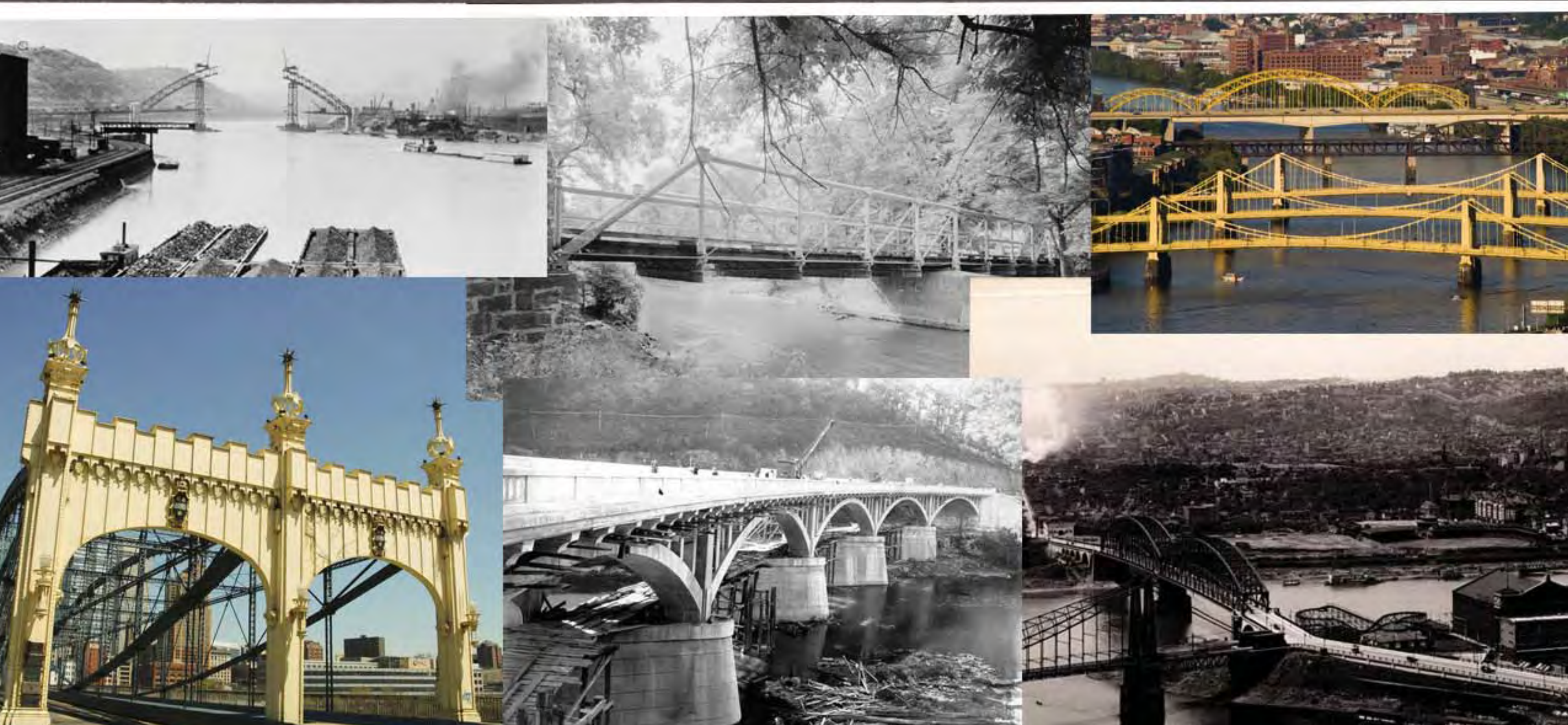
Pittsburgh ENGINEER

Summer 2009

Quarterly Publication of the Engineers' Society of Western Pennsylvania

Pennsylvania Bridges: Then and Now



Summer 2009 - Special Conference Issue

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Official Publication of the Engineers' Society of Western Pennsylvania

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Pittsburgh ENGINEER is the quarterly publication of the Engineers' Society of Western Pennsylvania (ESWP). The ideas and opinions expressed within *Pittsburgh ENGINEER* are those of the writers and not necessarily the members, officers or directors of ESWP. *Pittsburgh ENGINEER* is provided free to ESWP members and members of our subscribing affiliated technical societies. Regular subscriptions are available for $10 per year.

PENNSYLVANIA BRIDGES... *Then and Now*

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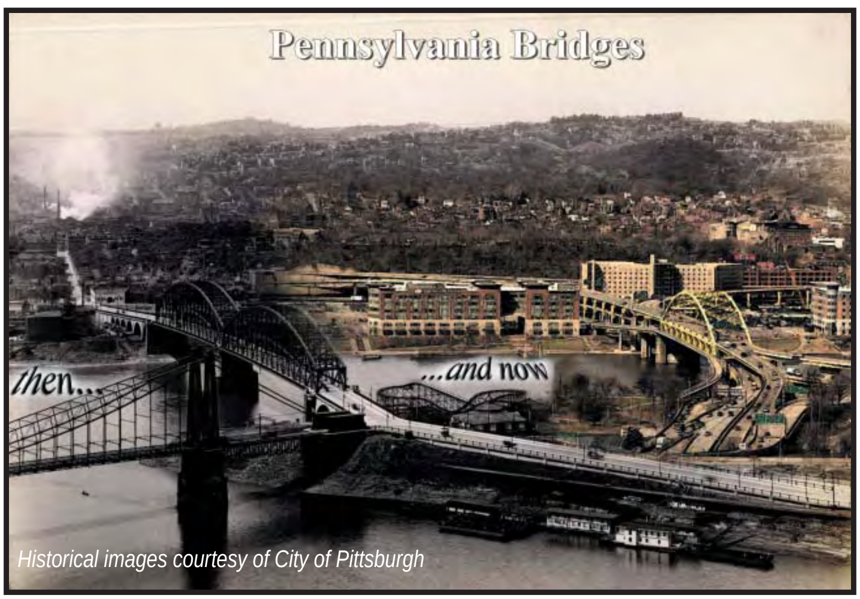
What is a single, visible yet changing measure of progress of a technological society–what marks our advance towards progress?

As one crosses the Commonwealth of Pennsylvania, the challenge of topography–streams, rivers, mountains–has historically provided barriers and opportunities to growth. As our society has become more and more mobile and interdependent on a myriad of resources, a variety of transportation networks have developed. While the modes and emphasis of transport can change quite quickly, the backbone of this transportation system can remain in place for many generations. The most visible elements of our many transportation systems–that is its backbone–are our bridges. It is this backbone of transportation that our special magazine edition is dedicated to.



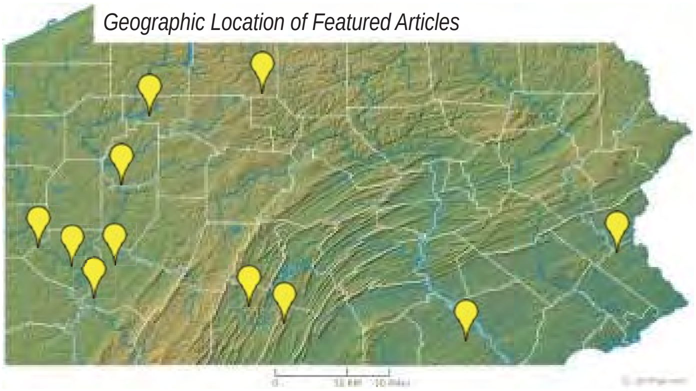
Historical images courtesy of City of Pittsburgh

The Commonwealth of Pennsylvania is crisscrossed with streams and mountain ranges. For a relatively short period of 150 years, the mode of transportation has changed from horse and buggy to train to automobile. The challenges of topography have provided engineers with many opportunities to design and build. From the rolling hills in the south east to the central mountain gaps to the steeply sloped stream dissected valleys in the west and to the glaciated plateaus in the north, nature has provided barriers to transportation. Through ingenuity the obstacles provided by these barriers have been overcome by many unique transportation modes and routes. The signature element of our transportation network is the bridges – bridges built in time with the resources and technologies of that time. As we look over the landscape of the bridges of our transportation system, we are not only looking at technologies of the present, but in many cases technologies of 100 years ago or more–and what a change has occurred in this time period.

If we could look at a bridge site and view it from a continuum of time for a period of say 150 years, we would watch the march of technological progress from rudimentary, simple yet practical structural forms to a more robust and in many cases sophisticated examples of skilled engineering and construction. We would watch the march away from trade construction to an era of scientific design capitalizing on the ingenuity and skill of a highly trained, well equipped and mobile construction work force.

This special issue is dedicated to the visible yet changing measure of progress as best illustrated by the bridges of PA. With Pennsylvania as the featured state of this year's International Bridge Conference®, what better way to represent this measure of progress than capture illustrations of bridges *then and now* from around the Commonwealth. The eleven feature articles of this magazine are dedicated to telling small bridge stories–vignettes–from the four corners and central core of the Commonwealth. Each article is a short, impressionistic scene that focuses on one or moments of the life of a bridge.

You, the reader, will walk away with a new and particular insight into the setting and character of the bridge. In the many locations that these articles illustrate, the bridge you see today is the third or fourth generation of bridges at that site. In other cases, the bridge is the original bridge, but its mode of transportation or purpose has changed from significantly from its time of inception. Each article has its own unique story–a story of birth–rebirth–and in many instances preservation.


Geographic Location of Featured Articles

Enjoy this trip through the Commonwealth–as we start at Pittsburgh at the point, travel north, then east then back west to our starting point. It is not only the Pennsylvania's story, but our nation's story. All of our contributing authors have enjoyed illustrating each of these visible yet changing measures of progress.

Bridge Quiz

The photographs below show bronze ornamental portals affixed to the Manchester Bridge, which was constructed across the Allegheny River in Pittsburgh in 1917. Which of the following names correctly represents ONE of the iconographic figures seen on the portals:

A. Joe Magarac
B. Chief Guyasuta
C. Jan Volkanik
D. Christopher Gist

(Answer on Page 30)

Chairman's Message

By: Louis J. Ruzzi, P.E.

Pittsburgh at the Point c. 1915

As this year's chairman, I am pleased to welcome all of you to the 26th Annual International Bridge Conference. The Executive Committee of the International Bridge Conference®, has been planning for 12 months in anticipation of the IBC-2009.

For those of you who are attending the IBC for the first time, we trust that you will find the Conference a rewarding and exciting educational experience. For those who have attended IBC previously, we eagerly anticipate your return to Pittsburgh. Come, learn about the latest technical developments and take full advantage of the many networking opportunities afforded by our Conference.

We are proud to announce the following major features and events at the 26th Anniversary of the IBC:

An Outstanding Keynote Session:

Our Keynote session will feature nationally known leaders, including:

- U.S. Congressman Representative James L. Oberstar, Chairman of the Committee on Transportation and Infrastructure (invited),
- M. Myint Lwin, P.E., Director of Office of Bridge Technology, FHWA,
- Pennsylvania DOT Secretary and AASHTO President Allen D. Biehler, P.E.,
- Malcolm T. Kerley, P.E., Virginia DOT's Chief Engineer and Chairman of the AASHTO Subcommittee on Bridges and Structures,
- Daniel L. Dorgan, Minnesota DOT Director, Office of Bridges and Structures.

