. The west side, for example, required only removal of the earth and shaping of the rock to receive the masonry.

The center pier, however, required the building of a caisson. The authority approved plans for the caisson in early September. Built in place, the timber caisson measured about 105 ft by 54 ft by 13 ft. The depth of bedrock below the caisson varied from 17 ft to 40 ft below the mean high water level. Sinking of the caisson began in mid-November. It reached its final depth of 40.6 ft below mean high water in April of 1887. By mid-July of that year the masonry for the center pier rose to the top of the skewbacks, 52.2 ft above mean high water.

Superstructure

Six steel ribs form each arch. The piers' granite-faced skewbacks backed by concrete resist the thrust and weight of the arch ribs. The main piers are 40-ft thick at the springing line of the steel arches and 98-ft long. They rise about 100 ft above the skewbacks to support the roadway. Three semicircular arches of masonry continue the roadway beyond each end pier, each having a 60-ft span.

The steel arches rise about 90 ft at crown. The steel rib webs are 13-ft deep and ⅜-in. thick with double flanges at top and bottom. Iron stiffeners are spaced at about 5-ft intervals. Each rib consists of 34 segments. Vertical steel posts that carry the roadway stand on top of the segment joints and are spaced at nearly 15 ft between centers. Lateral bracing connects the ribs on both top and bottom flanges; sway-bracing steadies the segment joints. All bracing consists of latticed beams and angles.

Flange-plates of the outer ribs are 20-in. wide, varying in thickness from 2 to 3 in. The flange plates of the inner ribs measure 12-in. wide and ¾-in. thick. Angle stiffeners at segment ends are riveted together to join the arch segments. Additionally, splice plates join the flanges.

Each rib rests at its ends on cylindrical pins of forged steel that are 34-in. long and 18 in. in diameter. The span between pin centers is about 509 ft. The pins lie in steel bearings carried on steel pedestals bolted to granite skewbacks.

The transverse floor-beams, spaced at about 15 ft, consist of plates and angles 2.5-ft deep under the roadway. The beams under the sidewalks are about 4-ft deep. Posts rise from the tops of the arch ribs to support the floor beams. The posts consist of two 10.5-in. iron channels latticed on the sides. The posts rigidly attach to the rib flanges, struts, and to the floor-beams. Pin-connected horizontal struts and diagonal ties brace the posts transversely.

The floor beams carry longitudinal stringers spaced about 3 ft between centers. The stringers are rolled I beams—15-in. deep under the roadway and 10.5-in. deep under the sidewalk. Steel plates that are 15 ft by 3 ft are riveted to the top of the stringers to form the flooring. The plates, called buckle plates, are slightly arched to increase rigidity. The entire flooring forms one rigid surface. While the floor is fixed to the arch at the middle of the span, it can slide at both ends on the masonry to compensate for contraction and expansion caused by changing temperatures.

Construction

The erection of the two spans took place between September 1887 and May 1888, employing about 200 workers. Travelers lifted the rib segments from trucks, setting them in place on falsework for bolting to adjacent segments. Lateral and sway bracing was then connected. Workers set the segments to a curve 3 in. higher at the crown to allow for the compression of the steel when supports were removed. The land span was completed first, then the travelers were removed and set up on the river span. Smaller hoists served to erect topworks for the land span.

Beginning at the crown, workers erected and braced the supporting posts, the transverse floor-beams, the longitudinal stringers and plate flooring. Then they filled all cracks and open joints with a cement of lead and iron filings. Drain holes were cut in all pockets where water could lodge. The final cost of the bridge was about $3 million.

The Bridge Today

During the late 1940s and early 1950s, the roadway deck was modified to accommodate increased vehicular traffic. The grassed center mall was removed to accommodate a 66-ft-wide roadway and the walkways reduced to 6-ft widths.

The bridge was added to the National Register of Historic Places in 1982. Over the years it has undergone extensive rehabilitation to ensure its structural integrity into the future. For example, in 1992 a $33 million project commenced to repair the bridge's deck, sidewalks, railing and supporting steel.

