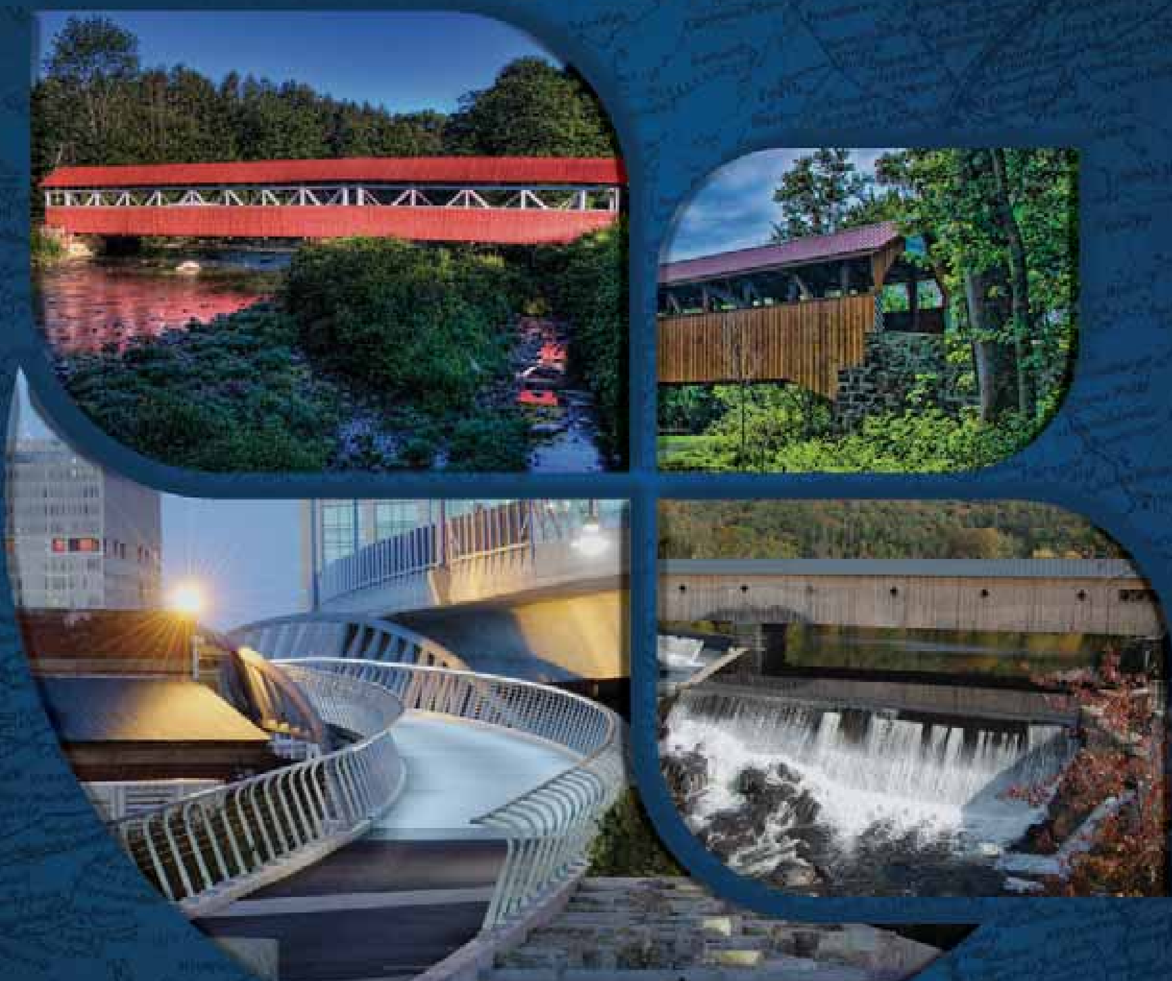
Pittsburgh ENGINEER

Summer 2013

Quarterly Publication of the Engineers' Society of Western Pennsylvania



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In this issue...

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From the Guest Editors

The Romance of New England & its Bridges

George M. Horas, P.E.

Thomas G. Leech, P.E., S.E.

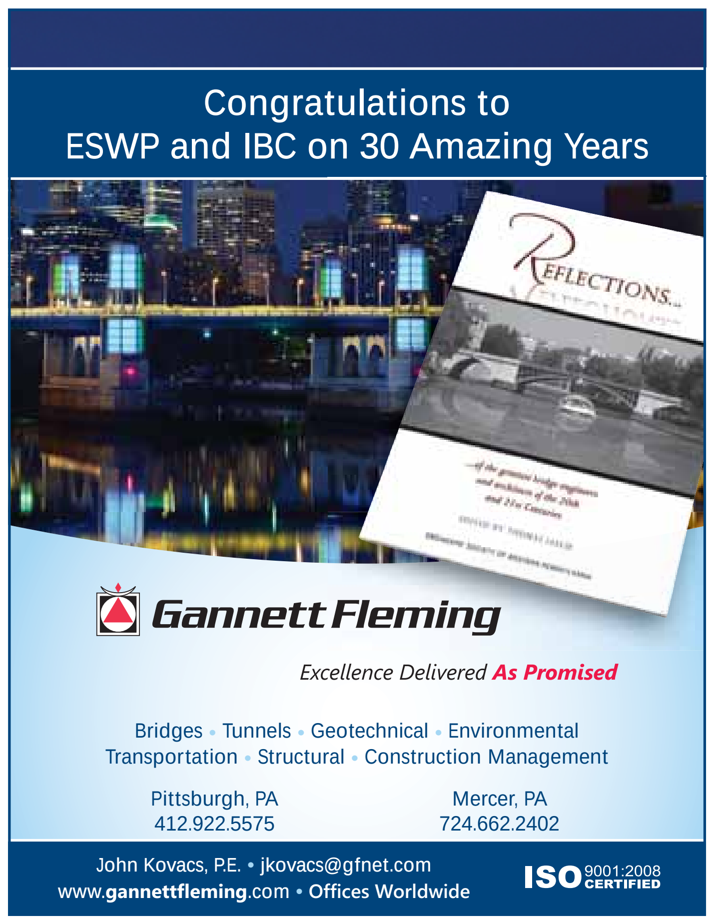
What do you think of, what comes to mind, when you say the words New England?

Is it 1776? Boston (Red Sox), The First Continental Congress, Cape Cod, the rugged Maine coast line, the rolling hills of Connecticut and Rhode Island, the fall foliage in Vermont & New Hampshire, covered bridges? Or is it all of these?

This special issue of the Pittsburgh Engineer is devoted to the bridges of New England. Through this issue we will acquaint (or reacquaint) you with many notable bridges throughout the states of Massachusetts, Maine, Connecticut, Rhode Island, Vermont and New Hampshire. Though our bridge quiz you will take a six state tour to see if you can identify various historic bridges and bridge types. Our feature articles start in downtown Boston, surveying two significant bridges along the Charles River and then travel to other southern locations in the state for innovative bridge solutions. After our tour of Massachusetts, our feature articles will travel to Maine for a project of engineering significance and then to Connecticut for a setting of historical and architectural significance. Finally our covered bridge photo contest will acquaint you with pleasant memories and nostalgia many of us have for the romance of the covered bridge era while traveling through New England and other parts of the country. Winter scenes, fall foliage and beautiful reflections abound.

This is the second year for our photo contest and by any measure it has been an outstanding success. IBC received over 160 entries – unbelievable in response and unbelievable in photographic quality. You may have never heard the names of Haverhill Bath, Sachs, Tohickon, Ashuelot, West Paden, Union, Corben, Flume, Stone Mountain, Sankey Park, Blair, Honeymoon, Yellow Creek, Academia/Pomeroy , Packsaddle/Doc Miler , Pioneer Road, State Park, Handcook/Greenfield, Barronvale, or Larwood, but now these names will leave you with strong visual impressions of classic & iconic structures in splendid natural settings with a new appreciation for many beautiful and scenic landscapes. We limited out search to the 20 most beautiful covered bridges – perhaps we have done a disservice in such a small limitation as all photos sent by interested photographers were indeed inspiring and worthy of consideration. IBC extends special thanks to all contributors to our photographic context and encourages all photographers and lovers of bridge photography to contribute in the coming years.

This year 2013, marks the 30th anniversary of the International Bridge Conference®. In celebration of this anniversary, The Engineers' Society of Western Pennsylvania is publishing a special book entitled *Reflections…* The book is a collection of essays from 21 bridge engineers and architects from eight countries and has been gathered in celebration of the 30th anniversary of the International Bridge Conference®. The spirit of the International Bridge Conference® is captured in the words of the many contributors to this book. Many of the contributing authors have been honored by receiving one or more of the awards bestowed by the conference. This book celebrates the achievements of these contributors and the bridge engineering community at large. The book is offered free to all who register for IBC 2013 and is available for purchase through ESWP. PE



BridgeQuiz:

Can You Identify These New England Bridges?

With this year's Magazine Quiz, we are asking you to match the bridge description in the left margin with the photo in the right margin – see if you can make a 100% match for all 12 bridges! All photographs of New England Bridges are courtesy of HAER, Library of Congress.

Question 1: My name is the Stanwich Road Bridge. I am located in Greenwich, Connecticut. I was constructed in 1937. I am one of the many rigid frame bridges crossing the Merritt Parkway. The distinctly unique architectural elements of me and my sister bridges were conceived by George L. Dunkelberger of the Connecticut Highways Department. These architectural elements which included experimental forming techniques were inspired by the Art Deco and Art Moderne styles of the 1930's. Can you identify my photograph?


Photo 1

Question 2: My name is the Main Street Bridge. I span the Israels River, a small tributary of the Connecticut River, in Lancaster, New Hampshire. I am one of 40, but the last remaining extant two span, cast in place, reinforced concrete spandrel, multi-rib arch bridge designed by the Daniel B. Lutton in the state. I was constructed in 1929. I am the sixth bridge at this location, preceded by two wooden bridges, one covered bridge, and two iron bridges. Natural disasters, mostly flooding, caused the destruction of my predecessors. Can you identify my photograph?


Photo 2

Question 3: My name is the Eagle Lake Bridge. I am a part of the Acadia National Park Road System and am located in Bar Harbor, Maine. My Gothic (pointed arch) features are only one of two such bridges within the National Park. I am the most visible of the 18 stone faced bridges built by John D. Rockefeller to restrict automobiles from using his carriage road system. I was designed by William Welles Bosworth, a graduate of the Ecole des Beaux Arts in Paris, France. I was built in 1927 and am now viewed by more park visitors than any other bridge in the park. Can you identify my photograph?


Photo 3

Q4: My name is the Taftsvile Bridge. I am located in Windsor Vermont. I was constructed in 1838. I am a two span bridge, 189 feet long, supported by a modified king post truss, supported by a semi-independent arch. I am not a patented bridge type but am a survivor of early craftsman tradition, possibly influenced by Swiss tradition at the time of my construction. My builder was Solomon Emmons III. Can you identify my photograph?

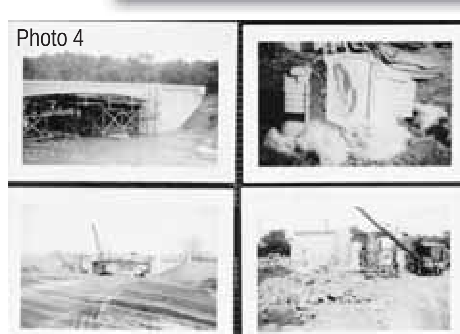


Photo 4

New England bridges have a certain charm and character. Many of the bridges illustrated in this quiz, were early proving grounds for bridge types whose styles were copied throughout the nation. Especially unique are the covered bridges. See the winners of the photographic contest on p. 33 to view some other interesting New England original displays of design and construction.

Some New England Truss Bridges

Question 5: My name is the Buzzards Bay Bridge. I am a vertical lift bridge located in Bourne, Massachusetts near Buzzards Bay. I carry railroad traffic (mostly waste and some excursion traffic) across the Cape Cod Canal, connecting Cape Cod with the rest of Massachusetts. While most lift bridges are kept down for land traffic to cross and lifted to allow boat traffic to pass under, I am one of only a few lift bridges in the United States kept in an up position and only lowered for the occasional land traffic. At the time of construction in 1935, I was the longest lift bridge in the world (with a 500 foot lift span). Can you identify my photograph?


Photo 5

Question 6: My name is the Mianus River Bridge. I was built in 1904, am located in Greenwich Connecticut and am a rolling lift moveable bridge. I, as well as eight other lift bridges on the system, carry AMTRACK, along the Northeast Railroad Corridor in Connecticut. Originally I was a part of the New York, New Haven and Hartford Railroad (commonly known as the New Haven - NH), which was a railroad that operated in the northeast United States from 1872 to 1968 which served the states of Connecticut, New York, Rhode Island, and Massachusetts. The HN's primary connections included Boston and New York. Can you identify my photograph?


Photo 6

Question 7: I am the Charles River Bridge. I carry the MBTA Commuter Rail traffic from the northern Boston Massachusetts suburbs across the Charles River into North Station (Fleet Center – Boston Garden). I am one of four double track, single leaf, rolling-lift, bascule bridges that were built in 1931, replacing the former steam driven, jackknife and swing bridge predecessors. Sadly only two of us remain. My span is approximately 90 feet in length and my counterweight weighs 629 tons. My lift mechanism is powered by an electric motor. Can you identify my photograph?


Photo 7

Question 8: I am the Court Street Bridge. Named in 1896 after the construction of the nearby court house, I span the Blackstone River in Woonsocket, Rhode Island. I was built in 1895 and am a Pratt Truss with pinned connections and stamped eyebars for diagonals and lower chord members, a rare example of a 19th century steel deck truss. As a Pratt Truss, all of my diagonals are subjected to tensile forces only. In many ways I am structurally deficient due to aging and deterioration and I will be eventually replaced. Can you identify my photograph?