A Superb Featured Agency–the Pennsylvania Department of Transportation:

As the featured agency for this year, the IBC Executive Committee sought to invite a DOT that has been a leader on numerous transportation issues over the years. This year is no different for PennDOT, as they have embarked on one the most aggressive bridge programs in the country with their Accelerated Bridge Program (ABP). In addition to the ABP, the Department will have a number of speakers on a variety of bridge topics including bridge problems/solutions, bridge fabrication QA/QC, 100 year life for bridges, historic bridges and bridge inspection to name a few.

Our New Location:

For the second year in a row, the IBC will be located at Pittsburgh's new David L. Lawrence Convention Center. The conference hotel headquarters will be the adjacent Westin Convention Center Hotel. The relocation of the Conference has allowed for major changes in the Exhibit Hall, a major feature of the Conference.

An Expanded Trade Show:

We are planning for an all-time-high number of Exhibitors. They are all providers of goods and services to the bridge industry. IBC has traditionally had a long list of exhibiting firms who see the value in IBC and return year after year. They are joined by some many, new firms. We heartily welcome both those returning as well as the first time exhibitors.

An Expanded Technical Program:

The Technical Program continues to build on its success from last year by offering over 100 technical presentations. The sessions topics include:

• Design	• Design/Build
• Bridge Evaluation	• Construction
• Context Sensitive Design	• Long Span Bridges
• Bridge Monitoring	• Bridge Rehabilitation
• Bridge Management	•Accelerated Bridge Construction

This year, the IBC will offer an additional 17 workshops on a variety of topics. A full schedule of these can be found on the IBC web site (www.eswp.com/bridge).

Concluding Thoughts

The end result of any one person attending IBC, is that you will be able to take back knowledge that will improve your preservation/rehabilitation/replacement projects, inspection/analyses of bridges, bridge maintenance techniques and constructability methods. Have a great conference!

Louis J. Ruzzi, P.E. is the District Bridge Engineer for PennDOT District 11-0.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THE MANY BRIDGES AT THE PITTSBURGH POINT

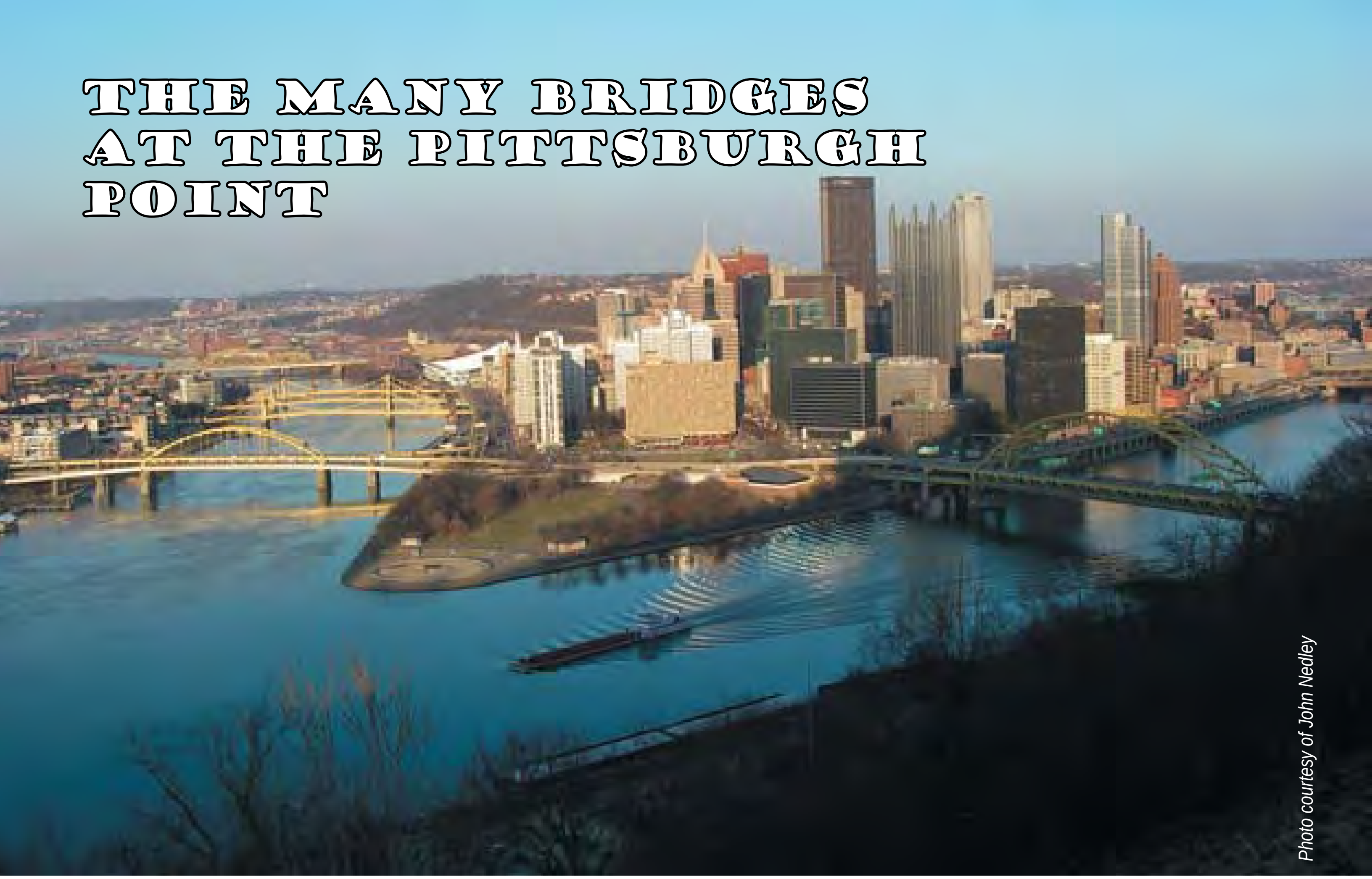


Photo courtesy of John Nedley

Contemporary Pittsburgh at the Point

By: John M. Nedley, P.E.

"As I got down before the canoe, I spent some time in viewing the rivers, and the land of the fork; which I think is extremely well situated…"
– Journal entry, George Washington, 1754

The Point at Pittsburgh where the Allegheny and Monongahela Rivers join to form the Ohio River is a widely recognized symbol of the city. Just as the rivers converge at the point, so have the transportation routes connecting at first the separate cities of Birmingham (south side), Manchester (north side) and Pittsburgh when the region was the hearth of the nation. The first crossings were modest but handsome structures, then utilitarian structures, and finally iconic structures. And perhaps the greatest bridges were never built. These are their stories.

First Generation Crossings.

In 1819, the first wooden bridge crossed the river upstream from the point, but was destroyed in the great fire of 1845. Around 1840, Captain Erwin established the first steam ferry across the Monongahela River at the point; but the ferry crossing at this location was not successful.

The first permanent Allegheny River crossing at the Point, the Union Bridge, was a wooden covered toll bridge that opened to traffic in 1875. It was the last of the wooden river bridges in Pittsburgh. The bridge's skeleton was a long Howe truss bridge supplemented with auxiliary arches. Its deck included twin sidewalks and the bridge was fitted with elaborate wood portals. The Union Bridge with five spans founded on heavy stone piers afforded low underclearance, making it an obstruction to river traffic. In 1903 the Secretary of War directed the bridge owners to make alterations to accommodate shipping on the Allegheny River. Unable to alter the structure as required, the company demolished it in 1907.

Two years later in 1877, the first bridge over the Monongahela River near the Point, Point Bridge #1 (as it was called), a handsome stiffened eyebar chain suspension bridge with an 800' main span, was completed. The specifications for the Point Bridge called for a moving load of 1,600 lbs. per lineal foot, to be carried by the structure in addition to its own weight, with a factor of safety of 5–a state of the art design for its day. As a direct connection to the Duquesne Incline, it remained in service until it was replaced in 1927, but had many persistent problems–the most interesting–the articulated hinge at the center of the main span, which would cause fully loaded trolleys to get "wedged" at the center of the bridge.

Second Generation Crossings.

It was not until 1915 that a replacement bridge was built over the Allegheny River at the Point. The Manchester Bridge, replete with ornamental symbols, had a pair of through-truss main spans at 531' each. It stood until 1970, when the north approach spans to the Fort Duquesne

Bridge were completed.

Point Bridge #1 remained in service until it was replaced in 1927 by Point Bridge #2, a through arch-truss with a cantilevered center span. Its main span over the navigable channel was 430' long. The design carried the approval of the Pittsburgh Art Commission, who had recommended that the top and bottom cantilever elements should curve downward to harmonize with the nearby newly constructed Manchester Bridge. The Point Bridge was taken out of service in 1959 with the completion of the Fort Pitt Bridge, but it wasn't dismantled until 1970, along with the nearby Manchester Bridge over the Allegheny River.

Third Generation Crossings.

From the genesis of the Allegheny Conference on Community Development, the Point Park Commission was established in 1945 and laid the plans for the present river crossings and park land integral to the new bridge alignments. By 1959 the interstate highways had come to Pittsburgh and the Fort Pitt Bridge over the Monongahela River was opened to traffic, followed by the Fort Duquesne Bridge over the Allegheny River. At present, I-279 approaching from the north, crosses the Allegheny River on the Fort Duquesne Bridge and merges on the Fort Pitt Bridge with I-376 from the east. The roadway continues toward the west and south as I-279.

Library and Archives Division, Sen. John Heinz History Center

Pittsburgh's Point 1960

The Fort Pitt Bridge was completed in 1959, connecting downtown with the south shore like the two previous structures, but also with the communities to the south and west by way of the Fort Pitt Tunnel. The double deck tied arch bridge has a main span of 750'. The tie is a warren truss.

The Fort Duquesne Bridge is also the third crossing at its location. With a main span of 423', the shorter Fort Duquesne Bridge is nearly identical to Fort Pitt. Although it was completed a couple years after the Fort Pitt Bridge, it wasn't put into service until 1969 with the completion of approach spans on the north side of the river. In the interim, the Fort Duquesne Bridge was well known locally as The Bridge to Nowhere.

The Fort Pitt and Fort Duquesne Bridges were among the last major bridges to be fabricated and erected with riveted construction. The approach spans on both sides of the Fort Pitt Bridge have riveted girder superstructures with the curves in the roadway formed by splayed and chorded girders.

The Fort Pitt and Fort Duquesne Bridges have four lanes on each of two levels. Both decks on both bridges have converging ramps at their entrances and diverging ramps at their exits, creating short, congested weave areas. The traffic conflicts can be particularly challenging on the Fort Pitt Bridge, which carries more traffic than any other bridge in Western Pennsylvania.

The approach ramps on the north side of the Fort Duquesne Bridge were completed at two different times, reflecting the evolution of bridge building. The first set was completed in 1969 and is supported on welded steel box girders. The approach roadways to the north, which were completed in the mid 1980's, have prestressed concrete I beam superstructures.

A wide pedestrian walkway was attached to the downstream side of the Fort Duquesne Bridge in 1998 to provide better access to Three Rivers Stadium from downtown.

The Greatest Bridges Never Built.

There were other interesting ideas for river crossings near the Point. Twice in the 19th century plans were presented to construct a three part bridge in which two parts crossed the mouths of the Allegheny and Monongahela Rivers, meeting over the water and joining a third part that extended from the Point. The original 1846 proposal for the Tripartite Bridge included design concepts by John Roebling, who began his bridge building career in Pittsburgh with his first cable suspension bridge constructed over the Allegheny River.