When the George Washington Bridge over the Hudson River was completed, in 1931, traffic coming off the bridge initially travelled into the Bronx over the Washington Bridge. The Alexander Hamilton Bridge over the Harlem River was built nearby to accommodate a second level added to the George Washington Bridge. When the Alexander Hamilton Bridge was completed, in 1963, it greatly relieved the heavy traffic levels carried by the Washington Bridge. Still, about 50,000 vehicles cross the Washington Bridge every day. MSC

Much of the information for this article is from The Washington Bridge over the Harlem River at 181st Street, New York City, *by William R. Hutton, published by Leo Von Rosenberg, New York, 1890.*

Wages (per day) on Construction of the Washington Bridge

Foreman (General)	$7.00 to $8.00
Foremen	$4.00
Masons	$3.50
Stonecutters	$3.50
Drillers	$2.00
Laborers	$1.75
Blacksmith	$2.50
Blacksmith helper	$2.00
Engine drivers	$2.50
Carpenters	$3.00
Foreman of painters	$2.50
Painters	$1.75
Carts	$3.00

A Day to Anticipate

BY TASHA WEISS

Begun in 2009 as a robust, grass roots-level effort, SteelDay has grown into a pre-eminent national event, earning its annual mark on the calendars of industry professionals throughout the U.S.

No Wheels on SteelDay?

For those who were unable to leave the office this year, AISC offered a live online presentation on "Practical Steel Metallurgy for the Structural Steel User," presented by Doug Rees-Evans of Steel Dynamics, Inc. It attracted a record-breaking webinar attendance with nearly 1,400 individual connections.

If you were out at an event or just couldn't make the webinar—don't fret! A recording of the presentation is now available for free online viewing on the AISC website at **http://bit.ly/oBAMej**.

Structural engineers, architects, fabricators and others in the steel construction industry will learn valuable information about the properties of steel and how they affect steel behavior. The presentation provides practical information on steel metallurgy and addresses common questions such as:

- Iron and Steel: What is the difference?
- How can a steel mill control chemistry? Isn't the chemistry dependent upon what scrap is used?
- Why are there multiple grades of steel?
- What is the basis of a Mill Test Report?

Registrants can download the presentation slides prior to viewing the webinar and will receive complete instructions for accessing the webinar on the AISC website at **http://bit.ly/o4QhwG.**

Upon completing the webinar, you can earn CEUs/PDHs by passing an online quiz available at no charge through the AISC Bookstore at **http://bit.ly/pPyMQb**.

IN SEPTEMBER 2009, if we were to ask you, "What are you doing for SteelDay?" you may have given us a puzzled, unknowing look—or thought it was just another gimmicky, themed "Day," ("Talk Like a Pirate Day," anyone?) purely intended to draw attention to ourselves. Fast forward to this year's event; we asked many of you that same familiar question and found your reaction to be quite different. In fact, you may already be looking forward to 2012.

SteelDay's "Have You Seen What We Do?" theme is not merely a rhetorical question. It is a literal call to action encouraging everyone within the steel industry and elsewhere to partake in a day of learning and interaction, and observe a process that so many of us read about but rarely see first-hand. AISC, its members and partners, have stepped up to the plate each year to offer valuable and fresh opportunities for all interested parties to see how the industry is building high-performance and sustainable projects, experiences that likely wouldn't have happened without this unique platform.

At Central Texas Iron Works in Waco, Texas, a group of more than 40 students learned about the fabrication process and 3D detailing software, which will help them tackle practical issues in steel construction. "These trips give our students a unique opportunity to see facilities and operations related to steel construction that they would not otherwise have a chance to see," said Michael Engelhardt, Ph.D., a professor at the University of Texas at Austin. "It enhances what they learn

Matthew Gomez, Gerdau

▲ SteelDay attendees get an up-close view of steel in construction at the First Baptist Church project site in Dallas.

in the classroom, and the up-close, hands-on experience they gain allows us to address a greater breadth of topics related to practical issues in steel construction."

And SteelDay proves to be just as an invaluable opportunity for experienced AEC professionals, such as Tom Kunsman with HWH Architects—Engineers, Cleveland. "At Steel Dynamics, a steel mill [in Indiana], this had been a first chance to visit a mill for one member of my group who had been an engineer for 30 years," Kunsman said. "For me, 17 years, also a first."

Sue Rasmussen, P.E., a senior design engineer with Siemens Industry, Inc., Waukesha, Wis., attended a facility tour of Independence Tube in Marseilles, Ill., "It's not often I get to see how the members I design with are made. As we walked through the stored bundles of tubes my coworker commented, 'Sure makes you want to build something.' To which I could only respond, 'yes!'"

Hosts and attendees alike have realized and reaped the mutual benefits that SteelDay provides, and it shows in its growth each year. More than 10,000 people attended nearly 200 free events across the U.S. on September 23 for the third annual event, drawing in thousands more attendees than in prior years with an increased variety of events—ranging from the very simple ("come on over and we'll give you a tour," or "learn more about this hot topic at our seminar") to the very complex ("we'll take you on a journey span ning the entire supply chain," or "let's explore this new job site"), and everything in between.