Photo 8

Some New England Suspension Bridges

Question 9: I am the Boston Garden Public Garden Suspension Bridge, the little suspension bridge over the lagoon in Boston Commons. I am sometimes called the “World’s Smallest Suspension Bridge.” In 1837, Boston politician and philanthropist Horace Gray petitioned City Council to set aside part of the Boston Common for use as a botanical park; however, I was not built until forty years later. The Public Garden has since become one of the city’s most beloved landmarks, known in particular for its picturesque lagoon, with its famous swan boats, and of course me. Can you identify my photograph?


Photo 9

Question 10: I am the Waldo–Hancock Bridge , the first long-span suspension bridge erected in Maine, as well as the first permanent bridge across the Penobscot River below Bangor. I was designed by David Steinman. I was first suspension bridge to employ twisted wire strand cables, decreasing the number of field adjustments during construction. I was also, the first suspension bridge to make use of a Vierendeel truss in my two towers, giving me an effect that Steinman called “artistic, emphasizing horizontal and vertical lines.” I was retired from service in 2006 when the new Penobscot Narrows Bridge was opened nearby. Can you identify my photograph?


Photo 10

Question 11: I am the Deer Isle-Sedgwick Bridge, Spanning Eggemoggin Reach the Atlantic Ocean in Hancock County, Maine. With my main span more than 90 feet above the ocean, I replaced an old and inefficient ferry. I was also designed by David B. Steinman and my funding source was the Public Works Administration. Before my construction was finished in 1939 I experienced some unexpected wind-induced vibration and diagonal stays, running from my main cables to the girders at the towers, were added. In the winter of 1942-43, some of these stays broke during an unusual winter storm and stronger longitudinal and transverse stays were then added. Can you identify my photograph?


Photo 11

Question 12: I am the New Portland Suspension Bridge, Spanning the Carrabasset River, in Somerset County, Maine. I was constructed in 1886 and am the only remaining wire, roadway suspension bridge remaining that has not been in some way altered from my original construction tradition. What makes me truly unique are my 23 foot high, 12” x 12” (covered) timber towers, which remain to this day. My cables are made of very thin, 1/8” diameter parallel wires, which are wrapped with wire and painted. I am also quite narrow; at a 12 foot width, I am only allowed to carry two cars (traveling in the same direction) at any one time. Can you identify my photograph?


Photo 12

For additional information on the bridges of the Merritt Parkway and the Penobscot Bridge see the accompanying articles on pages 26 and 22. For answers to the quiz, turn this page sideways. ☞☞☞

Question	Photo
1	4
2	3
3	2
4	1
5	6
6	8
7	7
8	5
9	12
10	9
11	11
12	10

The North Bank Bridge: a Pedestrian & Bicycle Link along the Charles River

By David Greenwold, Simon Fryer, Karl Haglund, and Anthony Ricci

The intersection of the Charles River and Boston Harbor has for much of Boston's history been highly industrialized. Despite a century's worth of efforts to improve the rest of the Charles River basin, this area had come to be known as the Lost Half Mile. Thanks to the fulfillment of remediation commitments made by the Central Artery /Tunnel Project, the area is now a series of vibrant public spaces and provides the first ever pedestrian and bicycle link along the river between Cambridge and Charlestown.

The North Bank Bridge project in Boston and Cambridge, MA, was opened in July 2012. The project features a 700-foot long multi-use pedestrian bridge with a highly irregular three-dimensional geometry.

... the owner requested an elegant but quiet structure …

Conceptual design of the bridge was carried out as a collaboration of Ammann & Whitney, Buro Happold, and Julian Hakes. The owner requested an elegant but "quiet" structure that would not compete for attention with the Zakim Bridge, which frames the east edge of the site. The structure also had to address a multitude of geometric constraints, including an amphibious vehicle launch ramp, active commuter rail, and a historic building.

The team presented several concepts to the community and the owner. The preferred concept was dubbed the "sinusoidal bridge" because of its snaking, undulating form in plan and elevation. The bridge is composed of a steel truss that is positioned alternately below and above the deck level according to the site constraints.

At the west and east, approach embankments are provided to a height of approximately ten feet at either end of the alignment. The structure commences with a minimal depth as the trusses sweep below the deck in the approach spans. They then rise above the deck over the railroad so that the necessary clearance is achieved while minimizing the overall length of the structure. Through the transition, the trusses fold in close to the walkway, accommodating the narrow gap between the historic building

and the adjacent highway ramp. The alignment was set to allow for the re-use of drilled shafts left over from Central Artery temporary ramps.

Steel pipes were chosen for the truss as these sections were viewed as most readily bent to form the required complex curves. Above the railroad, a required protective mesh screen is tucked neatly within the elevated trusses.

With the basic outline of the structure set, Ammann & Whitney proceeded to final design. During the design process, a holistic and iterative approach was used in which the superstructure and substructure geometry and member cross sections were continuously updated and analyzed for clearances, global buckling, lateral vibrations, and member stresses, all while prioritizing the approved concept, the user experience, maintainability, and constructability.

The tubular steel trusses are made up of deck chords, the sweeping outer chords, and the verticals which are intermittently reinforced with diagonals. At each vertical, there is a floorbeam that supports a fiber-reinforced polymer (FRP) deck. With the use of bolted connections, the deck is made composite with the truss.

The final geometry of the seven-span continuous superstructure was determined parametrically. The horizontal alignment consists of a simple reverse curve and the vertical alignment is simply tangent, curve, tangent. The deck chords follow the centerline, and the outer chord geometry was determined iteratively. At each iteration, the geometry was evaluated geometrically, structurally, and aesthetically.

The algorithm behind the outer chord geometry is straightforward. A series of circular arcs were set in elevation relative to the centerline. Thus, given a longitudinal position along the centerline, the vertical location of the outer chord relative to the centerline was fixed. Similarly, a series of curves were defined in cross section. Thus, given a vertical location relative to the centerline, the horizontal location relative to the centerline was fixed. These cross-section locations were then radially applied to the three dimensional centerline to get a set of three-dimensional working points. All of the geometry calculations were performed with a simple spreadsheet, which allowed the geometry to be reconfigured simply by modifying the input parameters.

At each iteration, the working points were used to generate a solid model of the bridge, which was referenced into a three-dimensional survey of the site. This allowed for a quick check of clearances and aesthetic quality for a particular geometry. The working points were also used to generate the finite element model using Lusas software. The model was used to determine member forces and to examine lateral vibration characteristics and global stability.

Photo credit to Chuck Choi.

Consideration of pedestrian-induced vibrations required several iterations of truss geometry, truss member sizes, arrangement of truss diagonals, bearing layout, and substructure and foundation design. The vibration analysis also led to the use of the FRP deck. The high stiffness-to-weight ratio of FRP had a dramatic effect on the vibration behavior of the bridge.

At several locations along the bridge (most notably at the main span), the outer chord is in compression, and bracing against buckling is provided only by the truss verticals acting as cantilevers. Further, the compression chords follow a non-planar path. A full nonlinear buckling analysis was therefore carried out on the final structure and on assumed crane picks.

Fatigue at the joints was also studied in detail. For many of the joints, tables were used to determine the “hot spot” stresses. At the connections of the floorbeams to the deck chords, it was necessary to model the joint using finite elements.

Because the users of the bridge are in close contact with the structure and traveling slowly, the details were considered very carefully. For example, all butt welds were ground smooth and the multi-piece curb was carefully detailed to allow access for the various trades during construction and to present a pleasing appearance to users.

The railing was custom designed for the bridge. To minimize visual clutter, the posts are set out with the truss bays, leaning away from the user at the ultimate slope of the trusses. A horizontal infill of tensioned wires maximizes transparency, but creates a ladder effect which can be dangerous for children. A return at the top of the railing post simultaneously eliminates this ladder effect and presents the handrail back to the user. Lighting is unobtrusively provided by an LED light strip integrated into the handrail.

The project was put out to bid in 2007 and the bids unfortunately exceeded the available funds. In 2009, the project was bid again under the American Recovery and Reinvestment Act and came in under budget. With the successful award of the contract to Barletta Heavy Division, construction was under way.

The fabricator, Newport Industrial Fabrication, proposed a simple and effective method for fabricating the complex geometry of the truss chords. First, a non-uniform rational basis (NURB) spline was defined using the working points provided on the drawings. This spline was used as the reference geometry; it was then broken down into a series of segments, the lengths of which matched the length of pipe which could easily be procured. Each segment was then approximated by a planar element, consisting of discrete bends and tangents. Each planar element is connected to its neighboring element with a slight rotation about the principal axis such that the overall reference geometry is approximated with these planar elements to within a few sixteenths. To ensure that this would produce the required aesthetic standard, a three-dimensional solid model of the proposed finished geometry was created by the contractor for review and approval.

The steel superstructure was fabricated in a series of nine assemblies, most in the range of 70 to 90 feet. Adjacent assemblies were pre-assembled at the fabrication plant to verify geometry prior to shipping.

The bridge was designed such that the full 22-foot cross section could fit through all local marine obstructions, but the contractor chose to ship the panels by road. To make this possible, the design included an optional floorbeam splice. Once the assemblies had been erected, the full penetration butt welds between assemblies were made using a sliding backing ring detail.

The deck was originally designed as a pultruded deck product, but a vacuumed product was ultimately used. The vacuum process allows for significant flexibility in panel design, so Composite Advantage was able to match the properties of their deck to those of the product assumed in the design. The original curb detail was also based on the use of pultruded sections. The use

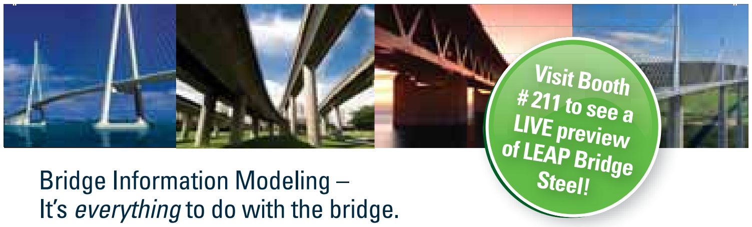
Photo credit to Chuck Choi

of a vacuum process allowed the Contractor and Engineer to collaboratively improve on the curb detail during the construction phase.

Ammann & Whitney's design partners in the project were Greenman-Pedersen, Inc., CRJA, and Stantec. The project was ably administered by MassDOT and the Massachusetts Department of Conservation and Recreation.

From the upstream side of the bridge, pedestrians and bikers move upward toward the tall towers of the cable-stayed Zakim Bridge and then come down directly under the ten elevated lanes of the big bridge and the massive concrete north tower. The reverse curve of the bridge alignment together with the geometry of the trusses – falling, rising, then falling again – offer a highly kinesthetic sense of motion to the pedestrians and bikers crossing the bridge. With planes taking off from Boston's nearby airport and the close proximity of the pedestrian bridge to cars, trains, and boats, the North Bank Bridge offers a striking and remarkable experience of the city. PE

David Greenwold, PE, is the Principal Engineer, of Ammann and Whitney. Simon Fryer, MICE, MIStructE, is the Associate Director of Infrastructure – Bridge Engineering, Buro Happold. Karl Haglund is the , Project Manager of the New Charles River Basin, Massachusetts Department of Conservation and Recreation. Anthony Ricci, PE, is a Structural Engineer with MassDOT, Boston, MA.



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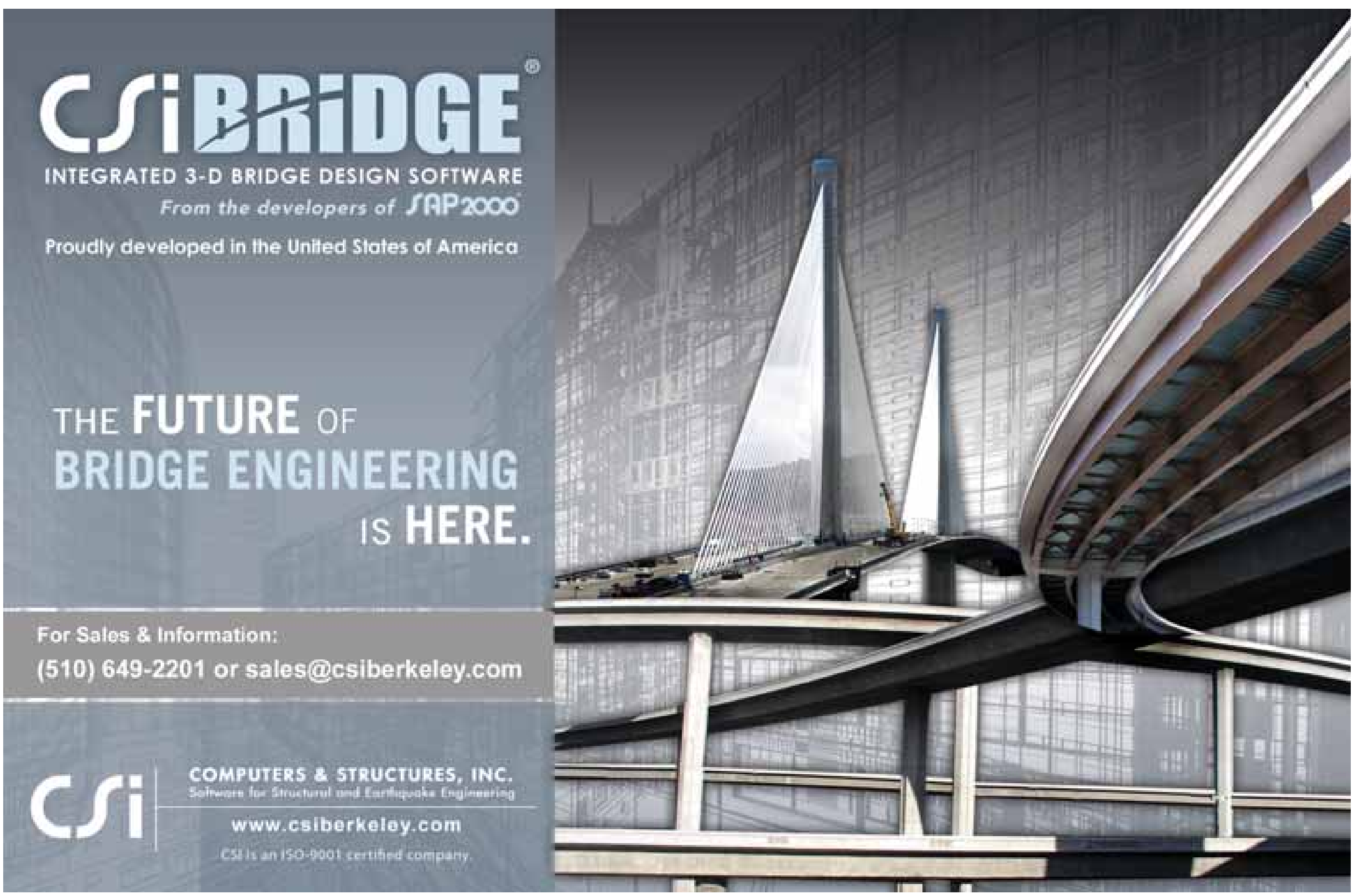