Image courtesy Jonathan McHugh

The Greatest Bridge Never Built

There were many reasons why the Tripartite Bridge wasn't constructed, including funding issues and concerns over obstructing river traffic. Furthermore, the three main spans were proposed to be suspension bridges with cables converging at the center. Although striking to view, it presented numerous structural design problems.

The idea was floated again in 1871 after Roebling's death, but there were still too many obstacles to overcome. Of course, the convergence of three roadways at an intersection over the water would likely have presented far greater traffic problems than that which currently exists.

If George Washington could revisit Pittsburgh in 2009, his journal entry might now read: *"As I traveled to downtown from the airport, I exited the tunnel onto the Fort Pitt Bridge and the skyscrapers and park burst into view …, I admired the rivers, and the land of the fork; which I think is extremely well situated…"*
– Journal entry, George Washington, 2009.

John M. Nedley P.E., is a forensic civil/structural engineer for EFI Global in Cranberry Township, PA. He can be reached at john_nedley@efiglobal.com.

Rebuilding a Basin of Bridges:

From Warren to Emlenton on the Allegheny River

By William C. Koller, P.E.

If you took a canoe trip from Warren to Emlenton in Northwestern Pennsylvania in 1982 and then again today, you would see some amazing changes in the highway bridges you paddle under. The bridges on this portion of the Allegheny River are a unique record of the advances in bridge technology, construction and design. The year 1982 is significant because it was the year Pennsylvania passed the "Billion Dollar Bridge" program. Supported with a new stream of funding dedicated solely to rebuilding bridges, this was the beginning of a new era in Pennsylvania bridge building. It is also the foundation of the bridge program we have in place today.

In 1982, you would have traveled under 9 trusses, 1 steel girder, 1 prestressed girder and 2 concrete arch bridges. Contrast this with a canoe trip now – 2 trusses, 7 steel girders, 4 prestressed girders and no concrete arches.

Design

The bridge design performed before 1982 used slide rules, hand calculations and Allowable Stress Design. Compare this to designs today that are done with computer programs using Finite Element Analysis and Load Factor Resistance Design. In the early 1980's, the computer programs were very primitive or did not exist. Today we have sophisticated computer programs for all the parts of a bridge and they do all the code checks and size the rebar.

Bridge drawings now commonly have over 60 sheets that include almost every detail; they are electronically stored and sent to the contractor for him bid on. Contrast this with the original Irvine Bridge, a 1927 open spandrel concrete arch, which was built from 6 sheets of ink drawn velum, with one sheet 6 ft long! In 1982, drawings were still done in ink but Mylar had replaced vellum. Ink gave way to pencil and then Computer Aided Drafting and Design, CADD, replace all hand drafting starting in the mid 1980's.

Alternate Bidding

PennDOT's alternate bidding process has played a part in the advance of bridge technology. The Irvine replacement bridge was designed as a three span steel bridge but the low bid was for a six span pre-stressed bridge using live load continuity. This was the first pre-stressed bridge built for live load continuity in Northwest Pennsylvania. Because of this the Emlenton Bridge was designed as a 6 span pre-stressed concrete and the alternate bid was for a three span steel bridge!

Continuous, multi-beam bridges replaced simple span trusses and used leak-proof expansion dams. The endangered mussel issue has changed the type of bridge since the mid 1990's to favor long span, multi-girder, weathering steel bridges. The last remaining bridge to be rehabilitated or replaced is the SR 62, Hunters Station Bridge (Figure 1) that is currently a three span, ½ thru truss with three steel girder approach spans. The current proposed bridge is a 4 span, weathering steel bridge.

Figure 1 – Hunters Station Bridge – the last bridge to be replaced

Steel and Fracture Critical.

The steel bridges on this stretch of the Allegheny River showcase the advance of steel technology from bridges with short, rolled section members (trusses) to deep plate girders fabricated from long plates of rolled steel. Steel yield strengths have gone from 30 ksi to 70 ksi. (Figure 2).

Figure 2– West Hickory Bridge – Long span, multi-girder, weathering steel bridge

In the progression of bridge design from trusses to long span, plate girders; the Route 62 Tionesta River Bridge is the only two girder bridge and the last fracture critical bridge (1961) built over the river. By the time the Billion Dollar Bridge program came about, bridge design had progressed away from two girder designs that were fracture critical (like the Minnesota, I-35 bridge) to non-fracture critical, multi-girders designs starting with the Emlenton and Glade Bridges. Weathering steel replaced painted steel in 1990 with the State Street Bridge in Oil City.

Prestressed Concrete.

Prestressed concrete beams were first used in 1975 with the new Warren Bypass and then again on the Irvine bridge as the first Billion Dollar bridge built over Allegheny River. The beams were 66 inch deep box beams and were the first made continuous for live load. The beams were also the first to use debonded strands instead of draped stands – all an alternate design. The Hickory Street Bridge (Figure 3) used deep adjacent box beams with façade panels, form liners, alcoves and special street lighting to replicate the look of the original concrete arch bridge – a first in the area. Prestressed concrete beams have also gotten stronger, going from 4,500 psi to 8,000 psi design strength.

Figure 3 – Hickory Street Bridge – Prestressed Bridge with arched fascia panels

Construction Equipment

The beams for Hickory Street were set with one of the biggest cranes in the area, a 750 ton crane. Big hydraulic cranes are part of the progression away from river spanning causeways, small cranes and smaller beam lengths to minimal causeways and temporary bridges, longer spans and a highway system that can handle longer, heavier beams.

The first track hoe appeared on the Warren Bypass project in 1975 and by 1982 was the standard equipment for demolition and excavation of piers and abutments. Track hoes have continued to revolutionize bridge building with attachments like the hoe ram, grapple and auger and they now come in any size.

Allegheny River Bridges - Warren, PA to Emlenton, PA		
Bridge Name	Current Bridge Type - Year Constructed	First Bridge - Year Constructed (if known)
Tidioute Bridge	Truss-1933	
Hunters Station Bridge	Truss - 1934 (scheduled for replacement)	(Ferry Crossing)
Tionesta River Bridge	Steel Girder - 1961	Truss
Warren Bypass	Prestressed - 1976	none
Irvine Bridge	Prestressed - 1985	Concrete Arch - 1927
Eight Street Br	Prestressed - 1986	Truss
Glade Bridge	Steel Girder - 1987	Truss
SR 38 Emlenton Bridge	Steel Girder - 1987	Covered Bridge–1856; Truss, Wrought Iron, 1883
State Street Bridge	Steel Girder - 1990	Truss
Petroleum Street Bridge	Steel Girder - 1995	Truss - 1924
Kennerdell Bridge	Steel Girder - 2000	Truss - 1907
Hickory Street Bridge	Prestressed - 2005	Suspension - 1871; Concrete Arch - 1917
West Hickory Bridge	Steel Girder - 2007	Truss - 1896

Conclusion.

When the Hunters Station Bridge is replaced all the bridges on this stretch of the Allegheny River will have been replaced or rehabilitated. The Tidioute Bridge will be the only reminder of the era of truss bridges that dominated the river crossings for more than a century.

District 1 has been only one part of this bridge building effort – we have accomplished this with the team work of many contractors, designers, planners, municipalities, and taxpayers. We can all be proud of the results and expect these bridges to carry our grandchildren into the next century.

This discussion would not be complete without recognizing that the advance of technology has not left your watercraft untouched either. The aluminum canoe you started with in 1982 is now a high tech, light weight, plastic kayak that you easily hoist onto your hybrid SUV!

William C. Koller, P.E. is the District Bridge Engineer, PennDOT District 1-0, Oil City, PA

THE FOXBURG BRIDGE: Design Faces Nature

By: Christopher T. Vollmer, P.E., PMP and Jim Andrews, P.E.

2009: Foxburg Bridge

***"An immense body of ice ... struck [the Foxburg Bridge]… last Friday [and] left not one stone upon another …"* (Winter 1873)**

Since the beginning of the engineering profession nature has played a vital role in dictating how structures are designed, and one unique example of this is the Foxburg Bridge where the design of the structure has adapted to these dictating forces of nature.

Ice related events consisting of ice jams, dynamic ice floes and static vertical ice forces are always a concern for the design of river crossings in cold weather climates and the history of the Foxburg Bridge, which spans the Allegheny River in northwestern Pennsylvania, proves that these forces must be respected.

Original Bridge

The original Foxburg Bridge on the border of Clarion and Armstrong Counties was constructed in 1873 by the Wrought Iron Bridge Company of Canton, Ohio. The original structure consisted of a two span, bowstring arch truss which was supported by stone masonry abutments and a center pier. The construction of this original structure immediately faced nature when the river pier was destroyed by an ice floe in the winter of 1873. The Titusville (PA) Morning Herald's headline read "Bridge Destruction: The pier for the new bridge across the Allegheny at Foxburg was built last fall and was masonry, but the immense body of ice that struck it last Friday left not one stone upon another...". This unfortunate event only delayed the completion of the arched structure and it was eventually completed late that summer.

This original structure was soon replaced by a wood Howe Truss bridge in 1883. The replacement of this structure was most certainly dictated by the rise in rail traffic in the late 1800's and this multi-level bridge had the capacity to carry trains across its top chord and wagon and pedestrian traffic along the lower level. The original center pier was replaced with two river piers which were required to support the increased loads however this new configuration was once again a victim of ice damage when the truss was damaged by an ice jam around the year 1900. All damage was quickly repaired and all traffic resumed normal operations.

1883 Foxburg Bridge: Howe Truss (Courtesy of Foxburg Library)

The 1921 Bridge

The 1883 bridge served the rail industry and the Foxburg community for nearly 38 years, however the need for a stronger, more durable structure was overdue and the dual purpose bridge was once again replaced in 1921. The 1921 replacement consisted of a 538 ft. long, three span, steel, riveted, warren through truss superstructure which was supported by ashlar stone abutments and piers. Like its predecessor this unique structure supported a single lane of vehicular traffic on the steel grid deck below while a rail line was supported by the top chord of the truss. This multi-functional feature remained in operation until the rail line was shut down 1964. Since then vehicles remained on the low chord of the narrow bridge until it was demolished and replaced in 2008.

Throughout the 87 year life of this historic structure it was able to avoid major ice events mostly due to a favorable climate but also because in 1964 the Allegheny Reservoir was built on the border of Pennsylvania and New York State. The construction of this reservoir was able to regulate the winter flood peaks therefore minimizing the potential for large ice floes and ice jams. Even with a favorable climate and flood controls in place the foundations of the existing steel truss bridge slowly began to show effects

2006: 1921 Foxburg Bridge spanning a frozen Allegheny River

of deterioration due to the continuation of ice moving and accumulating in the winter months around these river piers.

Such accumulation of ice around these structures causes the flow of the river to plunge downward against the river bed and this affect can increase both local and contraction scour. The existing masonry piers at Foxburg were susceptible to ice accumulation which made these supports vulnerable to ice induced scour.

The 1992 Bridge Inspection Report prepared for the Pennsylvania Department of Transportation indicated that significant scour, deterioration and settlement had occurred at the timber cribbing supporting both masonry river piers. This underwater condition of the piers as outlined in the report was deemed “serious” and prompted a temporary repair at both locations. This repair however did not limit the potential for ice induced scour. This was evident at one pier location by the regular appearance of a large area of cyclonic flow on the downstream side of the support consistently swirling until the day it was demolished.