Matthew Gomez, Gerdau

▲ Attendees on a mobile tour of the Gerdau Midlothian Mill observe how steel is recycled and produced.

▼ Federal Highway Administrator, Victor Mendez, lends a hand to students from Howard University, participants in the 2011 AISC/ASCE Student Steel Bridge Competition. The students assembled and displayed their scaled steel bridge in a mock race against Virginia Tech as part of a pre-SteelDay transportation and engineering event at the U.S. Department of Transportation in Washington, D.C.

AISC

Tasha Weiss is AISC's public relations specialist and the associate editor of MSC.

"SteelDay's theme has truly been embraced," said Chris Moor, AISC director of industry initiatives. "The lure of witnessing the day-to-day capability of the steel industry seems to provoke an increasing curiosity from the construction industry. It's just such a great opportunity for the AEC community and others to see some amazing machinery and technology, network and ask questions without having to go very far and without having to spend any money—crucial in these times."

Not unlike SteelDay in the past two years, architects, engineers, contractors, university faculty and students, government officials, and the general public visited steel mills, fabricators, service centers, galvanizers, and other steel facilities to see the industry's latest innovations in action and learn directly from industry experts. Steel facilities throughout the country opened their doors for tours, demonstrations, presentations and other celebratory activities.

"I have thoroughly enjoyed every SteelDay and taken advantage of the special opportunity to meet our members and learn more about their capabilities," said Roger E. Ferch, P.E., AISC's president. "Its first year I joined the flagship celebration in Chicago at Millennium Park—a wonderful networking event that also honored downtown Chicago's great structural steel heritage. Last year, I ventured to North Carolina and spent the day with Buckner Companies, viewing their crane and fleet GPS demonstrations. And, finally, this year I traveled west to Salina, Kansas, and was one of hundreds of guests at the PKM Steel Service, Inc. celebration featuring many supplier booths and a tour of Valmont Coatings/Salina Galvanizing."

A New Approach

Inspired by the "Have You Seen What We Do?" theme, this year's events essentially took shape and individually grew into their own unique gatherings. Activities evolved and hosts put forth a concerted effort to reinvigorate their event experience for both new and returning guests.

For example, Gerdau Ameristeel has hosted an event every year since SteelDay's inception. The first two years, they were part of the North Texas Integrated Tour that took attendees through their Midlothian, Texas, mill and three other local steel facilities: a service center (Metals USA), a structural steel fabricator (Qualico Steel Company, Inc.), and a galvanizer (Sabre Galvanizing). This year, the company decided to provide a new perspective.

"Entering into our third year of SteelDay events, we believed it important to breathe some new life into our approach," said Matthew Gomez, S.E., P.E., national sales manager, construction solutions, Gerdau. "Our 2011 tours reflected comments from previous years' attendees and allowed us to showcase steel in construction, as opposed to 2009 and 2010, when we offered attendees an up-close look at the steel supply chain."

Attendees were guided through a tour of the Gerdau Midlothian Mill, where they witnessed how steel is recycled and produced. Following the plant tour, they visited the construction site of the First Baptist Church in Dallas, a $100 million steel project in downtown Dallas. The event included an educational presentation by the general contracting, architectural and engineering teams.

Attendee Diane DeSimone, Ph.D., University of North Texas, Denton, Texas, commented on the event, "I took several pictures of the site to share with the UNT students majoring in Construction Engineering Technology. This was a project that was exciting to see, and one I will be able to share with students for a long time."

Gomez added, "The combination of the steel mill tour with a notable construction project brought back some returning attendees, along with a strong showing of first-time participants. The feedback was positive, and has been each of the three years. It's an excellent opportunity to educate professionals and students on the merits of steel construction, and we'll continue to look for interesting and original methods of delivering this message."

A Day for All

In addition to connecting AEC professionals with structural steel representatives at facilities in their local area, SteelDay also has given rise to special events in major cities, engaging government officials and the general public who recognize the steel industry's contributions to the nation's architecture and economy; its continuing progress; and the dedication of everyone involved.

If you've hosted or attended a SteelDay event, you're probably familiar with the name Maria Blood, AISC's marketing coordinator and SteelDay co-organizer. During her tenure, she's attended two distinct SteelDay events in two different regions of the country.

"SteelDay in New York City proved to be a welcome networking and educational opportunity within the AEC community,"

"Old Techniques Grasping New Technology"

The Creative Side of SteelDay

SteelDay's "Have You Seen What We Do?" theme has also encouraged participation from the other side of the coin—show others what *you* can do creatively with steel.