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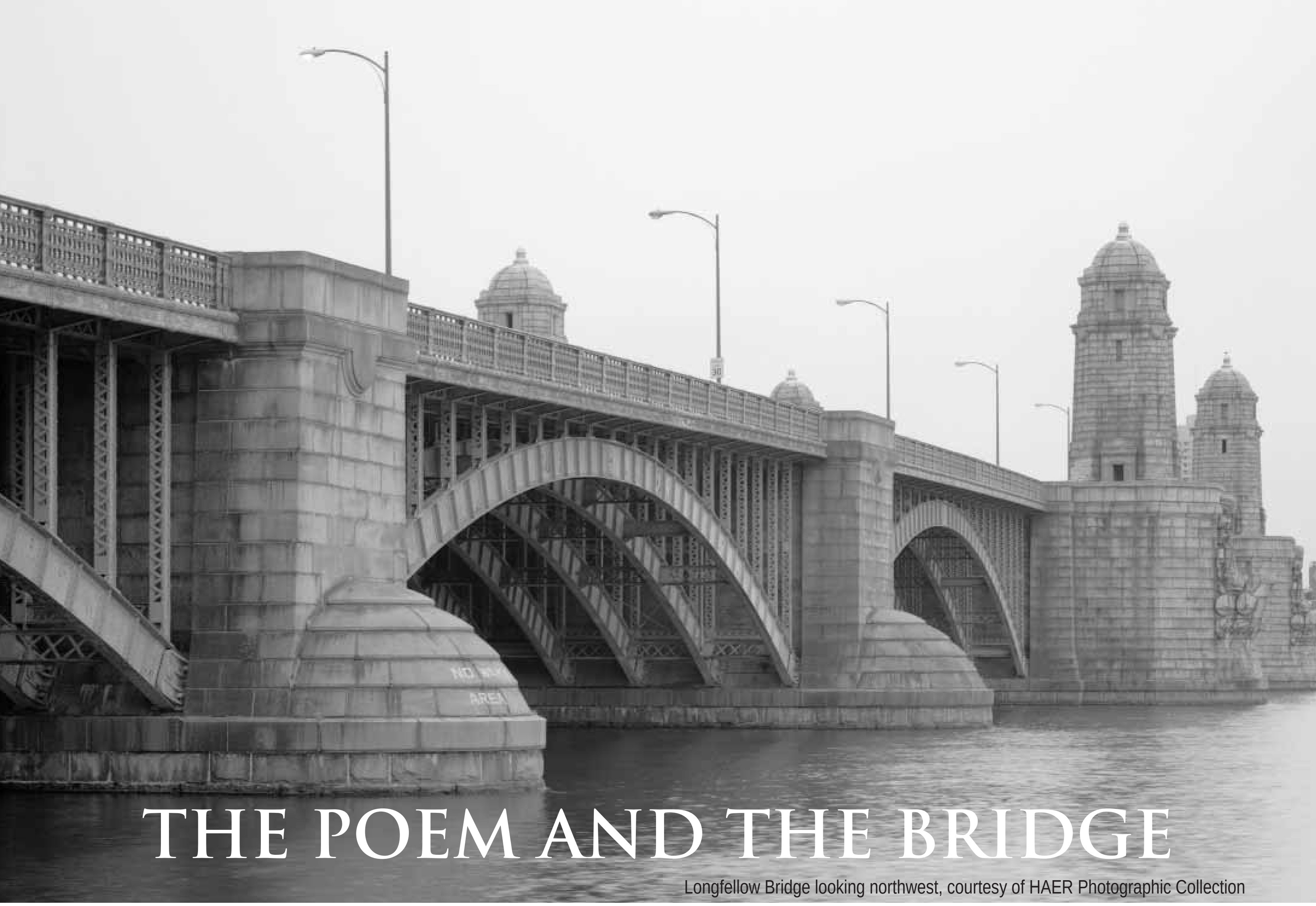

THE POEM AND THE BRIDGE

Longfellow Bridge looking northwest, courtesy of HAER Photographic Collection

By Thomas G. Leech

I stood on the bridge at midnight,
As the clocks were striking the hour,
And the moon rose o'er the city,
Behind the dark church-tower.

And so begins the words of the Poem entitled *The Bridge* by Henry Wadsworth Longfellow (from the book of poetry: The Belfry of Bruges and Other Poems). In the late evening in 1845, a thirty-eight year old Longfellow left his Cambridge Massachusetts residence, walked along Main Street, and heading eastward, ascended the bridge over the Charles River. From the deck of the wooden trestle Wadsworth, in a moment of solemn reflection, contemplated these words.

I saw her bright reflection
In the waters under me,
Like a golden goblet falling
And sinking into the sea.

And far in the hazy distance
Of that lovely night in June,
The blaze of the flaming furnace
Gleamed redder than the moon

The city of Boston that he looked upon to the east was quite different than the Boston of today. To the east, with moon rising he could make the outline of North Boston and perhaps the steeple of the Old North Church. To the southeast he would look up Beacon Hill ascending from the Commons and see the Massachusetts State House, declared several years later by Oliver Wendell Holmes, a noted American physician and author, to be the "hub of the universe." Longfellow would not have viewed the State House adorned with its characteristic gilded golden copper dome forged by Paul Revere, but instead a dome simply painted a dull stone gray. To the south there would be no thriving Back Bay community, just a wide expanse of tidal marshlands. Perhaps he could make out the silhouette of the recently built milldam, a toll road, the future extension of Beacon Street and at that time a narrow embankment built in these tidal marsh lands in an effort to capture and release tidal waters for hydroelectric power. The filling of the estuary behind the milldam would not begin for more than 10 years in the future and would take over 35 years to complete. Under his feet he could watch the ebb and flow of the tide. The tide would rise and fall in these waters for another 65 years, before the Charles River Dam was constructed, converting this tidal estuary into a fresh water basin.

Among the long, black rafters
The wavering shadows lay,
And the current that came from the ocean
Seemed to lift and bear them away;

As, sweeping and eddying through them,
Rose the belated tide,
And, streaming into the moonlight,
The seaweed floated wide. (text box)

Although Cambridge lay distance wise only one mile away from Boston, travel by land was lengthy requiring a circuit run around the Charles River estuary and entering Boston by the "neck", a narrow 120 foot wide strip of land well to the southwest of the city. The first river crossing at the eastern end of Main Street site was a ferry with service first recorded in 1630, the year the city of Cambridge was founded. The bridge upon which Longfellow was standing was built in 1793 with pine piles hand driven into the mud flats to create a wooden trestle bridge. The bridge, originally called the West Boston Bridge, had oils lights, a draw span and some relentless pine worms who, unbeknownst to Longfellow, were eating the bridge away underneath his feet as he contemplated his poem.

And like those waters rushing
Among the wooden piers,
A flood of thoughts came o'er me
That filled my eyes with tears.

How often, oh, how often,
In the days that had gone by,
I had stood on that bridge at midnight
And gazed on that wave and sky!

What Longfellow could not see coming was a grand steel and stone structure, replacing his pine worn trestle, that would inexorably link the cities of Boston and Cambridge and for years to come would define the character of the Charles River. Longfellow's wooden trestle was rebuilt in 1858; however, this second wooden trestle structure was short lived. Although sited for horse drawn trolleys, the bridge was too narrow to permit both trolleys and horse draw carriages and ill-considered for the coming electrified "rapid" transit system that was making a nationwide debut in Boston in the 1890's.

How often, oh, how often,
I had wished that the ebbing tide
Would bear me away on its bosom
O'er the ocean wild and wide!

For my heart was hot and restless,
And my life was full of care,
And the burden laid upon me
Seemed greater than I could bear.

The 1890's were an exciting time in the city of Boston. In response to the grid-lock, created by a pre-revolutionary war street pattern and a busting density of horse-drawn wagons, electric streetcars and pedestrians, the world's fifth and the country's first subway was constructed for a one and one-half mile distance under Tremont Street in 1895. (Tremont and Beacon Streets lie at the eastern and western borders of Boston Commons, respectively.) By 1898 the need to extend the underground subway from the city of Boston to the city of Cambridge became evident and was the catalyst for the construction of a new bridge across the Charles River. In June of 1898, bridge commissioners comprising the mayors of the cities of Boston and Cambridge appointed William Jackson, Chief Engineer and appointed Edmund M. Wheelwright as Consulting Architect. At that time all bridges in the region were pile bridges and were considered "unsightly" and generally not suitable for electrified trolleys. With a look to the future, both gentlemen were immediately dispatched to Europe to make a survey of notable bridges constructed in steel and stone which could serve as design models for a new bridge across the Charles River. One year later legislation was enacted for the construction of a new bridge paid for by both cities and the newly formed Boston Elevated Railway Company.

But now it has fallen from me,
It is buried in the sea;
And only the sorrow of others
Throws its shadow over me.

Yet whenever I cross the river
On its bridge with wooden piers,
Like the odor of brine from the ocean
Comes the thought of other years.

The new bridge, to be called the Cambridge Bridge, was originally conceived as a series of arched steel approach spans and stone foundations flanking back to back dual mid-river drawspans. This concept was the result of an exhaustive two year study considering various alternatives of masonry and steel structures based on the European studies. The War Department (predecessor to the Army Corps of Engineers) insisted on a draw span structure, not strictly for general navigational purposes but in consideration of the movement of the navy and the defense of the city. As this design progressed, a unified concept developed that included a single massive stone tower at mid-river adjacent to the two draw spans, one draw span for upstream and the second draw span for downstream river traffic. This massive stone tower was detailed to skillfully hide the rotating mechanisms of both draw spans.

And I think how many thousands
Of care-encumbered men,
Each bearing his burden of sorrow,
Have crossed the bridge since then.

I see the long procession
Still passing to and fro,
The young heart hot and restless,
And the old subdued and slow!

With one of the financiers of the project being the Boston Elevated Railway Company, a bridge solution with draw spans containing an overhead catenary line became untenable. After much consternation between the city governments and the War Department, the United States Congress enacted special legislation to build a "draw-less" bridge. The legislation was signed by President McKinley in March 1900, only 18 months before his untimely death. Quickly a new design concept was borne that included two signature architectural elements. Firstly, a long vertical crest profile was defined to optimize clearance of the main span over the tidal waters of the Charles River. And secondly and more important architecturally, the previously envisioned single

stone tower of the central span (initially conceived as an adroit means of hiding the lifting machinery) was modified to become two distinctive stone towers symmetrically flanking the main river span. This duality has led to the popular nickname of the “salt and pepper shaker” bridge due to the distinctive shape of the towers. Additionally the towers were fitted with sculptured motifs of Viking ships alluding to a supposed Viking navigator entering the Charles River in discovery of America.

And forever and forever,
As long as the river flows,
As long as the heart has passions,
As long as life has woes;

The moon and its broken reflection
And its shadows shall appear,
As the symbol of love in heaven,
And its wavering image here.

In 1906 the Cambridge Bridge was opened to both electrified railway, carriage and foot traffic. In 1927, the Cambridge Bridge was renamed as the Longfellow Bridge by the Massachusetts General Court in honor of Henry Wadsworth Longfellow, who contemplated the poem The Bridge while standing on the old West Boston Bridge. And after more than one hundred since its conception, the bridge remains an architectural heritage and an icon of the Charles River.

*For a detailed history of the construction of the present Longfellow Bridge, with the most interesting construction photos, see the Cambridge Bridge Commission Report – Construction of the Cambridge Bridge, 1909. The 363 page report can be viewed on-line (and downloaded in pdf) at http://openlibrary.org/books/OL7015322M/Report_of_the_Cambridge_bridge_commission_and_report_of_the_chief_engineer_upon_the_construction_of_*

Thomas G. Leech is the National Practice Bridge Manager of Gannett Fleming, Inc. and a member of the International Bridge Conference® Executive Committee.

The DCR Access Road Bridge over Route 24

Winner of 2011 PCI Design Award and Voted "Best Non-highway Bridge" by Aspire Magazine

By Matt Card and Thomas Cyran

The new precast concrete channel bridge (bottom photo) and the original steel I-girder bridge (top photo) and are shown for comparison. The new channel bridge provides nearly 2 ft of additional clearance over the original bridge without increasing the roadway profile on the bridge.

This project involved the replacement of Bridge R-01-012 which carries the Department of Conservation and Recreation (DCR) Access Road over Route 24 in the Town of Randolph, Massachusetts. The access road connects two large parcel of park land within Blue Hill Reservation that is divided by Route 24. The bridge is primarily used by recreational hikers, horseback traffic and DCR maintenance vehicles. This bridge reconstruction project was administered by the MassDOT – Highway Division and was completed in the Fall of 2010 at a cost of $3.9 million.