Although this historic structure avoided an extreme ice event during its service life, nature certainly impacted the bridge as ice slowly aided in the erosion of its supporting elements.

The 2008 Bridge

As the Pennsylvania Department of Transportation began studying potential replacement structures for the existing Warren through truss, many discussions revolved around the magnitude of the ice forces on the proposed piers. Additionally the thought to lower the existing profile made practical sense with the newly proposed upstream alignment and the approach roadways; however, this led to concerns for ice striking the low chord of the new bridge.

Based on the known history of ice related damage on the previous structures and the decreased effect on ice processes since the construction of the Allegheny Reservoir, the design team decided to further study the potential for ice related events at the project site. The study of the ice conditions at Foxburg were conducted in an effort to develop site specific design criteria to minimize construction costs while at the same time respecting potential ice conditions.

The findings of this report, “Ice

2009: Foxburg Bridge

Conditions and Design Criteria: Proposed Bridge on the Allegheny River at Foxburg, PA”, were based on the CRREL ice jam database, anecdotal accounts from the local residents, quantitative data on ice jams and ice-related water levels at nearby Parker, PA, and statistical modeling. The conclusions of this investigation included a design 100-year water elevation which was used to set the low chord of the new structure, and site specific ice forces which were used to design the 8 ft. diameter, drilled shaft river piers.

The newly constructed four span, steel, multi-plate girder bridge, which was completed in the fall of 2008, was able to benefit from the careful consideration of the project site history and the site specific ice criteria. These benefits included a reduced profile grade of approximately 7 ft. from the 1921 structure, the use of circular river piers reducing the potential effects of ice induced scour, and piers which were designed for more refined ice forces than those defined in the AASHTO code.

The design of the Foxburg Bridge has adapted since the first structure was constructed over 125 years ago by adjusting to the community mobility needs and the conditions induced by nature. By studying and respecting these local ice affects, the new Foxburg Bridge over the Allegheny River can now withstand these forces of nature in an effective and efficient manner and will serve a thriving Foxburg community for many years to come.

Christopher T. Vollmer, P.E., PMP, works for Gannett Fleming Inc. and Jim Andrews, P.E., is Bridge Engineer for PennDOT’s District 10-0.

The Foxburg Bridge is owned by the Pennsylvania Department of Transportation. Gannett Fleming was the Engineer of Record and Beech Construction Company was the General Contractor for the 2008 Bridge. Northwest Hydraulic Consultants, Ltd. prepared the Ice Report to support the design of the 2008 Bridge.

KINZUA MEMORIES

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

Photos courtesy of the HAER Collection

On July 21, 2003, a 300-foot-tall railroad structure spanning a gorge in north-central Pennsylvania collapsed dramatically as a tornado touched down just east of the structure. A bridge that was the tallest in the work when built in 1882 and that had carried trains for more than a century after it was rebuilt in 1900 was gone in just 30 seconds. Twenty-three of the viaducts forty-one spans catastrophically collapsed. The forensic investigation conducted in 2003 for DCNR determined that steel elements connecting the towers to the foundations at the east tower bases had fractured, making the structure, with its south to north orientation, vulnerable from winds from the east, which would only occur in the cyclonic flow of tornado winds.

Relive the history of the magnificent structure, which was an integral part of Kinzua Bridge State Park, the jewel of the Pennsylvania State Park system, through the eyes and expression of many who were truly close to the bridge. These eyewitness accounts, from both professional and lay perspectives, emote strong feelings of accomplishment, fear and wonder.

"We'll build you a bridge a thousand feet tall…if you'll provide the money"
Aldolphius Bonzano, Phoenixville Bridge Company to General Kane owner of the New York, Lake Erie and Western Railroad and Coal Company Railroad deciding between two alternative routes to the north; one was the construction of four miles of tortuous, twisting two percent grade; the other the erection of a railroad viaduct loftier than any yet built by men. The General had the money and built the first Kinzua Viaduct in 1882. The Phoenixville Bridge Works assembled the Kinzua Viaduct in an amazing 94 days.

"..as the Great Great Grand Daughter of General Kane I have a special spot in my heart for Kinzua Bridge and the whole Allegheny Forest Area…I have traveled with my husband and daughters there several times and am always in awe in the majesty and beauty of the area and the bridge" :
Susan Sclafani, Largo, FL, Family Descendant of General Kane, builder of first Kinzua Viaduct, as reported in Find Yourself in the Forest, Allegheny National Forest Vacation Bureau www.visitanf.com

"To span the valley, the Kinzua Viaduct had to be the loftiest Structure of its kind on earth. "
W. George Thornton, Erie Railroad Magazine, August 1949.The structure was rebuilt in 1900 to handle heavier trains. The rebuilt viaduct maintained the same grade line, the same foundations and same spans as the original viaduct. The company's chief engineer, Octave Chanute (the same Octave Chanute whose glider research would later inspire the Wright brothers) was instrumental in both the design of the first and second KinzuaViaduct. Trains rumbled over the gorge until 1959 when it was sold for scrap.

The Kinzua Viaduct is a "truly heroic nineteenth-century railroad bridge… it has stood rusting in a remote part of northwestern Pennsylvania ever since the Erie Railroad abandoned it in 1959, but its future is far happier than that of most unused bridges."
David Plowden, Invention and Technology Magazine, Winter 2003. Nick Kovalchick, a scrap and salvage dealer, got the contract to demolish the viaduct, but he could not bring himself to destroy such a beautiful structure, and he persuaded the state to build a park around it. Kinzua Bridge State Park and sold the bridge to the state in 1970 for the exact amount of money he had purchased the bridge from the Erie Railroad Company.

"A picture I have kept on my desk through three hard years of architecture school is my youngest brother and two eight year-old friends playing at the Kinzua Viaduct on a clear June day in 1998. …I measure nearly every building I visit against that moment with my brother at the girders of the viaduct. As I visit architectural landmarks, I ask questions of them, not of my architectural education, but of the childhood railroad bridge where I climbed as though life stood still. Would Wright's Falling Water invite children to play on its foundation? Would the Pompidou Center spark Paris tourists to race as they climbed its long staircase from bottom to top? Would parents and their babies at Gehry's Bilbao gleam with pleasure as they touched its curving metal walls?"
Rebecca Shaffer, Eugene, Oregon reported in Find Yourself in the Forest, Allegheny National Forest Vacation Bureau www.visitanf.com In 1977, the Kinzua Viaduct received national recognition when it was placed on the National Register of Historic Civil Engineering Landmarks.

"To everything there is a season … a time to be born, … a time to … "
Ecclesiastes 3. On July 21, 2003, a series of unfavorable weather conditions produced a mesoscale convective system (MCS) accompanied by intense storm fronts, encompassing eastern Ohio, western Pennsylvania, western New York and southern Ontario.

"We ran the tourists until October of 2004, but for the two years after the bridge closed, the number of riders declined by 75 percent,"
Teri West, daughter of owner of The Knox & Kane Railroad which opened in the early 1980s and started carrying passengers over the 301-foot high, nearly half-mile long bridge in 1987, prior to the sale of entire inventory from steam engines to lanterns, reported in The Daily Item, September 28, 2008.

"… all hell broke loose … trees were falling all around ... the wind was howling like I have never seen or heard before…"
Shawn Baker, construction worker and eyewitness to the July 21, 2003 collapse. The weather system produced a series of spiral-like cloud banks that moved in counterclockwise direction as the MCS tracked in an easterly direction. At the leading edge of the front, the combination of wind shear and moisture within afternoon instability initiated intense thunderstorms and a series of tornadoes along the Pennsylvania/New York border.

"It was raining and blowing very hard as I left the trailer and I heard a series of boom, boom, booms, like thunder. Leaves and branches were starting to fly, so we hurried to our truck, and by the time we reached the park gate, the trees on either side of the road were bending down toward each other… it took us a while to climb through the downed trees and wreckage to a point where we could see. It looked all right at first, but when we got closer, we saw that the whole middle was gone. Then I realized the booms I'd heard were the towers hitting the ground one by one."
Floyd Quillin, Site Construction Superintendent, W. M. Bodie Co., July 21, 2003, reported by Katie Jaeger, Invention and Technology Magazine, Winter 2004. The tornado produced a complex damage pattern, most likely the results of its fast forward movement and its interaction with the rugged terrain. The structure was attacked by easterly leading edge winds due to the cyclonic motion of the tornado and from the south by inflow winds generated by the tornado. In some locations tress were blown in multiple locations.

"[it] just laid over on its side."
Barrett Clark, manager of Kinzua Bridge State Park, who came to the site to find trees snapped off, a tangle of debris, and after freeing a park worker trapped inside a collapsed shed viewed the bridge. Pittsburgh Post Gazette, Wednesday, July 23, 2003

"After 121 years, viaduct falls victim to tornado "
Pittsburgh Post Gazette, Wednesday, July 23, 2003

"As professional engineers, we often design and build structures, such as the Kinzua Viaduct, albeit seldom of its magnitude. However, rarely does the opportunity arise to step outside the purely quantitative realm of design codes and material properties to conduct an investigation in the manner of a detective or private investigator."
Jonathan McHugh, a member of the team of engineers and scientists which conducted the (Board of Inquiry) forensic investigation of the collapse for the PA DCNR, PE Reporter March/April 2006.

"When a magnificent structure like this falls down, it drives home the importance of documentation … Though this is certainly not the ending we had anticipated, we are going to follow this story wherever it leads us... This tornado is just one more event in the life of the bridge."
Lisa Gensheimer, video documentarian, reported by Katie Jaeger, Invention and Technology Magazine, Winter 2004

"I've had people from Vermont, West Virginia, Maryland and even Vancouver, Canada, contact me about some of the items in the auction."
Mike Peterson, whose auction and realty company in Jamestown, N.Y. ran the sale of the Knox & Kane Railroad, reported in The Daily Item, September 28, 2008. Not to be dissuaded, the owner of the structure, PADCNR, has developed bold plans to strengthen the portions of the damaged viaduct and maintain the site as an interpretative center, attesting to the power of nature.

"It would be an octagon out at the end with a see-through floor…If you go all the way out to the end of what's left, it's about a 220, 240-foot drop."
Jason Zimmerman, manager of the park complex, describing ambitious plans of the PA DCNR to restore the site as an interpretive center which could include constructing a see-through platform on one of the remaining towers, as reported by Dan Majors, Pittsburgh Post-Gazette, March 2, 2009.

Thomas G. Leech, P.E., S.E., National Practice Bridge Manager, Gannett Fleming Inc. Tom was the principal investigator for the PADCNR Board of Inquiry Investigation into the cause of collapse. Tom has published articles on this topic in Civil Engineering Magazine, ASCE Fourth Forensic Conference Proceedings, American Scientist Magazine, and International Bridge Conference® Proceedings.

Cast- and Wrought-Iron Truss Bridges of in the Vicinity of Bethlehem, PA

By: Ben T. Yen and Ian C. Hodgson

There are three historic truss bridges of cast- and wrought-iron in the vicinity of Bethlehem, Northampton County, Pennsylvania. All three were built around 1860-1870 by Charles Nathaniel Beckel of the Beckel Iron Foundry on Sand Island between the Lehigh River and the Lehigh Canal in the city of Bethlehem. Beckel adopted the design and construction technique of master bridge builder, Francis C. Lowthrop, who worked for the New Jersey Central Railroad.