This year AISC introduced a SteelDay Sculpture Competition for full and associate members to create and display their own innovative steel sculptures. Seven were entered in the contest and posted to SteelDay's Facebook page where fans voted on their favorites. Because of the impressiveness of the sculptures and positive feedback they received, all entries will be going to the 2012 NASCC: The Steel Conference in Dallas where the winner will be decided by conference attendees.

View all of the sculptures on SteelDay's Facebook page at **http://on.fb.me/uUrGws**.

Also in conjunction with SteelDay, AISC again sponsored a Student Photo Contest as one way to involve students in the industry's largest educational and networking event. The contest is designed for college and university students to capture photos that best pictorially celebrate the visual experience of steel.

This year's winning photo was taken by Krystal Brun, a senior civil engineering student at George Washington University, Washington, D.C. View her photo and all honorable mentions on AISC's website at **www.aisc.org/photocontest**. You'll also find the photos featured as Steel Shots on the *MSC* website, posted every Friday.

Blood said. "In its third consecutive year, SteelDay confirmed once again that there is a demand among construction industry professionals to learn more about the structural steel industry and their roles within it." Although New York experienced a rain downpour that prevented a scheduled construction site tour of the International Gem Tower, the weather failed to dampen the enthusiasm of attendees. More than 100 New Yorkers gathered at McGraw-Hill headquarters for a networking luncheon and panel discussion led by some of the city's most prominent members of the AEC community.

"The lively panel discussion included highlights of recent steel projects in New York and concluded with a question and answer session allowing attendees to interact with the panelists," Blood said. "As the SteelDay audience's discourse oscillated between steel projects of the past and future in New York, attendees at the more than 200 other SteelDay events across the country observed steel-making processes that would ultimately bring so many of the buildings in discussion to fruition. I reflected on my SteelDay experience a year earlier when I visited Gerdau's steel mill in Midlothian, Texas and had toured a steel mill for the first time. The palpable power of the steel-making process had left an impression on me and other attendees." Blood learned on that tour that many on the tour with her had been working with steel for decades, yet had never toured the inside of a steel mill or been exposed to the sights and sounds of the impressive process that results in the steel they use on a daily basis.

"Although my two SteelDay experiences differed in format," Blood said, "their functions were undeniably consistent. SteelDay has distinguished itself not only as a valuable educational tool within our industry, but as a fundamental demand within the design community as evidenced by the thousands of individuals who have participated in events across the country each year."

After participating in a steel erection rodeo last year at Davis Erection, a division of Topping Out, Inc., in Omaha, Neb., I was looking forward to a new experience in 2011. This year I attended a pre-SteelDay event on September 22 at the U.S. Department of Transportation in Washington, D.C., and watched student teams from Howard University and Virginia Tech, participants in the 2011 ASCE/AISC Student Steel Bridge Competition, demonstrate their engineering prowess through assembling and displaying their modular bridges in a mock race. FHWA Administrator Victor Mendez, ASCE president elect Andrew Hermann, Brian Raff from the National Steel Bridge Alliance (NSBA), and Lawrence Cavanaugh, president of the Steel Market Development Institute (SMDI) also spoke about the role of innovative technologies in bridge building. At the event, both student teams demonstrated the value of engineering education and training. Administrator Mendez said, "We certainly need all the bright, creative minds we can get to help build our 21st century transportation system, especially people who excel in science and math."

Have you seen what we do? Whether you spend SteelDay next September touring a steel mill or attending an educational presentation, we can guarantee you will answer that question in the affirmative. MSC

AISC

In Chicago, AISC hosted a special SteelDay event at the Thompson Center Plaza. Guests networked while exploring a pictorial display tracking the history of steel-framed construction. The evening prior, AISC welcomed local structural engineers into its headquarters to meet with staff and attend a special continuing education seminar by AISC vice president and chief structural engineer, Charlie Carter, S.E., P.E., Ph.D. Carter presented on the great structural engineering insights of the late Kurt Gustafson.

AISC

SteelDay 2012 is scheduled for Friday, September 28. For more information, visit www.steelday.org.