Randolph, Massachusetts is located 15 miles south of Boston, The town was originally called Cochaticquom by the Cochato and Ponkapoaq tribes. The town was renamed after Peyton Randolph, first president of the Continental Congress.

The I-girders of the original steel bridge were removed and then reused as temporary erection beams to support the precast concrete channel segments during erection.

The original bridge, built in 1958, consisted of a 247-ft-long, four-span steel I-girder bridge supporting a 7.5-in concrete deck slab and asphalt wearing surface. The substructure featured two concrete stub-type abutments supported on steel piles and three reinforced-concrete piers supported on spread footings.

Partly due to its low 13'-9" vertical clearance over Route 24, the existing bridge had become structurally deficient. In fact, the steel I-girders had repeatedly been hit by trucks driving below on Route 24 and had been torn through in numerous areas due to hit damage. Officials at the MassDOT – Highway Division wanted to increase the vertical clearance without having to perform extensive roadway work either underneath the bridge or at the access road approaches. Raising the profile of the approach roads beyond the abutments was not an option, as they transition to heavily wood areas and hiking trails within the park. The hiking trails were also used as horse paths that accommodate horse-rental farms nearby. MassDOT officials also wanted to create a design that would blend with the scenic surroundings, minimize disturbance to the surrounding woodlands and minimize long-term maintenance needs.

To reach those goals, MassDOT engineers selected the precast concrete "channel" bridge concept with post-tensioned, segmental construction. In addition to meeting the immediate goals, the new bridge provides long-term durability through a minimum service life of 75 years. The channel cross-section features a precast concrete superstructure with an unusual U-shaped design that provides a very shallow structure depth (12") from the bridge deck and it's underside. The section consists of two edge beams that function as the main load-carrying elements, with the roadway slab supported between them. The two edge beams serve the dual purpose of acting as bridge parapets as well.

The new DCR Bridge is a 248-ft-long, two-span continuous precast segmental concrete structure that increases the vertical clearance over Route 24 to 16'5", adding more than 2 ft. to the clearance provided by the previous steel stringer bridge. The substructure consists of two new reinforced concrete stub-type abutments supported on steel piles and a new center pier consisting of two 59-in.-diameter reinforced-concrete columns supported on a common concrete spread footing. Utilizing only a center pier, the DCR Bridge eliminates the need for side piers along the edge of the northbound and southbound roadways. This provides added safety for highway users, and also reduces material cost and construction time.

The new superstructure is 29.7 ft wide and 5.38 ft deep. The precast concrete edge beams are fully post-tensioned using a mix of 12-, 15-, and 19-strand tendons. Additional longitudinal tendons are provided in the deck slab, using flat 4-strand tendons. Transversely, the structure is fully post-tensioned using flat 4-strand tendons. All reinforcing steel consists of epoxy-coated bar.

The 8.2-ft-long U-shaped segments feature a flange on the top of both sides that temporarily supported the precast segments on steel erection beams.

Alfred Benesch & Company (formerly Purcell Associates) served as the Engineer of Record on the project and designed the substructure elements. The firm subcontracted the superstructure design to International Bridge Technologies (IBT), which has experience with the channel concept. It was originally created and patented by the innovative bridge engineer Jean Muller, whose firm designed two such bridges in upstate New York in the 1990s and others in Europe. Daniel Tassin, IBT's chief technical director, worked with Muller for many years.

Unistress Corp. served as the precaster for the project. They purchased forms that were specifically designed for the channel cross section and then shipped them to their precast yard, for assembly and casting. R. Zoppo Corp. served as general contractor, with Finley Engineering Group Inc. performing construction-engineering services.

Minimizing waste and remaining environmentally aware were project goals and resulted in an innovative reuse of materials. The steel I-girders of the existing bridge were re-used to fabricate erection beams, thus serving as the temporary shoring needed while the segments were being erected. Upon completion of segment erection and subsequent grouting and post-tensioning, the steel I-girders were removed and recycled for reuse. The existing bridge piles were retained where possible and supplemented with new ones set between the existing ones. To minimize excavation needs along the highway, the center pier's footing was retained. The contractor removed the existing material to the top of footing and simply poured the new concrete on top of the existing footing.

A total of 31 precast concrete channel segments were cast for the project. Typical segments were 8.2-ft long, with the abutment segments being 5.1-ft long. In order to avoid deflection issues resulting from unequal weight distribution, all of the segments were placed onto the erection beams prior to their actual assembly. Then, groups of 2 to 4 segments were assembled together incrementally using post-tensioning bars, starting from the center of the bridge and moving towards the abutments in a balanced sequence. Each group of segments was assembled in a one-day shift. Once all of the segments were assembled together, the permanent post-tensioning was stressed in the edge beams and deck slab, and the temporary steel shoring was removed.

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

Timber guard railing and posts were added within the project limits at all four corners of the bridge for traffic safety. The guardrail has a special steel backing for added strength and safety.

Owners, contractors and engineers are constantly looking for ways to build structures that provide longer durability, a faster speed of construction and pleasing aesthetics. The channel design provides a new alternative for achieving these goals. The channel design provides a sleek, low-profile appearance that provides functional clearance benefits while keeping it unobtrusive in scenic areas. Best of all, it minimizes long-term maintenance needs that will improve safety of construction crews and users while reducing costs over its service life. PE

Underside view of completed bridge.

Matt Card is a Project Manager at Alfred Benesch & Company in Boston, and Thomas Cyran is a Bridge Engineer with International Bridge Technologies in San Diego.

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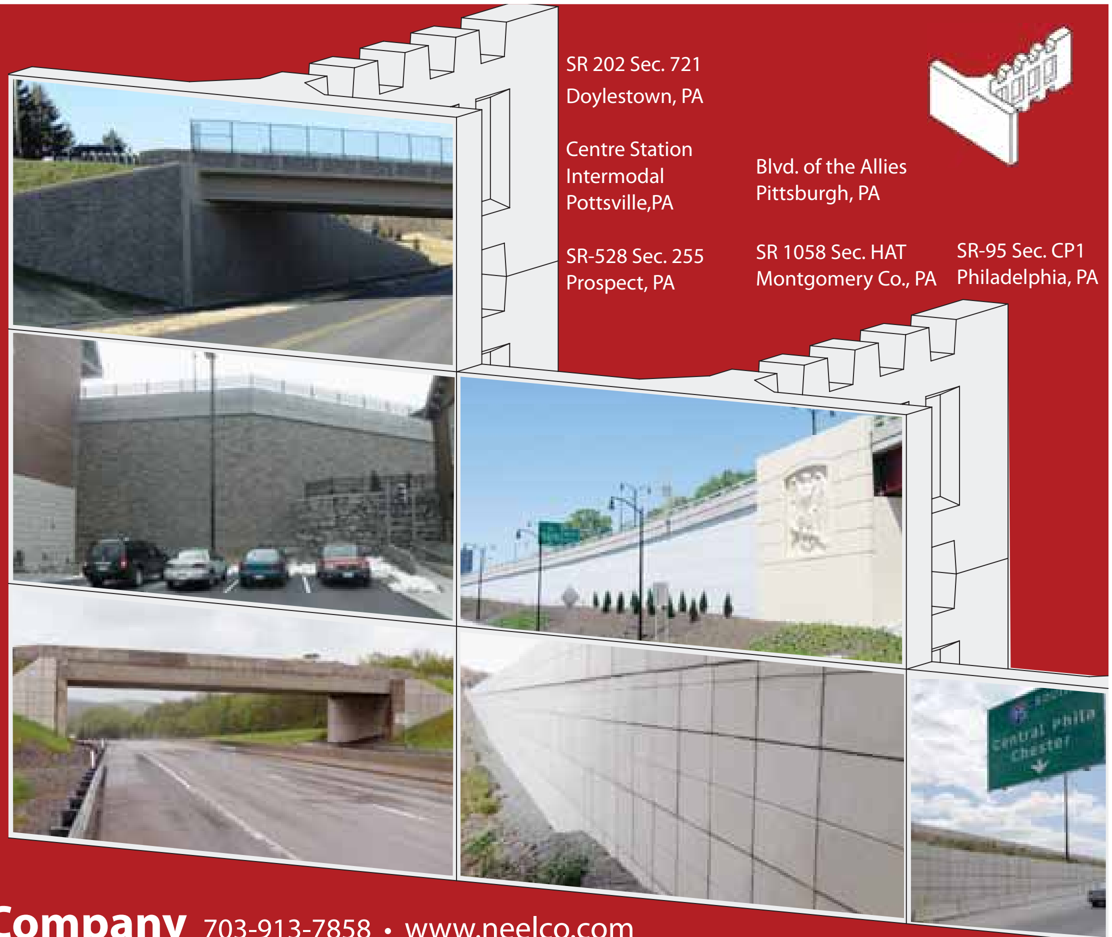

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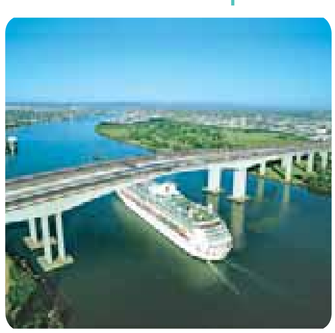
A continuum of exemplary bridge design

Lewisville Lake Toll Bridge
Texas | 2009



Sir Leo Hielscher Bridges
Australia | 2010

Peace Bridge
Northern Ireland | 2011

Charles W. Cullen Bridge
Delaware | 2012

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A New Steel Solution for Short Span ABC Bridge Replacements in Massachusetts

By: Thomas G. Zink, P.E.

The Massachusetts Department of Transportation (MassDOT) has proven once again that innovative thinking and the willingness to incorporate new technologies into a bridge program can lead to the successful acceleration of a bridge replacement project.

As an industry leader in the use of Accelerated Bridge Construction (ABC) technology, MassDOT chose to replace a small bridge carrying River Road over Ironstone Brook in the Town of Uxbridge, Worcester County with a folded steel plate girder structure. The first application of its kind, folded steel plate girders are fabricated from a single steel plate of uniform thickness that is then bent along multiple lines using a hydraulic metal press break to form an inverted tub shaped section. A patented system applicable for spans up to 60-ft in length, this type of fabrication eliminates costly details and processes that have made steel alternatives less competitive than other materials for short span bridges. The need for welding is significantly reduced, and the stability of the resulting girder shape eliminates the need for both internal and external cross framing.

Photo 1: Former bridge supporting River Road over Ironstone Brook.

Uxbridge, is a town in south central Massachusetts, 40 miles south west of Boston, near the Rhode Island border which was first settled in 1662, incorporated in 1727, and named for the Earl of Uxbridge in England. The town's motto is "Weaving a Tapestry of Early America". This harkens to the textile industry which developed in the early 1800's along the lines of the Rhode Island System, a labor and production model characterized by hydro driven textile mills, family employment including children as young as age 7, company homes, company stores and Sunday school education where the children learned to read and write.

The former two span bridge was constructed in 1900 and reconstructed in 1930. It consisted of an 18 inch deep reinforced concrete slab supported by stone masonry gravity abutments and a reinforced concrete wall pier located in the waterway. Located on an urban local off-system roadway with an ADT of approximately 3,300 vehicles, the bridge carried two lanes of traffic with no shoulders and measured approximately 26'-9" in total width and approximately 32-ft in length. The former bridge railing consisted of guiderail supported by steel pipe posts bolted to the concrete slab. The profile within the project vicinity is relatively flat, and the roadway crosses the waterway with no skew. Based on previous inspections, the substructure was determined to be in "serious" condition due to the deterioration of the mortar surrounding the abutment masonry. Combined with its substandard geometry and safety features, MassDOT decided that a full structure replacement was in order.

In March of 2009, Gannett Fleming, Inc. was selected by MassDOT to serve as the consulting engineer of record for the replacement structure. During preliminary design, it was determined that the new bridge would be constructed wider to accommodate a 12-ft lane and 4-ft shoulder in each direction. It was also determined that the new bridge would consist of a single span with substructures placed behind the masonry abutments to minimize disturbance to the waterway. The new structure would therefore be approximately 50-ft in length and 35-ft in width and provide a 42-ft wide hydraulic opening between the new abutments. In addition, the limited space on site would necessitate the complete closure of the roadway throughout the duration of construction, resulting in a 4.5 mile detour. It was therefore decided that the proposed structure type would need to be compatible with current Accelerated Bridge Construction (ABC) practices to minimize the duration of the detour.

Several alternatives were investigated as part of the Mass-DOT Type Study Selection process, including adjacent precast concrete box beams, steel multi-stringers, and a concrete arch frame. However, the characteristics present at this particular site were also compatible with an experimental system developed by the University of Nebraska-Lincoln consisting of folded steel plate girders. In November of 2009, MassDOT decided to utilize this project as a pilot for such construction, and Highway Bridge Services, LLC of Lincoln, Nebraska was brought on board to perform the design of the girders and provide assistance to Gannett Fleming for the inclusion of details and specifications into the bid documents.

Photo 2: Erection of a prefabricated superstructure module.

To accelerate construction, the design utilized four (4) 50-ft long, 24" deep folded steel plate girders, each prefabricated with a 6.5" deep, 4 ksi concrete deck section attached using 3/4" diameter end welded shear studs. Each beam utilized a single 0.50" thick, 50 ksi steel plate measuring 50-ft in length and 106" in width. These dimensions were critical to ensure that the multiple bends could be made using a standard press break. After bending them to the required shape, a minimal number of welded components were then attached to the beams, including end plates, sole plates, and headed shear studs. Four bolted flange separator plates were also attached to the bottom of each girder to help maintain shape, and the entire beam was galvanized. The decks were then cast in a precast shop with the beams oriented in an upright position with falsework supporting the cantilevers. The shipping width of each interior superstructure module measured 10'-2" including headed rebars protruding 11" from each edge of the precast slab. Each exterior module was 8'-7" in width including a single edge of protruding rebar and an integral concrete curb cast along the exterior slab edge.