One of these bridges is the Walnut Street Bridge over the Saucon Creek in Hellertown, south of Bethlehem. The bridge was erected at another site in 1860 as a three-truss "double-wide" through-truss bridge with a span of about 55 ft. One half of the bridge with two trusses was moved to the Walnut Street site in 1879. The two-truss bridges was replaced by a now-conventional beam-and-deck bridge in the 1960s, and was restored as a historical structure by volunteers from the Hellertown Historical Society. The project was initiated and managed several graduate students in the Department of Civil Engineering and ATLSS Research Center of Lehigh University. The bridge stands near its Walnut Street site, spanning a mill race from an historic grist mill, as shown in Figure 1.

The other two bridges are of the pony-truss type. The first bridge is a single span structure, built in 1870 on City Line Road in Bucks County. The bridge was moved in the 1980s from its original location to Sand Island in Bethlehem, spanning the Lehigh Canal and now serves as a pedestrian bridge. This bridge, currently called the Sand Island Bridge, "has come home to the Foundry", so to speak. The essential features of the bridge are basically the same as those of the Walnut Street Bridge and the other pony-truss bridge of this paper.

Figure 1 – View of the rehabilitated Walnut Street in Hellertown, PA

The second pony-truss bridge is the Old Mill Road Bridge, a two-span structure also over Saucon Creek in the township of Lower Saucon south of Bethlehem and west of Hellertown. Each span is 52 ft. long. Figure 2 is a photograph giving an overall view of the bridge. It was constructed in 1870 and remains at its original location. It is one of the oldest metal bridges in the country. In the 1920s, steel I-beams were strapped beneath the cast-iron deck beams (floorbeams) to strengthen them. These strengthening beams can be seen in Figure 2. A closer view is provided in Figure 3. The bridge was closed to vehicular traffic in 1983 because of cracks discovered in the deck beams. Today, only pedestrians are permitted on the bridge.

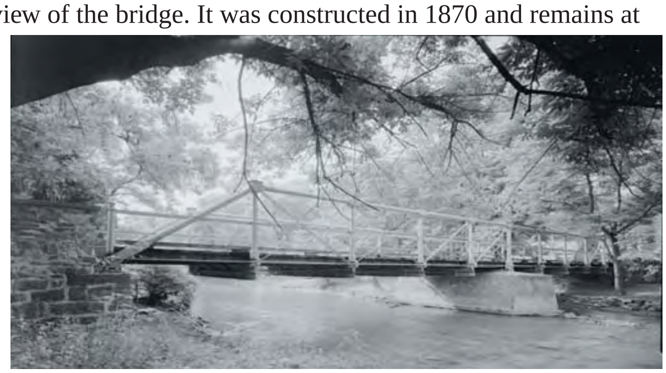


Figure 2 – View of the Old Mill Road Bridge in Lower Saucon, PA

Materials and Bridge Members

In the period of constructing these three and many other similar bridges, the strength and cost of cast-iron and wrought-iron were well recognized by the bridge builders. Cast-iron, brittle under tension, was less expensive whereas wrought-iron, relatively strong and ductile, cost more to produce. Consequently all

Figure 3 – Floor System of the Old Mill Road Bridge

compression members of the bridges were fabricated from cast-iron and the tension members, from wrought-iron. To increase the buckling strength, all compression members were made from tubular cross sections and sometimes tapered for aesthetics reasons as well as for reducing material and weight.

All verticals of the trusses were tubular-shaped compression members, including the hip vertical at the first panel adjacent to the end bearing. This is different from the usual condition of Pratt trusses in which the hip vertical is a hanger in tension. The change was achieved through the use of counters in the panels, as can be seen in Figures 1 and 2. With all verticals in a bridge being identical, this facilitated fabrication. The grouping of all compression chord members, tension chord rods, and web diagonals into respective identical shapes and sizes further simplified the fabrication process.

For the I-shaped cast-iron deck beams, the area of the tension element was increased by adopting a tapered width of the lower flange, being wider at the mid span of the deck beams. It is interesting to note that these deck beams contained integrally-cast vertical and diagonal web stiffeners, as can be seen vaguely in Figure 2 and Figure 3. These stiffeners rendered the deck beams to serving as floor trusses as well as floorbeams.

Panel Point Connections

The special features of the bridges are the connections of the truss and deck members at the panel points. At the upper chord panel points, the cast-iron compression members were in bearing against each other while the wrought-iron tension rods were attached using coupling nuts. Two examples from the Walnut Street Bridge are shown, at the hip joint (Figure 4) and at an interior upper chord joint (Figure 5). The ends of the cast-iron members are contained in an iron casting. The wrought-iron rods pass thought the casting with the securing nuts on the opposite side.

The lower chord panel point joints must incorporate the connection of the deck beams and the horizontal lateral bracing rods in addition to the lower chord rods and the compression verticals. These joints were the features of patents by master bridge builder Francis C. Lowthorp. Charles N. Beckel modified the configuration for his design. Examples from the Old Mild

Figure 4 – Chord panel point at hip joint on the Walnut Street Bridge

Road Bridge and the Walnut Street Bridge are shown in Figure 3 and Figure 6, respectively. In both cases the casing or "plate" of the joint was cast integrally with the deck beam. The lower chord rods were connected by pin in the Old Mill Road Bridge but by threaded rods and nuts in the Walnut Street Bridge. The cast-iron vertical sat on the "plate". The rods of the truss diagonals and the lateral bracing system pass through the connection casting and were secured by nuts.

Figure 5 – Upper chord interior panel point on the Walnut Street Bridge

All of these feature of the connections at panel points, with the prefabricated chords and web members, made the bridges "erector sets" by current description. This condition permitted easy moving of a bridge from one site and reconstructed at another site, as was the case for both the Walnut Street Bridge and the Sand Island Bridge. For the Walnut Street Bridge, it transformed a three-truss-line symmetrical bridge to a two-truss-line bridge with a sidewalk on one edge. This can be seen in Figure 6, which represented the connection under the center truss of the three-truss system. In its current configuration represented by Figure 6, the floorbeam only exists on one side, whereas originally floorbeams were present on both sides of this connection.

Figure 6 – Lower chord interior panel point on the Walnut Street Bridge

Pretensioning

The tightening of wrought-iron rods is essentially pretensioning of these members. As mentioned earlier, this technique applied at the truss diagonals and counters of the end panel permitted the conversion of the hip verticals of the bridges to a compression members. As a result, all truss verticals could be made of cast-iron.

The technique also allowed the two span continuous trusses of the Old Mill Road Bridge to act as single span Pratt Trusses. The situation avoided compression and buckling of the slender lower chord rods adjacent to the center pier, or tension and separation of the cast-iron upper chord members from their connections. Pretensioning of the lateral bracing members of wrought-iron rods at the lower level of the deck beams induced compressive forces in the beams and an upward, negative bending moment to the beam. This condition further increased the strength of these deck beams to carry live loads on the bridge.

Then and Now

The bridges were built about one and a half centuries ago for horses and buggies. That was then.

Now the knowledge and technology of bridge building have progressed tremendously due to the development of new materials, new construction techniques, new design concepts and the use of the computer. There are guidelines for reference and specifications to follow, strong and ductile steels for constructing structures, high strength and light weight concrete for use, and many newly developed composite (synthetic) materials to explore. With the vehicular loads on bridges much heavier than the horses and buggies, these advancements greatly aid in building safe and economical bridges.

Yet, are the concepts and methods of building those old bridges still applicable to some modern ones? Not all bridges are built for heavy tractor-trailers. Could the "erector set" concept be utilized for bridges on secondary roads in counties and cities? Would that help in maintenance of these bridges? These may be questions for interested bridge engineers to ponder. The concepts developed by the original bridge masters may be applicable to design challenges faced by today's bridge engineers.

Ben T. Yen is an Emeritus Professor of Structural Engineering, at Lehigh University. Ian C. Hodgson also works at Lehigh University

The photos used in Figures 2 and 3 are courtesy of the HAER Collection. Further information on these and other landmark bridges can be found in the Historic American Engineering Record (HAER) collections maintained by the US Library of Congress. The website is: http://memory.loc.gov/ammem/collections/habs_haer/

THE PINE GROVE COVERED BRIDGE

By: Robin Dominick, P.E.

The Pine Grove Covered Bridge carries SR 2006 over the Octoraro Creek between Chester and Lancaster Counties. The current bridge built by Elias McMellen in 1884, is a two span Burr-Arch Truss 198 feet, portal to portal and is one of the longest covered bridges in the Pennsylvania. The bridge is listed on the National Register of Historic Places (12/11/80) and the Octoraro Creek is listed on the Pennsylvania Department of Conservation and Natural Resource's (DCNR) Pennsylvania Scenic Rivers Program and is considered a 1-A Priority Waterway. The bridge is located just downstream of the Chester Water Authority's facilities.

Crossing the Octoraro

The location of the Pine Grove Covered Bridge was host to a ford and two bridges prior to the building of the current bridge. Before 1816, a ford was utilized to connect the two roads on either side of the Octoraro Creek. In 1813, citizens of the surrounding communities rallied Lancaster and Chester Counties to have a bridge built since this location was located on the National Stage Coach Highway from New York to Washington D.C. and the general inadequacy of the ford at this location. In 1816, the courts approved the bridge– one of the first bridge crossings over the Octoraro Creek.

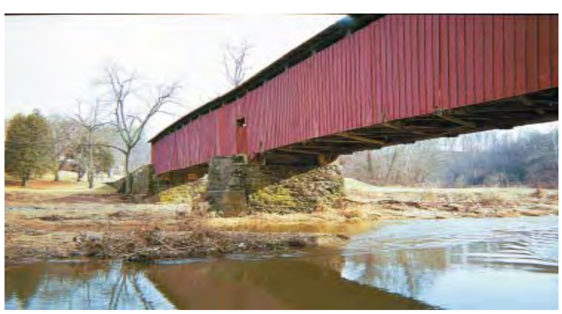
The first bridge at this site was built by Jonathan Webb of Lancaster County in 1816 and was either destroyed or washed away around 1845. This is known since there is a petition on record for a bridge identified as the Pine Grove Iron Works Bridge, at this location. The second bridge at this site was built in 1846 by Robert Russell and Joseph Elliot. In 1881 significant repairs were completed to the bridge. Three years later a significant storm that raised Octoraro Creek approximately 25 feet, damaging nearly all the bridges along its banks and destroying thirteen bridges, including the Pine Grove Iron Works Bridge.

The present Pine Grove Covered Bridge, completed in December of 1886, is based on the 1817 patent by Theodore Burr. In Burr's design, the posts are in tension, while the diagonals are in compression. The manner in which the diagonals connect to the posts reduced the need for expensive carpentry work at the connections. The simple connections aided in the success of the Burr Arch Truss.

Rehabilitation of the Pine Grove Covered Bridge.

The bridge has been subject to numerous rehabilitation strategies over the past 30 years. In 1977 extensive repairs were completed on the bridge. In the mid–1980's the bridge was closed to traffic as a result of deterioration in the bottoms of the arch chords and the need for substructure repairs. Consideration was given to the complete replacement of the bridge, but the local community and regional historic societies rallied to save the bridge. Consequently, the substructures were patched and the arch chords were spliced with steel channels. The bridge remained posted for 4 tons, thus excluding access for local delivery trucks or emergency response vehicles.