Visit a Mill at The Steel Conference

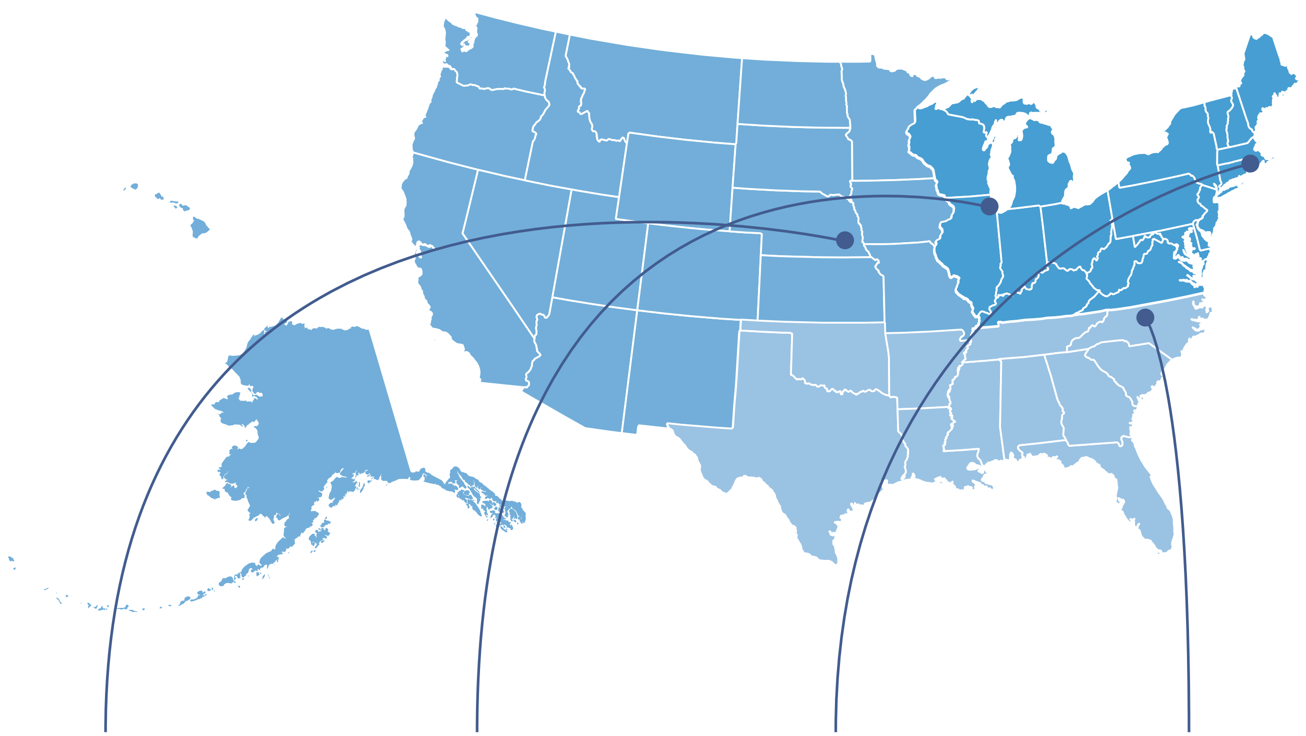
Didn't see a steel mill on SteelDay? Gerdau is providing a tour of its Midlothian, Texas, facility as part of the 2012 NASCC: The Steel Conference, April 18-20, in Dallas. Attendees will be bused from the Gaylord Texan Convention Center to the mill where they'll see the entire process of how steel is made—from mounds of scrap to charging the furnace to continuous casting. You'll witness quality control processes in action and develop an understanding of rolling schedules and steel availability.

There is no charge to attend this event. However, space is limited. Learn more at **www.aisc.org/nascc**.

Contact Us

NATIONAL STEEL BRIDGE ALLIANCE

a division of American Institute of Steel Construction



WEST

Calvin Schrage
NSBA Regional Director
Lincoln, NE
schrage@steelbridges.org
(402) 466-1007

NSBA HEADQUARTERS
1 E. Wacker Dr. Ste. 700
Chicago, IL 60601

Roger Ferch
Executive Director
ferch@steelbridges.org
(312) 670-5401

Brian Raff
Marketing Director
raff@steelbridges.org
(312) 670-5415

NORTHEAST

Bill McEleney
NSBA Director
Cranston, RI
mceleney@steelbridges.org
(401) 943-9660

SOUTHEAST

Christopher Garrell, P.E., LEED AP
NSBA Regional Director
Cary, NC
garrell@steelbridges.org
(484) 557-2949

American Institute of Steel Construction
One East Wacker Drive, Suite 700
Chicago, IL 60601

312.670.2400 www.aisc.org

National Steel Bridge Alliance
A division of American Institute of Steel Construction
One East Wacker Drive, Suite 700
Chicago, IL 60601

312.670.2400 www.steelbridges.org

Item NSBA-005