To further accelerate construction, the replacement bridge also incorporated precast concrete integral abutments. Each abutment consisted of four match-cast precast concrete wall sections with a 2-ft diameter void formed at the base for installation over a steel H-pile. The design also called for the use of a modular retaining wall system for the wingwalls. Formliners were specified for the exposed faces of the new substructure components in an effort to replicate the masonry patterns of the former bridge.

The bid documents were developed for this $1.7 M project which also included approximately 600-ft of roadway reconstruction in the approaches necessary to accommodate a slight alignment shift caused by the widened bridge section. The design was completed in July of 2010, and the construction contract was awarded to the John Rocchio Corporation of Smithfield, Rhode Island in October of the same year.

With the detour in place, the former bridge was demolished and the steel H-piles were installed for each of the proposed abutments. The piles were set in 2.5-ft diameter augured holes that included a 5-ft long embedment into rock. The piles were anchored to the rock using concrete, and the remainder of the void surrounding the piles was filled with crushed stone. The piles were set to template with a small (1") plan tolerance. This was necessary to ensure proper alignment with the formed pile voids at the base of each precast concrete wall panel. Four wall panels, each measuring 8'-10" wide and 4'-0" thick, were placed over the piles at each abutment location. The panels were then locked together using sixteen (16) 1" diameter bars set into transverse post tensioning ducts. Once tensioned, the ducts and anchorage block-outs were grouted, and the pile voids were filled with a 4 ksi self-consolidating concrete through metal fill sleeves cast into the wall panels. This allowed the contractor to gravity feed the anchorage concrete from the bridge seats. The contractor then installed a T-Wall type modular retaining wall system that served as the bridges wingwalls.

The four superstructure modules were delivered to the site on October 7, 2011 and erected using a 240 ton Liebherr Model LTM 1200 boom crane. Since the approach fill had not yet been placed, the crane could be positioned behind one of the new abutments without imposing any significant lateral pressure on the substructure. The superstructure modules were delivered to the site one at a time, allowing the crane to pick and place the modules with no more than a 90° swing. All four superstructure modules were delivered and erected in a single day.

Work continued by backfilling the abutments and placing embankment material while completing the T-Wall installation. The superstructure modules were then locked together using 4 ksi concrete closure pours along their longitudinal interfaces. The modules were detailed to ensure that the protruding headed rebars of one module would not interfere with the rebars of the adjacent module. Once the closure pours were constructed and

Photo 3: Completed bridge.

cured, the four modules began functioning as a unit. The backwalls and approach slabs were also constructed simultaneously with the longitudinal closure pours. The deck was then overlaid with a hot mix asphalt system, and a TL-4 metal bridge railing was installed using threaded rods protruding from the precast concrete curbs.

Bridge replacement required thirteen weeks to complete, and the roadway was opened to traffic in November of 2011. As this structure was the first folded steel plate girder bridge ever constructed and placed in service, MassDOT decided to instrument the bridge components with strain gauges to monitor stresses in the steel plates, deck, and closure pours. Performance is currently being monitored by the University of Massachusetts.

MassDOT considers this project a success since a new technology was implemented at a competitive price and resulted in a 28% reduction in on-site construction schedule when compared to a more conventional adjacent precast concrete box beam alternative. In addition, their willingness to implement an innovative structure type has opened the door to the industry to consider a steel alternative in a span range generally dominated by precast concrete solutions.

Thomas G. Zink, P.E. is a Vice President of Gannett Fleming Inc. He serves as the firms Regional Bridge Practice Manager in the northeast as well as the Manager of the Transportation Division of Gannett Fleming's Mount Laurel, New Jersey office. Mr. Zink holds B.S. degrees in both Civil and Architectural Engineering from Drexel University.

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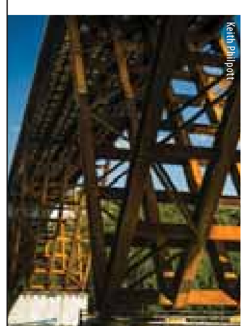


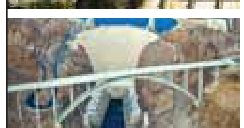

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MAINE'S PENOBSCOT NARROWS BRIDGE & OBSERVATORY

SOME CALL IT "WICKED COOL"

By William (Jay) Rohleder Jr.

Along scenic New England Route 1 in beautiful "Down East" Maine near Bucksport, drivers who travel toward Acadia National Park will cross The Penobscot Narrows Bridge and Observatory. The bridge opened to traffic on December 30, 2006 and deftly entices travelers to stop at the 420-foot public observation tower for what the New York Times called "…an awe inducing panorama of Maine's mountains and coastline and a bird's-eye view of the nearby village of Bucksport." The crossing over the Penobscot River is adjacent to the Fort Knox State Historical site and connects Waldo to Hancock counties in Maine. The Cable-Stay Bridge is a replacement for the Waldo-Hancock Suspension Bridge, originally opened to traffic in 1931.

In July 2003, the Maine Department of Transportation awarded a contract to renovate the over 70-year old Waldo-Hancock Suspension Bridge. Inspections found that considerable corrosion had taken its toll on the bridge. It was immediately posted and steps were taken to strengthen the bridge and reduce the superstructure weight by adding supplemental cables designed to reduce the load on the corroded main cables. At the same time, officials began planning for a The Penobscot Narrows Bridge and Observatory at night. A cable-stayed bridge with a 1,161-foot main span over the Penobscot River in Bucksport, Maine. replacement bridge, since the strengthening project was a temporary measure providing a limited number of years to the service life of the existing suspension bridge.

The Maine Department of Transportation initiated a new delivery method they called an 'Owner- Facilitated Design/Build Process," for quick delivery of the new Penobscot River crossing combining both design and construction under separate contracts. The Maine DOT was an early pioneer of Design-Build projects in the United States and from their experience, they knew an emergency bridge replacement project would require more control over the design-development than a traditional Design-Build process would allow. Thus was born the "Owner-Facilitated Design/Build Process" which is now more familiarly known in the transportation industry as the Construction Manager / General Contractor (CM/GC) method of project delivery. To begin the process the department selected a designer, and FIGG went to work quickly on initial bridge solutions.

Design decisions were made rapidly, while at the same time maintaining and focusing on a creative community engagement process to select the bridge's aesthetic elements. The optimum new bridge was selected as a 2,120 feet long (646 meters) cable stayed bridge with a main span length of 1,161 feet (354 meters).

The Penobscot Narrows Bridge and Observatory at night. A cable-stayed bridge with a 1,161-foot main span over the Penobscot River in Buckport, Maine.

Within six months of determining the emergency need to replace the old bridge, the Maine Department of Transportation had design underway and had negotiated a staged contract for construction with Cianbro/Reed & Reed, LLC, a joint venture of two premier contractors in the state. Construction started in a harsh winter with a "Ground Chipping" of shovels in the icy ground on December 3, 2003 with many dignitaries and the design-build team present.

BRIDGE TECHNOLOGY ADVANCES

Cable Stay System:

As the new bridge design progressed, there was extensive discussion amongst the team about details of the cable stay system. FIGG had worked with the Ohio Department of Transportation and Federal Highway Administration to complete testing and receive approval in 2001 for installing a "Cradle System" in a new cable stayed bridge, the I-280 Veterans' Glass City Skyway in Toledo, Ohio. The Maine Department of Transportation elected to use the same cradle system, recognizing the advantages of its long-term durability, its ease of inspection and its low maintenance requirements.

FIGURE 1 – Cable Stay Cradle with Encased 1 inch diameter Pipes for Individual Strands.

Given Maine's experience with the deteriorating suspension cable conditions on the old Waldo-Hancock Bridge, considerable efforts were directed toward developing a new cable stay system that prevented opportunities for corrosion. The "Cradle System" (patent U.S. 6,880,193; 4-19- 05) encases individual stay strands in a protected sheath (see Figure 1) which helped


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accomplish Maine's goal for preventing corrosion in Maine's harsh climate.

With the cradle design, cable stay strands serve as tensile elements that are individually threaded continuously from an anchorage at the bridge deck, up through a free length of pipe sheathing, through the cradle in and over the pylon then back down through another sheath into an anchorage at bridge deck on the opposite side of the pylon.

Compressive forces are transmitted from the strands in the cable stay into the pylon through the curved portion of the cradle. Epoxy coated seven wire steel strands are housed in individual, 1" diameter steel tubes through the curved portion of the cradle. During fabrication of the cradles, grout is injected into the spaces between the tubes, allowing the vertical component of force from the stays to be transferred into the pylon while the strands remain ungrouted within the 1" diameter sleeves. This allows each strand to act independently, simplifying inspection and future replacement for the longest possible life of the bridge and considering possible new materials.


FIGURE 3– Location of Stays with Two Demonstration CFRP Strands included

To enhance the long-term inspection opportunities, each multi-strand cable stay incorporates two reference strands that can be removed, inspected and replaced with the same or newer materials, at any point in the future. Stay forces are regularly recorded on permanent monitoring equipment allowing for comparison with predicted values. The owner can easily monitor the health of the bridge without additional expense, special equipment or interruption of traffic.

Cable Stay CFRP Strand Innovation:
The design team recognized an opportunity to explore the use of carbon fiber reinforced polymer (CFRP) strands in the cable stays. The cradle system with reference strands and monitoring equipment allowed for the selective substitution of replacement CFRP strands for the traditional steel strands. The coastal northern environment in Maine provides a wide array of weather conditions for testing that includes large temperature variations and high humidity in a brackish water environment. The Federal Highway Administration (FHWA) and the State of Maine provided financial support for this CFRP Demonstration Project through the use of Federal Innovative Bridge Research and Deployment Program Funds. The team of Maine DOT, FHWA, FIGG and Lawrence Technological University collaborated to develop design details for incorporating CFRP strands into the bridge as special reference strands.

Bridge construction was completed with traditional epoxy coated steel strands installed for the stays, and the bridge opened to traffic on December 30, 2006, just 42 months after identifying the need for an emergency bridge replacement. In June 2007, six steel strands – two in each of the three stays (see Figure 3) - were removed and replaced with CFRP strands while the bridge carried traffic. One test was immediately validated – that carbon fiber strands can be easily installed in a bridge with cradles. Monitoring activities will capture variations in structural response due to thermal effects, initial versus long-term bridge stresses, and flexibilities in the overall bridge system.

Going forward, the CFRP strands will be monitored and inspected to evaluate the structural behavior and long-term durability, and serve as a guide to using CFRP prestressing strands for many more future applications in long-span bridge design.

PUBLIC OBSERVATORY

A major consideration for the design team was accommodating the Public Advisory Committee's desire to celebrate their community with a special bridge while achieving the budget. The bridge had for decades provided access to area businesses such as the paper mill, granite quarries, and boat constructors. It also provided access to Maine's scenic coast, including nearby Acadia National Park. The Design Team and the Advisory Committee invited the public to participate in community workshops, where ultimately preference was expressed for simple, elegant shapes and a theme based on the use of granite, an important local resource. The bridge design theme was "Granite, Simple and Elegant."

A major challenge toward gaining public approval was the pylon height. The pylon needed to be of sufficient height to support the cable stay system for the 1,161-foot long main span, and at the same time be an asset to the surrounding site.

To address the public's concerns, the design team made two major decisions. First, the 420-foot tall pylons were designed with an obelisk shape, reminiscent of the Washington Monument, which was constructed with granite from the local Mt Waldo quarry. Secondly, the decision was made to create a multi-level glass-enclosed observation deck at the top of the pylons located in the state park, which would provide 360-degree scenic views of Fort Knox State Park below and the overall Maine landscape, providing the area with a landmark destination.

FIGURE 4 – Cable Stay Bridge Tower

Today, visitors to Fort Knox State Park can take the footpath to the bridge, accessing the base of the cable-stay pylon, where they enter the belly of the bridge and take a high speed elevator that takes them up 420 feet above the Penobscot River to the Observatory at the top (see Figure 4.)

FIGURE 4.1 – View at the Top

At the entrance to the cable-stay pylon is a plaque detailing the historic significance of the region and the bridge. A compass rose, designed and fabricated by a local artist has been inlayed at the top floor of the observatory to orient visitors as they view the breath-taking 360-degree panorama, where other landmarks such as Cadillac Mountain can be seen. Today, a trip to Acadia National Park is only complete with a stop at the Penobscot Narrows Bridge and Observatory.

SUCCESS OF A VISION

The Penobscot Narrows Bridge and Observatory has been open to traffic for seven years. An innovative "owner-facilitated" emergency replacement project-delivery method, participation from local residents, and visionary design and construction has given Maine a sustainable, iconic landmark bridge that draws thousands of visitors each year as both a destination and important transportation route.

- The Owner is the : Maine Department of Transportation;
- The Designer is FIGG;
- The Contractor is Cianbro / Reed & Reed, LLC, Joint Venture. PE

William (Jay) Rohleder Jr., P.E, S.E. is Senior Vice President with FIGG and served as the Project Manager for FIGG's design and construction engineering on the Penobscot Narrow Bridge and Observatory in Maine serving the Maine Department of Transportation.

BRIDGE FACTS

- First and only cable-stay bridge in Maine.
- Only bridge with an Observatory in North and South America; one of only three such bridges in the entire world (other two are in Thailand and Slovakia).
- 331 miles of epoxy-covered strands make up the cables (roughly the distance from Portland to Fort Kent, ME).
- There is enough concrete in the foundations to fill a football field 19 feet high.
- Total weight of the reinforcing steel rods in the bridge piers and pylons is 1.02 million pounds.
- 373,000 hours of labor • Total bridge weight is about 10,500 African elephants (roughly 126 million pounds).
- Total bridge length is 2,120 feet.
- 340,000 tons of rock were blasted from the Prospect side to create the new Route 1
- The observatory elevator is the tallest and fastest in the State of Maine.