In 2002, PennDOT District 8-0



determined there was a need to address the Pine Grove Covered Bridge's deterioration, maintenance and overall deficiencies. By improving the structure, the adjacent Chester Water Authority and local residents would be better served and it would be possible to preserve the covered bridge– a historical landmark.

When the project started, there were no preconceived notions regarding saving, replacing, relocating, or rehabilitating the bridge. In addition, no formal local committees were formed, but due to the interest in the bridge in the early 1980's and community activism generated at that time, it was anticipated that the community need would be a driving factor in choosing an alternative.

Alternatives Analysis

During the preliminary analysis of the bridge it was determined that strengthening the existing superstructure, was the most cost effective method to update the capacity of the bridge and rehabilitate the historical structure. By strengthening the bridge, the load capacity of the bridge will be increased and provides a community benefit by allowing access for emergency response vehicles as well as local deliveries. The choice to rehabilitate the existing bridge in its existing location reduced the overall environmental impact and need for archeological studies by minimizing the disturbed area.

Restoration of Truss and Rebuilding the Substructures

Originally, jacking the superstructure from the streambed and replacing individual members while the covered bridge remained in place was considered. Concerns about flooding of the creek at the bridge while jacked, as well as the need to do a complete substructure replacement eventually led to identifying the superstructure for complete removal from the existing abutment and piers. An additional benefit to completely removing the superstructure was that the roadway and bridge profile could be raised to allow for additional hydraulic capacity.

Non-historic elements of the covered bridge were identified for complete replacement, including the siding, portals and roof. The main members of the Burr-Arch truss that were deteriorated and damaged due to impact as well as members with previously completed substandard repairs were completely replaced while the Burr-Arch trusses were off the substructure and on blocking. Based on the visual inspection of the bridge, it was determined that 35 main members of the bridge were in need of replacement. Non-destructive testing of the members was completed and identified 5 additional members to be replaced.

Due to the deterioration of the stone masonry on the substructures, complete substructure replacement was recommended. Since typical concrete abutments and piers would have detracted from the overall historical appearance of the bridge, stone formliners were recommended. Staining each "stone" and mimicking

the geometry of the original abutments, piers, and wingwalls enhanced the overall appearance of the bridge.

Strengthening the Structure.

The superstructure and deck of the rehabilitated covered bridge is a completely separate entity from the covered bridge. The liveload crossing the bridge is carried by four steel girders with a glulam deck, thus the covered bridge is carrying its own weight only. Since the floor system has been removed, the covered bridge is tied together under the deck with tension rods and wood blocking with elastomeric pads to help resist transverse loads. From the exterior, the covered bridge cleverly masks the steel beam and glulam superstructure.

Final Product and Impact.

While the beauty of the Pine Grove Covered Bridge is universally easy to agree on, the improved function of the bridge is also appreciated by the community. On a recent field trip to the site, the project received the highest complement, when a driver slowed down to say, "Isn't this bridge a huge improvement?". The rehabilitation and reuse of the structure is a true 21st Century Revival!

Robin Dominick, P.E. is a Senior Structural Engineer with AECOM. Historical Photographs courtesy of HAER.

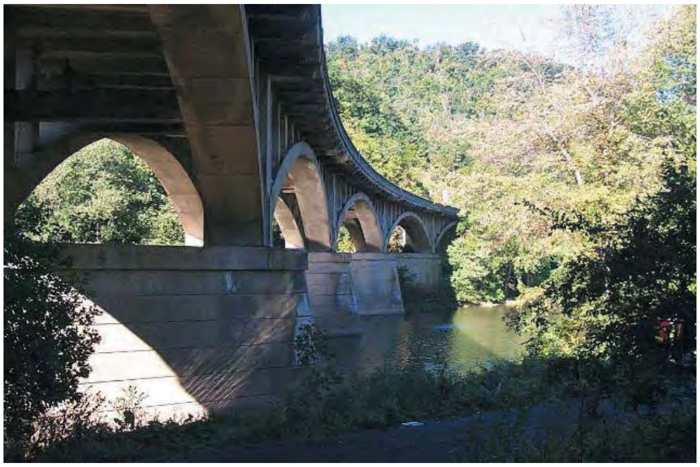


Figure 1 - Existing Structure - 1997

Figure 2 – Rehabilitated Structure - 2007

The Narrows Bridge – *Preserving History*

By: Rodney Miller, P.E., Glenn Seibert, P.E., and Jason Reisinger, P.E.

The U.S. Route 30 Narrows Bridge was recently rehabilitated by the Pennsylvania Department of Transportation (PennDOT), District 9-0. The project was part of the 4.7 mile, $67.7 million U.S. Route 30 Transportation Improvement Project in Bedford County, Pa. The Narrows Bridge is the focal point of the project and carries Route 30 over the Raystown Branch of the Juniata River just south of the Pennsylvania Turnpike. The existing open-spandrel, concrete arch bridge was constructed in 1935. In 1997, it was listed on the National Register of Historic Places and also declared a part of the Lincoln Highway Heritage Corridor. As such, one of the primary goals of the project was to preserve and replicate both the function and the architecture of the main structural elements of the arch bridge. PennDOT and its design team worked closely with the Pennsylvania Historic and Museum Commission to produce the desired appearance, as shown in Figures 1 and 2.

Early History

In the Historic American Engineering Record Report No. PA-449, writer Blythe Semmer, provides a detailed account of the notable events at the site with references to several local historians. She notes that the existing arch structure is actually the sixth bridge at the location. Starting in 1806, and for the entire century that followed, the crossing was under the control of the Chambersburg-Bedford Turnpike Company. This company was one of 10 private groups that was charged by the Pennsylvania General Assembly to construct and operate a road from Harrisburg, PA., to Pittsburgh, PA. Known as the Pennsylvania Road, it was completed in 1818 and carried 90 percent of all east/west commerce in the United States until the completion of the Erie Canal in the fall of 1825.

There were five bridges at the Narrows site prior to the 1935 construction. The first four were all wooden structures and were destroyed by various accidents, fires, and vandalism. The fifth structure was made of steel and was replaced when the alignment of the Lincoln Highway was shifted slightly for the 1935 reconstruction.

Like most of the other early highways, canals, and railroads, the Pennsylvania Road, was built and operated by a private company. This philosophy lasted until the era of big government began in the 1920's when the states took control of many private facilities and highways. It was in 1929 that the Pennsylvania Department of Highways assumed control of the Pennsylvania Road and was the actual design engineer for the concrete arch structure. Ironically, it is interesting to note that there is currently a trend back to private operation of some tolls roads and transit systems through public-private partnerships, which is similar to the philosophy that was in place nearly 200 years ago.

The Design of 1935

The original open-spandrel, concrete arch bridge was built in 1935 by the Pittsburgh Bridge Company and was designed by the engineers of the Pennsylvania Department of Highways. The challenges were many, from both a design and a construction perspective. The alignment was curved to match the topography and the piers were sharply skewed and set parallel to the flow of the Juniata River. The obvious structure configuration was to curve the roadway, chord the arch ribs, and skew the piers at 42 degrees. There is some question as to the selection of an open-spandrel arch structure as the most appropriate type, given the complex geometry at the site. There was speculation at the time that this was the only bridge of this particular arrangement in existence at the time of construction and, a guess might be that the uniqueness may have driven the selection of the bridge type. If conceived today, this type of continuous arch structure would have the designer running to the computer looking for the Structural Analysis and Design (STAAD) program. In fact, STAAD was the main tool used for the current rehabilitation design. Unfortunately, no such tools existed in the 1935 time frame. However, during that era there were other methods available to the designers. Both approximate and exact methods of analysis existed at the time to assist in the design of arch type structures. Classical methods developed by J. Melan, D. B. Steinman, S. P. Timoshenko, and others, provided acceptable results for proportioning arch and other frame type structures.

Also of interest, were the difference in the rules and regulations and other factors that influenced the selection of the structure type at this early time. The previous steel structure was not historic, so there was no attempt or desire to mimic existing functions or architectural themes. Labor costs were cheap, so in 1935, cast-in-place concrete with wooden forming was the construction material of choice for many bridges in the rural areas. Protection and preservation of natural habitats at the site was not a primary focus and, as such, did not influence either structure configuration or construction methods. This can be seen quite vividly when comparing the photo (Figure 3) of the 1935 construction, where the river was used as a dumping site for excess and unused materials, with a photo (Figure 4) of the more recent activities showing a much cleaner operation.

Figure 3 – Original Construction – 1935 (Photo courtesy of HAER)

Figure 4 – New Construction: 2006

Rehabilitation Design

The current work, which was completed in 2006, included the rehabilitation of the existing arch ribs and foundations and the replacement of the spandrel columns, floorbeams and the bridge deck. Special efforts were made by the design team to produce a finished product that closely matched the appearance of the original historic structure.

Although the Narrows Bridge project provides an example what can be achieved in the replication and preservation of an historic landmark, a comparison to a more current structure type, driven by today's design codes and construction techniques and materials, can be seen directly beside the arch structure. The overall project highway design required an increase in traffic capacity at the bridge site. Accordingly, in addition to the rehabilitation of the existing arch structure, an additional two-lane bridge was required to handle the traffic demand. This new structure is a typical modern PennDOT design that includes slender hammerhead piers supporting prestressed, concrete I-beams and a concrete deck.

Rehabilitation Construction

As noted above, the existing bridge consisted entirely of cast-in-place elements which included a concrete deck composite with the concrete-encased steel I-beams that acted as the transverse floorbeams. The construction was tedious with little duplication of dimensions. Given the curved, skewed, chorded configuration, all of the arches and columns were of different lengths and required unique forming, rebar lengths, etc. Of interest to today's bridge contractors and engineers, is the construction time required to build the 1935 version of the crossing. The surprise is that the structure, even with the complex configuration, was completed in one construction season. Of course, in the "old days", there were no arbitrary work stoppages or delays that hinder many current projects located in similar sensitive areas.