Sidebar Facts were provided as a courtesy of Maine.gov.

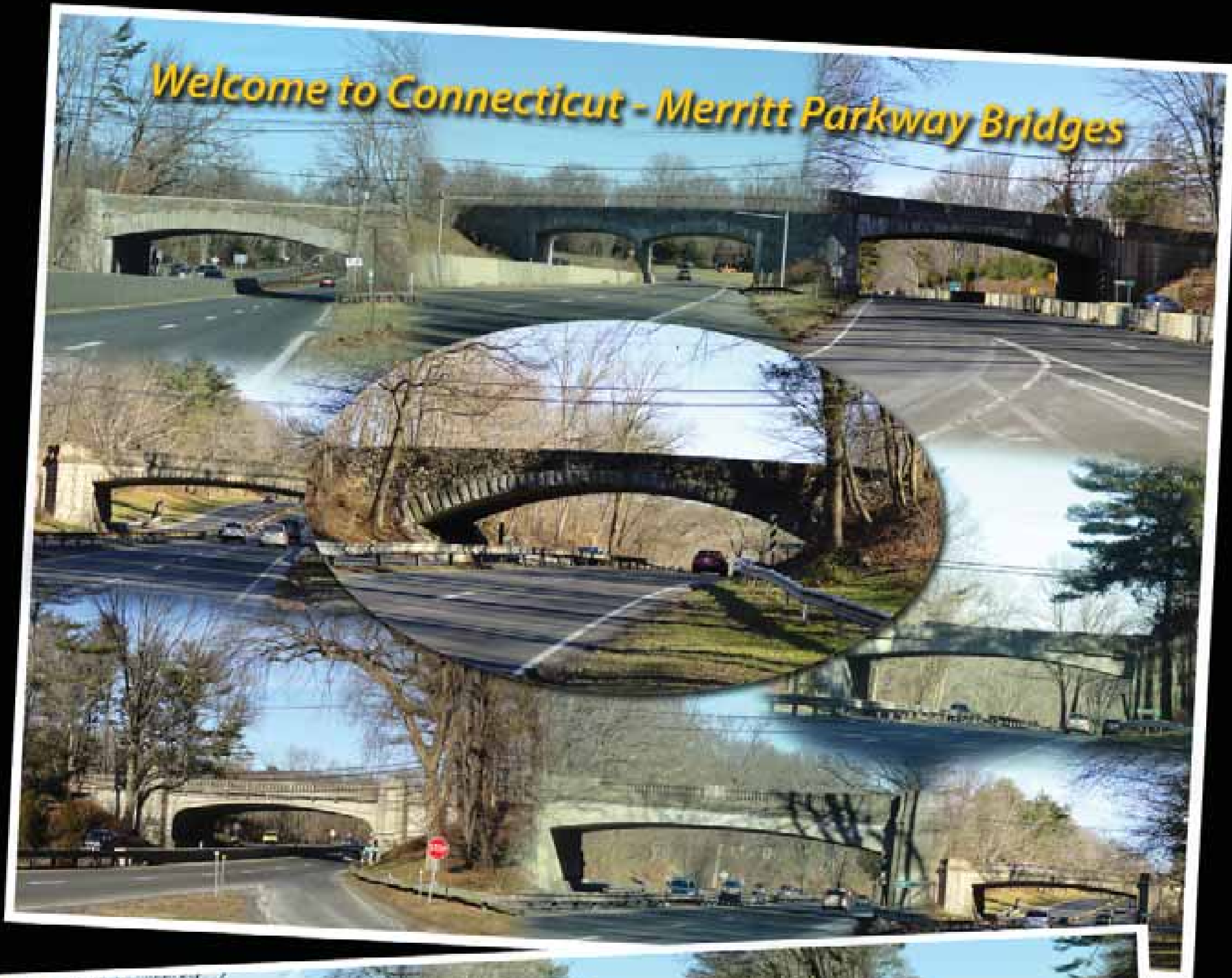
The Bridges of the Merritt Parkway

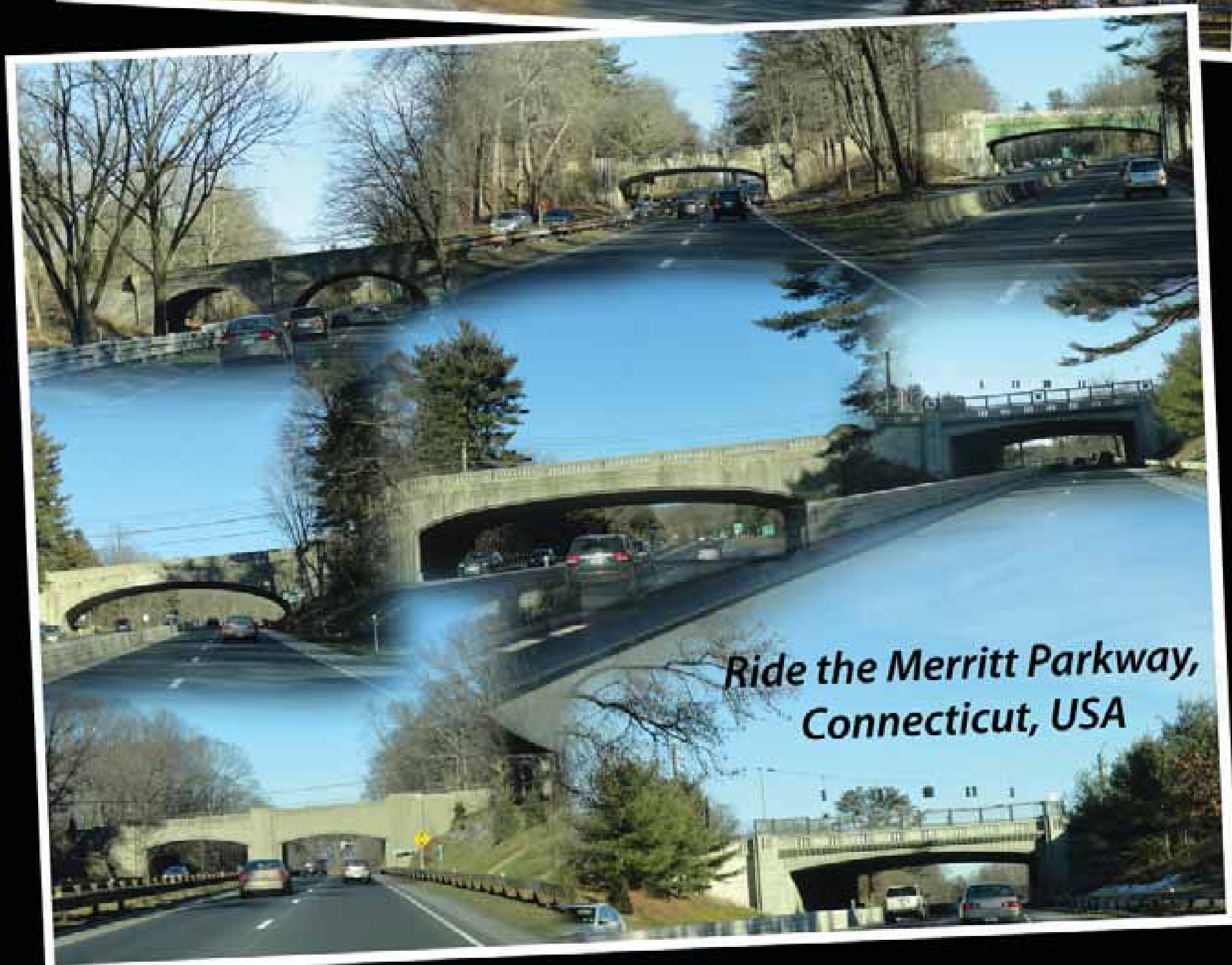
A Blend of Rustic and Art Deco Expression

By Thomas G. Leech

Aerial View of the Merritt Parkway, looking west, Fairfield Rest Area, Connecticut.
Photograph courtesy of HAER, Library of Congress

On June 29, 1938, the architectural vision of the forty six year old George Dunkelberger was finally realized as the first section of the Merritt Parkway was opened from Greenwich to Norwalk Connecticut. The road, a limited access highway, conceived as a bypass for Route 1, was considered a model of its day, most notably due to the architectural qualities of its more than 60 bridges. Route 1, originally called the Post Road or Kings Highway, was considered the gateway from New York City to New England. The Merritt Parkway became a second gateway. The parkway's undulating profile follows the gentle contours of the Connecticut landscape and the tree lined wide right of way presents a continuous visual buffer from nearby population centers. By design, there were no at grade intersections, with interchanges and grade separations for all overpassing and underpassing roadways and passenger rail lines. Completed in six years by 1940, the Merritt Parkway stands as Connecticut's greatest Depression-era public works project, employing over 2,000 workers.


Welcome to Connecticut - Merritt Parkway Bridges


Ride the Merritt Parkway,
Connecticut, USA

The Merritt Parkway is characterized by a conscious design effort to create an ever changing picturesque appearance through well conceived structural and landscaping design. And the more than 60 concrete and steel, rigid frame and arch bridges are the celebrated features of the parkway, each individually styled and purposefully developed. Each of the bridges crossing the parkway is individually unique in its architectural character. The styles, while rustic, incorporate the art deco motifs popular at the time of construction.

The Merritt Parkway may be considered the apex of the era of scenic motorways with its bridges as its crowning achievement

In 1931, the Connecticut Highway Department assembled a team of specialists who traveled throughout the northeast to systematically and comprehensively study all roads and parkways under construction in efforts to surpass the accomplishments of all others. The team included Leslie Sumner, chief structural engineer, A. Earl Wood, engineer of roadside development, W. Thayer Chase, landscape architect and most notably, architect George Dunkelberger, who designed the unique and individualized finishes for each of the bridges. George Dunkelberger would also serve as site coordinator for the parkway. Certainly imagination was in play with the various architectural designs of George Dunkelberger, with some designs evoking mid-evil sentiments while others evoking modern and futuristic (for the time) elements. When completed the Parkway would achieve its intended goal of scenic motoring (at a designed speed of 45 mph). The Merritt Parkway may be considered the apex of the era of scenic motorways with its bridges as its crowning achievement.

The structurally efficient rigid frame was the perfect structural form for low clearance modest span structures. While most of the structures are constructed from cast in place concrete, several of the overpasses are supported by a slender steel rigid frame skeleton covered in a veneer of unusual surface treatments. The Art Deco theme is interesting and variant throughout the parkway. Even the most modern of rehabilitations and reconstructions of the bridges have held strictly to the tradition and style of the George Dunkelberger. Much of the architectural expression can be witnessed closely by driving over any of the bridges where you are greeted with unusual railing treatments and in some cases unusual ornamentation such as flower boxes. With careful observation the drivers and passengers of the parkway can view unusual motifs cast into the surface features of the wing walls and girder spans. As one travels the parkway, anticipation builds, from one bridge to the next, surmising what new architectural expression will be revealed in the next overpassing bridge.

What is Art Deco?

Art Deco is a visual arts design style which first appeared in France during the 1920s, flourished internationally during the 30s and 40s, then waned post World War II, Art Deco may be considered a lavish style, often characterized by rich colors and bold geometric ornamentation, that combines traditional craft motifs with Machine Age imagery and materials. The most well known example of this style is the Chrysler Building in New York City.

So, drive the parkway eastbound as I did this past January. Enter the Parkway at the Connecticut state line in early afternoon, when the sun is at your back, and watch the light and shadow dance before your eyes as you pass under each bridge, quietly anticipating the next bridge to enjoy. And enjoy the postcards I found along the way. PE

Thomas G. Leech, P.E, S.E. is the National Practice Bridge Manager of Gannett Fleming, Inc. and recently had the privilege of participating in the restoration of one of the overpass bridges, consistent with the tradition of George Dunkelberger and his colleagues.

Ed note: There are many interesting web sites telling the story of the construction of the parkway, its history and its listing in the National register of Historic Places. See:

www.trumbullhistory.org/merrittpkwy/
www.themerrittparkway.com/
www.merrittparkway.org/pages/history.asp
www.roadfan.com/merrittpage1.html

All "postcard" photographs were taken by the author.