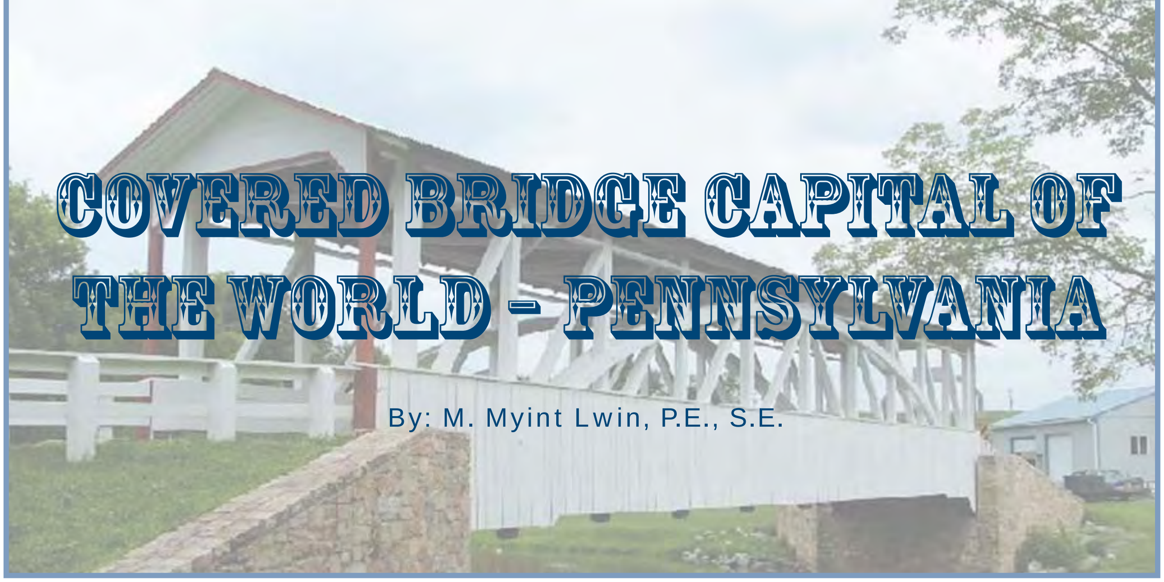
The rehabilitation work included the demolition of the existing bridge elements down to the arch ribs. The existing square rebar, that served as the connection between the arch and spandrel columns, was preserved and was supplemented by additional reinforcement that was drilled and grouted into the arches. After casting the new spandrel columns, precast concrete floorbeams were placed on the column tops. Neoprene bearings and restrainer brackets carried the vertical and horizontal loads and directed the movement of the superstructure. Precasting the floorbeams allowed the contractor to expedite construction by fabricating the floorbeams prior to taking the bridge out of service. Additionally, the design allowed the contractor to support the deck-finishing machine from the cantilevered ends of the floorbeams, thereby simplifying deck construction. Transverse restraint brackets, consisting of galvanized steel plates and angles, allowed longitudinal movement of the bridge deck, while transferring transverse forces into the spandrel columns and arch ribs. The contact surfaces of the transverse restraint brackets utilized PTFE (Teflon®) to accommodate the movements without transmitting longitudinal forces, while short slotted holes allowed the brackets to be turned after the deck pour, ensuring a uniform bearing surface. Longitudinal restraint brackets are located at the fixed pier columns and provide the longitudinal fixity of the superstructure.

Preserving History

One of the primary goals of the narrows Bridge project was to preserve and replicate both the function and the architecture of the main structural elements of the historic Narrows Bridge. Through a commitment to quality and attention to detail by all parties, these goals were achieved and a bit of history along the Lincoln Highway Heritage Corridor was preserved.

Rodney Miller, P.E., Glenn Seibert, P.E., and Jason Reisinger, P.E., of Gannett Fleming, Inc.

The Narrows Bridge is owned by the Pennsylvania Department of Transportation. Gannett Fleming was the Engineer of Record for the rehabilitation. New Enterprise Stone and Lime was the general contractor. The success of all three parties efforts are reflected in the recent awards bestowed on the project. The Narrows Bridge project won the 2008 Diamond Award from the American Council of Engineering Companies of Pennsylvania (ACEC-PA), the Globe Award in 2007 from the American Road and Transportation Builders Association (ARTBA), and the 2007 Susquehanna Chapter Award from the Susquehanna Chapter of the Association of Bridge Construction and Design (ABCD).



COVERED BRIDGE CAPITAL OF THE WORLD - PENNSYLVANIA

By: M. Myint Lwin, P.E., S.E.

Today there are about 800 to 900 covered bridges remaining in 30 states of the Nation. Over 220 of these covered bridges are found in over 50 of Pennsylvania's 67 counties. At one time, Pennsylvania had about 1,500 covered bridges! Pennsylvania has more covered bridges remaining than in any other state. There is one on the way to Paradise – Paradise, Lancaster County, PA. Lancaster County has more covered bridges than any other county. Lancaster County also had the longest covered bridge in the world. Pennsylvania is the "Covered Bridge Capital of the World"!

How do you extend the life of a bridge? Painting or using high corrosion resistant steels, controlling cracking in concrete, chemical or pressure treating wood. What if these technologies were not available? Timothy Palmer built the first American covered bridge over the Schuylkill River at 30th. Street in Philadelphia in 1800. The bridge owners asked to have the bridge covered to extend the life of the bridge. Since then the benefits of covered bridge was recognized. The cover protects the structural members from the elements. Without cover a wooden bridge would last 10 to 15 years, while covered wooden bridges last 70 to 100 years and beyond.

Structural Forms

Covered bridges were mostly built between 1800 to 1930. Various truss types and untreated wood were used in the construction. Fig. 1 shows the different types of trusses that could be found in covered bridges in Pennsylvania and across the country.

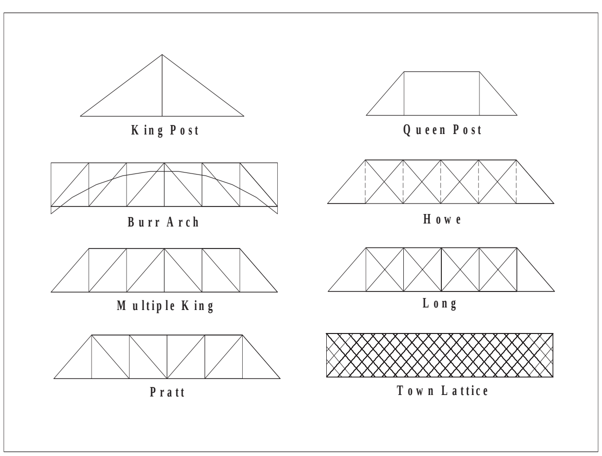


Figure 1 – Types of Trusses

National Historic Covered Bridge Preservation Program

In 1998, the Transportation Equity Act for the 21st Century (TEA-21) as amended by the TEA-21 Restoration Act (the Act) established the National Historic Covered Bridge Preservation (NHCBP) program. The program was re-authorized in the Safe, Accountable, Flexible, Efficient Transportation Equity Act (SAFETEA-LU) legislation. The program provides funding in two categories (1) assisting States in their efforts to rehabilitate, restore, repair, or preserve the Nation's historic covered bridges, and (2) for conducting research to find improved means of restoring, and protecting these structures and for education and technology transfer.

The bridges that are eligible for funding under this program have to be listed or be eligible for listing on the National Register of Historic Places. The program provides funding for preservation, rehabilitation, and restoration, including installation of a fire protection system, a fireproofing, fire detection system and a sprinkler system. The program funds may also be used for installation of a system to prevent vandalism and arson or relocation of a bridge to a preservation site. The program, however, does not provide for reconstruction of a historic bridge. Therefore if a bridge is destroyed by arson or natural event, this funding cannot be used to rebuild the structure. Since 2000, over 180 covered bridge projects have been funded under this program. The projects awarded in 2000 to 2008 to Pennsylvania's historic covered bridges are shown in Table 1.

Table 1 Preservation and Restoration of Historic Covered Bridges

Name of Bridge	County	Name of Bridge	County
Knapps	Bradford	Shriver	Greene
Speakman	Chester	Academia	Juniata
Kramer	Columbia	Moreland	Lycoming
Patterson	Columbia	Kreidersville	Northampton
Shoemaker	Columbia	King's	Somerset
Cox Farm	Greene	Hillsgrove	Sullivan

FHWA Covered Bridge Manual

FHWA publishes the Covered Bridge Manual, FHWA-HRT-04-098, April 2005. The manual is intended primarily for engineers and historic bridge preservationists to provide technical and historical information on preservation of covered bridges. It will also be of interest to others involved with these bridges—including lay people, owners, and contractors. The manual is separated into several sections with a number of chapters devoted to the specifics of each. The sections include background, description of bridge components, technical engineering issues, existing bridges, and references. The appendices include multiple case studies of existing bridge rehabilitation and construction of new authentic covered bridges. Web version of the manual is available at http://www.tfhrc.gov/structur/pubs/04098/index.htm.

Pennsylvania Covered Bridges Web Site

The Pennsylvania Covered Bridge web site (http://pacovered-bridges.com/) is dedicated to the preservation and restoration of all remaining covered bridges throughout the United States. Nearly 14,000 authentic wooden covered bridges once existed in our Nation. Today less than 900 remain. Time and technology took its toll on the bridges until recent years when Federal grants become available for states to preserve, restore and rebuild many of the historic structures. Many covered bridges are being destroyed by Mother Nature and at the hands of arsonist plus those that were on the verge of collapse. The Federal National Historic Covered Bridge Preservation Program has already provided funds for the preservation and restoration of over 180 historic covered bridges since 2000.

Pennsylvania, Ohio, Indiana and Vermont have a combined total of over 550 authentic covered bridges with Pennsylvania leading with over 220. Many of the covered bridges still standing are over 150 years old.

The historic data given in the web site is as accurate as could be found through researching the bridges. Finding correct information about covered bridges is a never-ending process. There will always be conflicting documentation regarding year built, builder, length of bridge, truss type and even the waterway it crosses.

The web site has a wealth of information about the covered bridges in the counties in Pennsylvania. Please visit the web site and enjoy the fascinating history of bridge building.

When In Pennsylvania

When you are in Pittsburgh in June, please take time to visit the covered bridges in the neighboring counties. With a GPS you can easily find the interesting and exciting covered bridges in the counties of Allegheny (3), Beaver (3), Washington (24), Greene (8), Westmoreland (1), Indiana (5), Somerset (17), Bedford (14) and others – the number shown in parenthesis is the number of covered bridges in the county. You will experience the challenges and evolution of bridge building in the 17th and 18th Centuries – motivated by the quest for longer life and longer spans.

The Theodore Burr Covered Bridge Society of Pennsylvania, Inc. is formed to promote interest and active participation in the preservation and restoration of the remaining historical covered bridges in the Commonwealth of Pennsylvania. The Society publishes a magazine, *Wooden Covered Spans*, twice a year (Winter and Summer), and issues a newsletter, *Pennsylvania Crossings*, three times a year (Fall, Spring and Summer). The publications are for members only. Annual membership dues are $15 for individual, $20 for couple and $20 for a business or organization. The Society organizes an annual Covered Bridge Safari. A covered bridge safari is when a group of covered bridge enthusiasts caravan to covered bridges in a particular county or geographic area. The 2009 Safari will be in June 5-7, visiting the covered bridges of Columbia County. For more information about the Society, visit http://www.tbcbspa.com.

Counties welcome visitors to see their proud heritage of covered bridges. Most counties have maps showing the locations of the covered bridges in the counties. Lancaster County has a map showing the locations of the 28 remaining covered bridges in the county. Bedford County has a brochure titled "Covered Bridges" with brief descriptions of the 14 remaining covered bridges, and a map showing the locations of the covered bridges. Bedford County also provides specific directions on covered bridge driving tours ranging from 30 minutes to 3 hours. Contact or send an e-mail to Bedford County at www.bedfordcounty.net.

You are encouraged to bring your sweetheart to discover why the timeless treasures of covered bridges of Pennsylvania, the Keystone State, were also known as "kissing bridges."

M. Myint Lwin, P.E., S.E, is the Director of the Office of Bridge Technology for the FHWA

If you want to read more about covered bridges, please see:

1. Duwadi, Sheila R., and Wacker, James P., "Covered Bridges in the United States and the Preservation Program", Proceedings, 2008 World Congress on Timber Engineering.