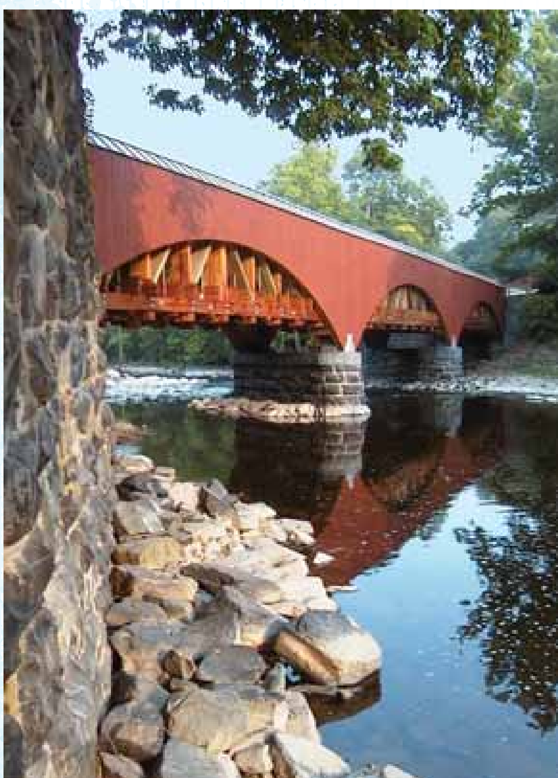
IBC PHOTO CONTEST

The International Bridge Conference is conducting our second annual Photographic Contest. With this year's magazine theme of "New England Bridges", it is only fitting that we select a photographic contest of bridge styles that typify New England, So, this year the Executive Committee has selected the theme of "Covered Bridges – 20 Most Beautiful Bridges" for our second annual contest. Our request for entries has been truly remarkable – over 160 entries were made from within to beyond the borders of the U.S. Needless to say, the Committee has had a difficult time ranking and selecting the photos for publication as they were all winners in some real sense. Never the less, we are sure that you, our readers, will find these photographs to be outstanding. Congratulations to Jerry Russell of Salem Oregon, our first place winner for a most outstanding photograph of a covered bridge. Enjoy! – IBC Executive Committee

1. Haverhill Bath Covered Bridge over the Ammonoosuc River, Woodsville, New Hampshire, Photographer: Jerry Russell, Salem, Oregon. *Judges Comments: "… a beautiful bridge in a most interesting natural setting … a great reflection of the ingenuity of its builders …"*

2. Sachs Covered Bridge, Adams County, Pennsylvania, Photographer: James Smedley, Nottingham, Maryland.
Judges Comments: " … intriguing symmetry … a handsome form … in a crisp winter setting …"

3. Tohickon Aqueduct (Delaware Canal National Landmark), Point Pleasant, Pennsylvania, Photographer: William Collins, Norristown, Pennsylvania
Judges Comments: " … a beautiful bridge setting … a creative photo composition … "



4. Ashuelot Covered Bridge, Winchester, New Hampshire, Photographer: Jerry Zoller, Concord, New Hampshire
Judges Comments: " … creative geometric context . .. fascinating perspective …"

5. West Paden Covered Bridge, north of Orangeville, Pennsylvania, Photographer: Linda Sones, Orangeville, Pennsylvania
Judges Comments: " … pleasant winter composition … with a hint of a twin nearby …"

6. Union Covered Bridge (over the Elk Fork of the Salt River), Monroe County Missouri, Photographer, Cathy Morrison, Jefferson City, Missouri
Judges Comments: " … a beautiful twilight composition with an interesting color contrast …"

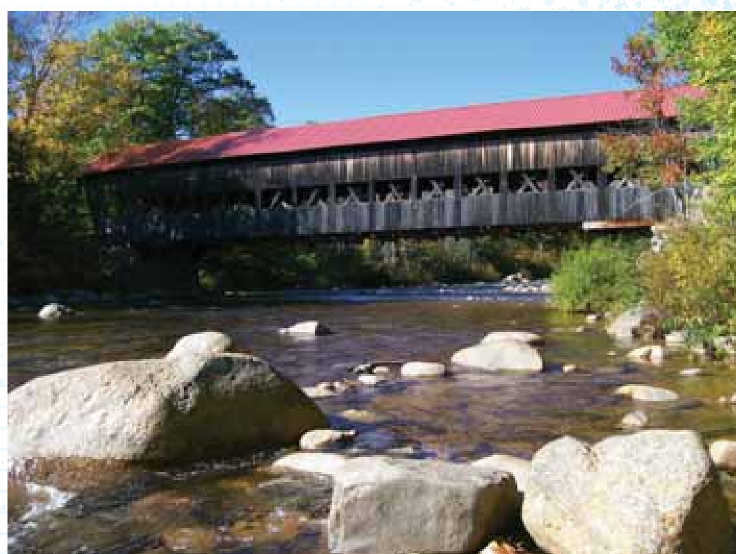
7. Corbin Covered Bridge over the Croydon branch of the Sugar River, northwest of Newport, New Hampshire, Photographer: Jerry Russell, Salem Oregon
Judges Comments: " … a tranquil mood with contrasting colors and reflection …"

8. Flume Covered Bridge, Lincoln, New Hampshire, Photographer: Jerry Zoller, Concord, New Hampshire
Judges Comments: " … stopped by woods on a snowy evening …"

9. Stone Mountain Covered Bridge (also known as Effie's Bridge), DeKalb County, Georgia, Photographer: Dennis Baughman, Beaver, Pennsylvania.
Judges Comments: " … a splendid composition of symmetry and natural setting …"

10. Sankey Park Covered Bridge, Sweet Home Oregon, Photographer: Jerry Russell, Salem, Oregon.
Judges Comments: " … a beautiful bridge in simple but colorful setting … "

11. Blair Covered Bridge, Campton, New Hampshire, Photographer: Jerry Zoller, Concord, New Hampshire.
Judges Comments: " … a splendid winter scene …"



12. Albany Covered Bridge off the Kancamagus Highway, Albany, New Hampshire, Photographer: Jerry Zoller, Concord, New Hampshire.
Judges Comments: " … a creative contrast of color that works in harmony with the bridge's composition …"

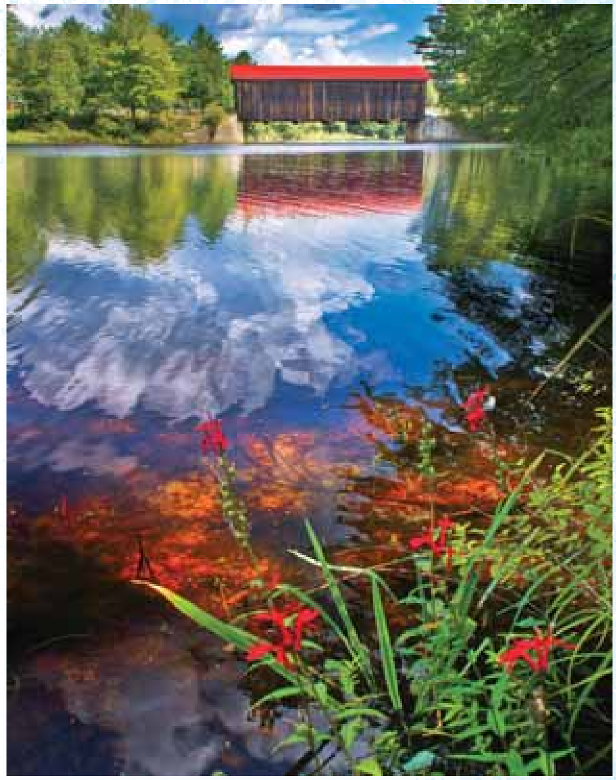
13. Yellow Creek Covered Bridge, Bedford County, Pennsylvania, Photographer: Thomas Walczak, New Castle, Pennsylvania.
Judges Comments: " … not only a perfect reflection, but, a reflection of history with modern art …"

14. Academia/Pomeroy Covered Bridge, Juniata County, Pennsylvania, Photographer: Len Shirlinski, South Williamsport, Pennsylvania.
Judges Comments: " … an elegant structure … a well preserved bridge … an excellent blend of texture, color and composition …"

15. Packsaddle/Doc Miler Covered Bridge (over Brush Creek), Somerset County, Pennsylvania, Photographer: Len Shirlinski, South Williamsport, Pennsylvania.
Judges Comments: " … an interesting subject matter … a simple engagement of bridge and natural beauty …"

16. Pioneer Park Covered Bridge, Stayton Oregon, Photographer: Jerry Russell, Salem, Oregon.
Judges Comments: " … creative use of imagery and color … a perfect capture of reflection ... "

17. State Road Covered Bridge crossing Conneaut Creek, Ashtabula County, Ohio, Photographer: Thomas Walczak, New Castle, Pennsylvania.
Judges Comments: " … interesting interior perspective … with good interplay of light and shadows …"



18. Handcook/Greenfield Bridge, Hillsborough County, New Hampshire, Photographer: James LaMorder, West Halifax, Vermont.
Judges Comments: " … an unusual composition … an interesting reflective subject matter .. the surroundings accentuate the bridge … "

19. Barronvale Covered Bridge (over Laurel Hill Creek), Somerset County, Pennsylvania, Photographer: Len Shirlinski, South Williamsport, Pennsylvania
Judges Comments: " ... a quiet subdued, reflective mood …"

20. Larwood Covered Bridge over Crabtree Creek, southeast of Scio, Oregon, Photographer: Jerry Russell, Salem Oregon.
Judges Comments: " … pastoral setting … elegant bridge …"

IBC 2013
Bridge Awards Program

By Herbert Mandell

Watching the International Bridge Conference®, (IBC) working on its executive committee, making friends both within the committee and at the conference, and getting to know some of the greatest bridge engineers in the world are all things that make me continue to be active on the IBC. I realize that the IBC is much more than a meeting. It is a celebration of bridges and the people who design and build them. I am so glad that while all of this was going on, I was not a bystander.

The awards subcommittee, that I have been a member of since its inception, has a difficult task, because of the numbers of wonderful bridge engineers who are nominated for the Roebling medal and because of the superbly unique and beautiful bridges whose photographs and data are submitted as candidates for the bridge awards. But being able to discuss and select the winning bridges is also a pleasure and a privilege, and is one of the perks of being a member of the subcommittee. Before we discuss this year's awards, it would be good recap the wonderful history of these awards from their inspection.

In 1987, the Awards program was established with the selection of the late Gerald F. Fox to receive the first John A. Roebling medal, lifetime achievement award. Among the 26 recipients of the Roebling medal, I am happy to count nine professional friends, and six of the other awardees have come from Europe or Asia. In 1988 the George S. Richardson medal was introduced. Unlike the Roebling medal, which has been awarded for a lifetime of achievement in bridge engineering, the Richardson medal is awarded for a single bridge engineering achievement. The first recipients, Jean M. Muller and the late Eugene C. Figg, Jr., who designed the outstanding Sunshine Skyway bridge over Tampa Bay in Florida, later went on to win the Roebling medal, Muller in 1994 and Figg in 2000. Eleven international bridge projects have received this award.

In 1999 the Gustav Lindenthal medal was established to honor a bridge project that demonstrated environmental harmony, aesthetics, and community participation. Among the 14 awards presented, six have been international. The first award, however, went to a domestic project, the H-3 Windward Viaduct, constructed by the Hawaii DOT, a project I did preliminary planning on in 1970. I recused myself from participation in the discussions of that award! Incidentally, the Pennsylvania Turnpike Commission has won this award twice, first for the Mingo Creek Viaduct in 2004, and more recently for the I-76 Allegheny River Bridge in Oakmont, PA.

The Eugene C. Figg, Jr., medal, first awarded in 2002 soon after the death of its namesake, is for a community icon. It has been awarded 11 times, first for the Jiangyin Bridge in China. Subsequently, three more Chinese bridges received the award, as did a bridge in Thailand and a bridge in Bolivia.

The Arthur G. Hayden medal, for special use bridges, such as pedestrian, people mover, or other non-traditional structures, was established to fill a perceived need. First awarded in 2003 to the Duisberg, Germany, Inner Harbor footbridge, only two of its ten medals have been awarded to U. S. bridges

The IBC's newest award, the Abba G. Lichtenstein Medal, for restoration and rehabilitation of bridges of historic significance, was created and awarded at the most recent IBC, in 2012. It went to the Bridge of Lions, a bascule bridge in St. Augustine, Florida. However, this award was preceded in 2010 by a special historic preservation award to the Poughkeepsie Highland Railroad Bridge over the Hudson River in New York, now a pedestrian walkway, leading to the realization that there are and would be more and more of these historic restorations, and that they were deserving of recognition. So the Lichtenstein Medal was established

As noted the International Bridge Conference in conjunction with Roads and Bridges Magazine, Bridge design and engineering Magazine and the Bayer Corporation, annually awards 6 five medals to recognize individuals and projects of distinction. The medals are named in honor of the distinguished engineers who have significantly impacted the bridge engineering profession worldwide. The student award is named in honor of a former IBC General Chairman, a champion of the student award's program and a friend to the community at large. Interest in the IBC awards program is quite robust nationwide and internationally. This year the Awards Committee reviewed more than forty nominations for the various bridge metal categories alone, half of which were projects nominated beyond the borders of the United States. After lengthy deliberations, the following individuals and projects were deemed worthy of this year's awards.

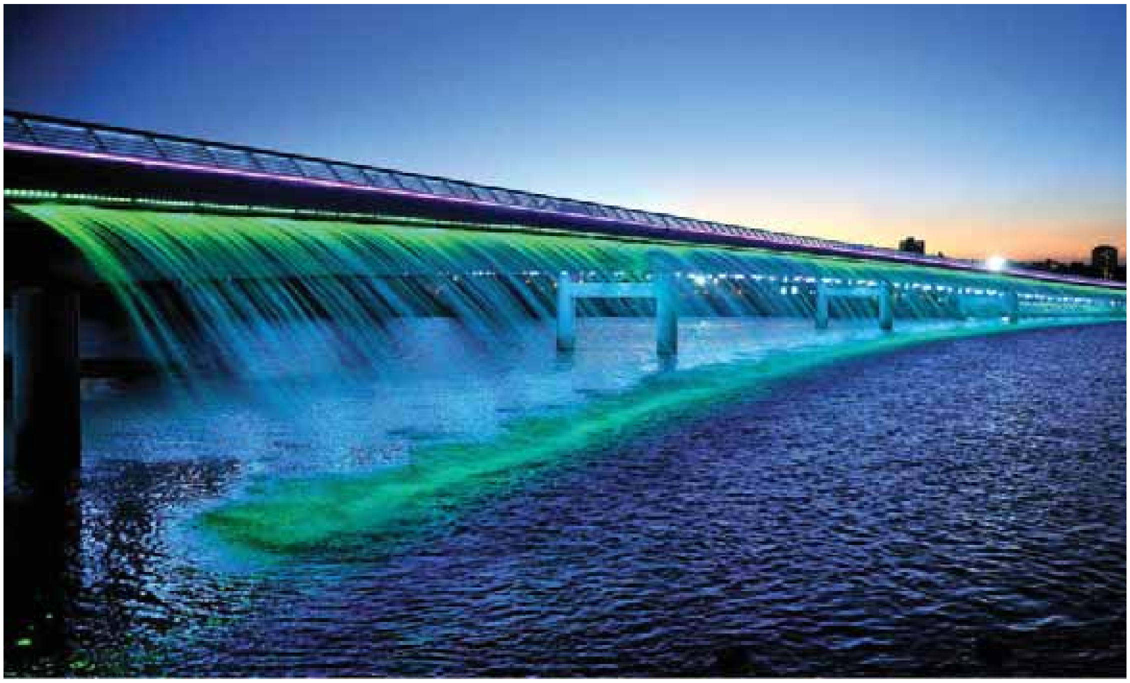
George S. Richardson Medal

The George S. Richardson Medal, presented for a single, recent outstanding achievement in bridge engineering, is presented to recognize the Jiaozhou Bay Bridge (pronounced Gee-yeow Choe) located near Qingdao City, Shandong Province, China. This 42.5 meter (26.4 mile) long bridge – yes 26 miles long! - spans an open water estuary and several shipping channels in Jiaozhou Bay. The bridge includes an interchange in the middle of the span plus three channels including a single pylon cable stayed structure, a double pylon cable stayed structure and a single pylon, self-anchored suspension structure in addition to the 5000 columns supporting the viaduct segments of the structure. The entire project, 17 years in the making, is an outstanding engineering project meeting challenges with studies, community support, sustainability considerations, innovations and teamwork requiring a workforce of over 10,000 workers. The many technical challenges included a corrosive environment, severe winter with ice formations in the bay, annual typhoons, earthquake potential, likely vessel impact and considerable annual fog. Special technologies employed for this project include offshore auger drilling technology (for drilled caissons 2.5 m in diameter by 88 m in length), an underwater concrete pouring jacket method specially developed for this project, LED lighting for drivers' safety in foggy condition, and structural performance monitoring employed both during construction and after bridge is in service.

Awards Committee Comment: "This is a major accomplishment for the Country of China."

Arthur C. Hayden Medal

The Arthur C. Hayden Medal, recognizing a single recent outstanding achievement in bridge engineering demonstrating vision and innovation in special use bridges, will be presented to recognize the Starlight Pedestrian Bridge, in Ho Chi Minh City, Vietnam. The bridge is curved in the horizontal plane to blend into the environment by matching the circular road that surrounds the adjacent Crescent Moon Lake, creating a structure that is in harmony with the surrounding. The 5 span, 130 m (427 ft) structure is a continuous box girder structure built with corrosion resistant lightweight aluminum alloy composites. There are many special and unique design, architectural and ornamental features built into the bridge including a non-slip deck with illuminated "starlights" impressed in the surface, an ergonomically designed railing, solar panels (a 'green bridge' concept) mounted attractively to the superstructure, and an illuminated fountain system that highlights cascading night time waterfalls. The bridge has been a local pride and tourist attraction since its opening. Local folks, as well as tourists from Vietnam and abroad, come to walk across the bridge or simply sit on the concrete steps to enjoy the sight and sound of lights and waterfalls.



Awards Committee Comment: "… simply stated … this is most sensational …."

Gustav Lindenthal Medal

The Gustav Lindentahl Medal, awarded for an outstanding structure that is also aesthetically and environmental pleasing, will be presented to recognize the DEH Choe Bridge, an unusual cable stayed structure over the Mackenzie River in the Northwest Territories of Canada. The bridge replaces a former ferry (in summertime) and ice bridge (in wintertime). This steel structure, near Fort Providence, is the largest bridge project ever undertaken in the Northwest Territories. The bridge's remote location in the upper latitudes endures severe winter conditions with ambient temperatures as low as -40 degrees Fahrenheit. The project considered an ambitious construction schedule required new thinking with respect to design and erection. Applying ecological light-weight bridge design principles and innovative design methods (Assembly Line Design Approach, Failure Mechanism Concept, Fuse Design Philosophy2) led to significant cost savings and one of the world's longest continuous superstructures with a length of 3,430 feet (1,045 m) and expansion joints located only at the abutments. The local communities were closely involved in the project from the beginning. For them the DEH Cho (Big River) is more than a pristine and precious resource of fresh water and food; it is the physical and spiritual foundation of their lives. For that reason it was important to understand that the bridge is not just another infrastructure project creating an important link using a ribbon of steel and concrete; but with well-defined proportions, symmetry, simplicity, and clarity, the aesthetically pleasing structure has become an iconic part of their lives and hope for a better future.

Awards Committee Comment: "… stark beauty in a rugged environmental setting …."

Eugene C. Figg, Jr. Medal

The Eugene C. Figg, Jr. Medal for Signature Bridges, recognizing a single recent outstanding achievement for bridge engineering, which is considered an icon to the community for which it is designed, will be presented to recognize the Lake Champlain Bridge. The bridge replaced an aging, iconic structure between Crown Pont, New York and Addison Vermont and features a main span comprising a modified network, tied arch bridge. The bridge is strongly reminiscent of the former bridge, a through truss, it replaced at the same site. Public input demanded a structural expression replicating the 1928 landmark. During the planning process, local input was vital, and resulted in modification of the design to include "rigid frames" at each main pier supporting the arch. The result was an aesthetically pleasing structure which fits well into its environment. Additionally there were a number of innovations for the 480 foot (146 m) main span, where the construction was fast tracked. The arch span was completely assembled off site and floated to the piers, where it was hoisted onto the supporting rigid frames; and subsequently the concrete deck panels, which were prefabricated, were then be placed quickly.

Awards Committee Comment: "…the bridge effectively replicates historic setting … without the clutter ..."

John A. Roebling Medal

M. Mwint Lwin, P.E., S.E.

The John A. Roebling Medal recognizes an individual for lifetime achievement in bridge engineering. We are pleased to recognize Mr. M. Mwint Lwin of the Federal Highway Administration. Mr. Lwin is currently the Director, Office of Bridge Technology, Federal Highway Administration, U.S. Department of Transportation in Washington D.C. In his current position he is responsible for providing national guidance in the design, construction, inspection, maintenance and preservation of highway bridges, tunnels, and related structure, he develops national bridge and tunnel programs and engineering policies, he supports research, development, deployment and education/training to continually improve the quality and safety of bridges and tunnels and he provides program direction for the Highway Bridge and Tunnel Programs. He has been a chairman of both NCHRP Project 12-38 Improved Design Specifications for Horizontally Curved Steel Girder Highway Bridges and NCHRP Project 10-57 Structural Safety Appraisal Guidelines for Suspension Bridge Cables. Previously he held positions of Structural Design Engineer, FHWA Resource Center at San Francisco and Bridge and Structures Engineer, Bridge & Structures Office, Washington State Department of Transportation. In 1994, Mr. Lwin was cited by ENR Editorials as one of "Those Who Made Marks in 1993 in Construction"; in 1997 Mr. Lwin received Special Recognition and Appreciation for Exceptional Services rendered toward the Success of the Hood Canal Floating Bridge Replacement; and in 2010, Mr, Lwin received an FHWA Awards In Recognition of Leadership and Support of the Hoover Dam Bypass Bridge Project.

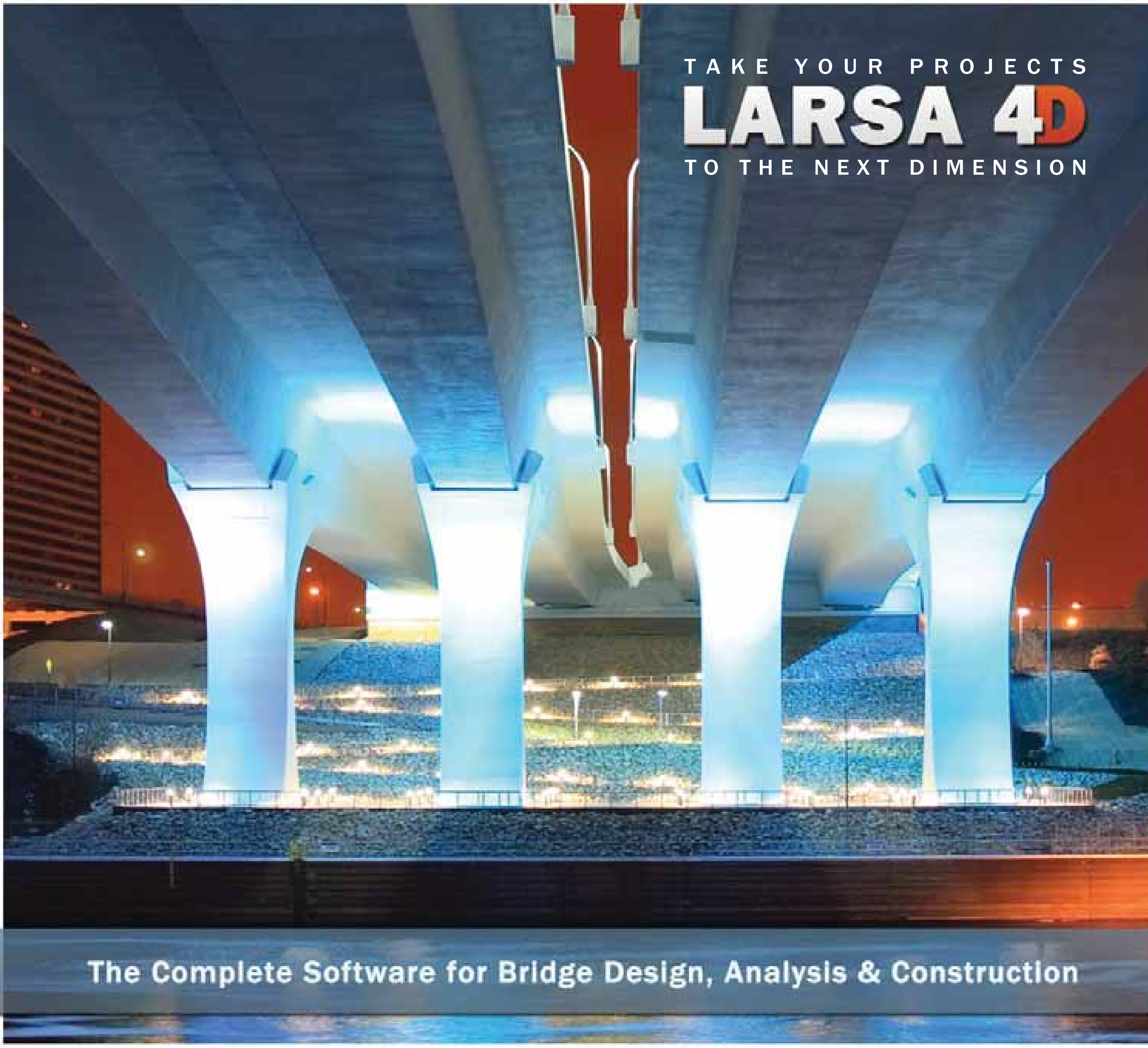
Abba G. Lichtenstein Medal

The Abba G. Lichtenstein Medal, recognizes a recent outstanding achievement in bridge engineering demonstrating artistic merit and innovation in the restoration and rehabilitation of bridges of historic or engineering significance. The Abba G. Lichtenstein Medal is presented to recognize the Willamette River Bridge Rehabilitation Project, linking the communities of Oregon City and Linn Oregon. This rehabilitation recreated all original aesthetic elements of the original construction. The bridge is a part of a nationally-recognized program that Conde B. McCullough created at the Oregon State Highway Department in the 1920s and 1930s including striking bridges over rivers, bays, and inlets on the Oregon Coast Highway. McCullough, an engineer, professor & lawyer, advocated that bridges be built economically, efficiently, and with beauty. For this structure, McCullough covered the supporting steel through arches with gunite (a new proprietary product at that time) in order to protect the steel from the caustic emissions of nearby paper mills. McCullough heightened architectural interest on the Willamette River Bridge with textures and colors; much of the bridge has a smooth surface but many features have recessed panels that were bush-hammered to create a pebble-dashed surface of exposed aggregate. McCullough also built entry obelisks, or pylons, with ornamental lights at the bridgeheads and atop the piers. All of these elements were carefully restored to original context by removing and repairing gunite and providing a precast railing system that is true to the original design but is also crashworthy.

Awards Committee Comment: "… a marvelous restoration … McCullough would be proud that his structure endures ..."

The IBC Awards Committee includes Carl Angeloff, Lisle Williams, Jim Dwyer, Richard Connors, Gary Runco, Myint Lwin, Rachael Stiffler, Enrico Bruschi, Matt Brunner, Ken Wright, George Horas, Helena Russell, Bill Wilson, Fred Graham, Herb Mandel and Tom Leech.

Herbert Mandel, P.E. (retired) was named Emeritus Member of International Bridge Conference Executive Committee in 2010 and for many years has faithfully served on the IBC Awards Committee. Herb has most recently written the wonderful "Introduction" to the IBC's 30th anniversary book entitled "Reflections". The historical narrative of this article is based on this Introduction. – Editor



BRIDGE SERIES

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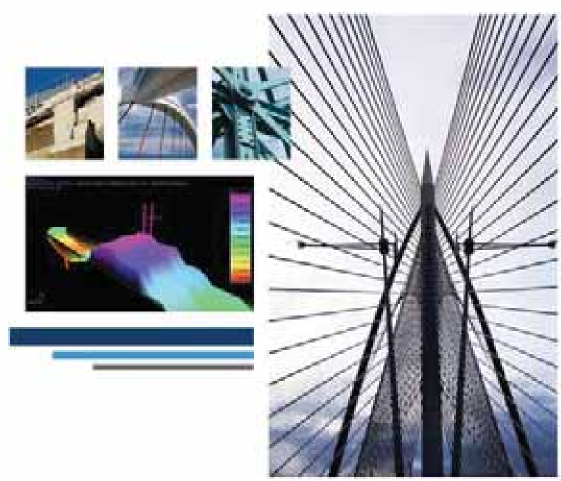

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