2. Pierce, Phillip C., R.L. Brungraber, A. Lichtenstein, & S. Sabol, Covered Bridge Manual, FHWA-HRT-04-098, Federal Highway Administration, McLean, Virginia, April 2005. Web version at www.tfhrc.gov/structur/pubs/04098/index.htm.

3. The Secretary of the Interior's Standards for the Treatment of Historic Properties, National Park Service, Web address: www.nps.gov/history/hps/tps/standguide/.

4. Strengthening Historic Covered Bridges to Carry Modern Traffic, TechBrief, FHWA Publication No. FHWA-HRT-07-041, Federal Highway Administration, McLean, Virginia. Web version at www.tfhrc.gov/structur/pubs/07041/index.htm.

Some Covered Bridges In Pennsylvania

The White Rock Forge Covered Bridge, Lancaster County

The White Rock Forge Covered Bridge is located south of Kirkwood on White Rock Road, Route 337. It is a single span, covered wooden bridge. The superstructure consists of Burr-type wood trusses in combination with a double arch and steel hanger rods. The span of the bridge is 103 feet and 13 feet wide. The bridge is in good condition as a result of a major repair performed in 1992.

Hall's Mill Covered Bridge, Bedford County

The Hall's Mill Covered Bridge is located on Route 1020, just off Route 26, about 10 miles north of Everett in Bedford County. It was built in 1884 of Burr Arch Truss design. It spans 97 feet across the Yellow Creek, and it's width is 12 feet, 6 inches. It is open to vehicular traffic. The bridge is in excellent condition.

Patterson Covered Bridge, Columbia County

The Patterson historic covered bridge is located on Route 575 between Orangeville and Rohrsburg off 4041. The bridge was built using the Burr truss design in 1875 for $804. It was named after Patterson's saw mill. The bridge length is 82 feet and a width of 14 feet, 7 inches. The bridge is open to traffic. The bridge has gone through a major refurbishment in 2006. It is now one of the finest covered bridges in Columbia County.

St.Mary's Covered Bridge, Huntingdon County

The St. Mary's covered bridge is located on Route 358 just east of U.S. Route 522, about 2.5 miles north of Shade Gap in Cronnvell Township, directly across the highway from St. Mary's catholic church. It was built in 1889 utilizing the Howe truss design. It crosses Shade creek in Cromwell Township. The bridge is 65 feet long and 17 feet, 6 inches wide. The bridge is open to traffic. The condition of the bridge is excellent. This is one of the most beautiful setting for a covered bridge and the only remaining bridge in Huntingdon county.

The *Homestead Grays Bridge* and Pittsburgh's STEEL Industry

By: Dan Wills, P.E.

The Homestead Grays Bridge–known as the Homestead High Level Bridge prior to 2002–connects the City of Pittsburgh and Homestead, in southwest Pennsylvania, spanning the Monongahela River and The Waterfront.

Constructed in 1936, the bridge's history is linked to Pittsburgh's steel industry and an evolving community. The steel industry was crucial to Homestead, a borough situated on the left bank of the Monongahela River, just seven miles east of downtown Pittsburgh. By the turn of the century, more than 7,000 men were employed at the Homestead Works plant, owned by steel baron Andrew Carnegie.

Pittsburgh approach to Homestead High Level Bridge – 1937

Before the current bridge was erected, Brown's Bridge served the Homestead community as the main river crossing to Pittsburgh. Built in 1897, the through truss with five spans carried a street railway and eventually two lanes of motor vehicles.

Because of employment at the plant, growth continued in the area. The population of Homestead increased from 18,713 in 1910 to 20,452 in 1920. In need of repair and expansion, the Brown's Bridge was replaced with the Homestead High Level Bridge in 1936. The new bridge and attached Fifth Avenue Ramp were built for $2.8 million; the bridge has 17 spans and is 3,102.5 feet long. To this day the bridge is owned by its original owner and designer, the Allegheny Department of Public Works.

The Homestead High-Level Bridge was the first-ever Wichert Truss bridge. Developed by E.M. Wichert and his Pittsburgh engineering company in 1930, the bridge is one of only a few built using this design. As a result, the bridge has been listed on the National Register of Historic Places by Pittsburgh History and Landmarks. The Wichert Truss is unique as it lacks the vertical member at the interior supports of the continuous trusses. The structure has a six span continuous Wichert deck truss in spans 8 to 13 over The Waterfront, and a four span continuous Wichert deck truss in spans 14 to 17 over the Monongahela River. The remaining seven spans are girder spans.

Browns Bridge - Looking upstream from Homestead – 1931

"The Ward," a sizable housing development consisting of 1,225 units, existed under and adjacent to the south portion of the newly constructed bridge. However, to support war efforts in 1941, the Homestead Works, under U.S. Government-ordered expansion, removed most of the homes to expand its steel mill, relocating 3,500 people. When the expansion was complete, the plant was capable of producing armor plates for the U.S. war effort.

After World War II, the steel industry flourished from 1950 to the late 1970s, with annual domestic steel production increasing from around 100 million tons to a peak of 150 million tons in 1973. However, due to a heavy increase in imported steel and the slow adaptation of new cost-efficient steelmaking technologies, by 1980 it became virtually impossible to obtain employment at the once-thriving Homestead Works plant. With domestic steel production at an all-time low, the facility closed in 1986 and the mill was entirely razed except for a few buildings at the east end of the site and a row of 12 smokestacks at the west end of the site. Consequently, the area under the Homestead High Level Bridge's once bustling southern end now sat abandoned, but it would not remain that way for long. In order to improve the access to prime river front property, a second ramp, the West Ramp, was built in 1997 directly opposite the existing Fifth Avenue Ramp.

Homestead High Level Bridge construction – 1936

In 1999, The Waterfront retail and entertainment complex

Homestead High Level Bridge under Homestead approach – 1937

was developed where the Homestead Works once stood, taking its place under the southern part of the bridge. The Waterfront is home to more than 70 shops, restaurants and entertainment venues. The smokestacks still stand as a reminder of the site's industrial history. Although the population of Homestead had dwindled as a result of lost steel jobs, the development is helping the area rebound economically as a result of an enlarged retail tax base.

In 2002, the Homestead High Level Bridge was renamed the Homestead Grays Bridge. The renaming honors the historic roots of the Negro National League. Two teams resided within the area, the Pittsburgh Crawfords and the Homestead Grays. The Crawfords were the 1935 Negro National League champions, and between 1937 and 1945 the Homestead Grays won nine consecutive league pennants.

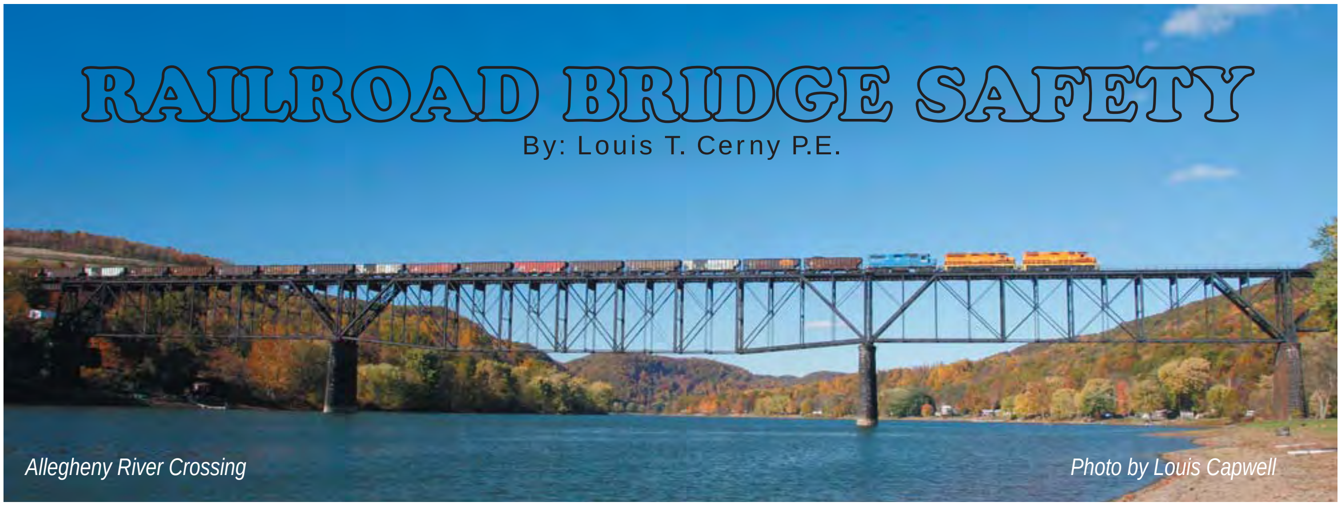
Rehabilitated Homestead Grays Bridge

To maintain this historic landmark and keep the bridge in safe operating condition, the Allegheny Department of Public Works orchestrated an extensive $35 million bridge rehabilitation in 2006. Renovations encompassed a wide range of work–widening the roadway to 46 feet from 40 feet; replacing both sidewalks; replacing the grid deck in spans one to five with a concrete deck; constructing a PA Barrier (new PennDOT type 42-inch high concrete/steel barrier) along the curb lines; and restoring the existing pedestrain railings and replacing the lighting with reproductions of historic models. Several millon dollars were saved when it was determined that most of the existing 70 year old grid deck was in good codition and could be reused by only replacing the existing bitumious wearing surface.

Today, the bridge serves not only as a form of transport but as an historic icon, bearing witness to the rise and fall of the steel industry and the ongoing evolution of a community. From housing hub to steel mills to shopping and entertainment, the Homestead Grays Bridge has stood fast as industries and economies have come and gone. As the Monongahela River valley focuses on continued economic viability and historic preservation, thanks to the extensive rehabilitation, the bridge will add yet more chapters to its story.

All historic photos used courtesy of County of Allegheny, PA

Dan Wills, P.E. manages the structural engineering department in the Pittsburgh office of ms consultants. He has worked with the firm for more than 20 years, and served as the project manager for the rehabilitation and widening of the Homestead Grays Bridge. Dan published articles on this topic in Civil Engineering Magazine and The International Bridge Conference® Proceedings.



Allegheny River Crossing Photo by Louis Capwell

RAILROAD BRIDGE SAFETY

By: Louis T. Cerny P.E.

Railroad bridges safely and reliably carry heavy freight traffic even though many are over 100 years old (the oldest still in use is 179 years old) and some are built of timber.

> ***"Railroads' safety record is unparalleled - zero bridge fatalities since 1957!"***

A recent survey indicates that there are about 61,000 railroad bridges, with a total length of 1440 miles, on the large freight railroads in the United States. In addition, there are approximately an additional 30,000 bridges on shortline and commuter lines with an additional 700 miles of length.

Excellent Safety Record

It has been over half a century since there was a fatality caused by the structural failure of a railroad bridge on any United States railroad, and this stands as one of the most exemplary transportation safety records in history. If trestle failures in the 1950's on one shortline railroad are not included, the no-fatality record goes back 67 years to before World War II. Railroad bridges are generally inspected at a minimum of once a year, with more frequent inspections taking place in situations where they have been judged by experienced engineers to be necessary.

In addition to frequent inspections and normal repairs, many older bridges continue to be replaced or strengthened, and many new bridges have been installed where new second or third tracks have been added to increase capacity. 2006 was the all-time highest railroad freight traffic year in the United States and rapid growth is expected to resume once the current financial situation improves. The need for a high level of investment to accommodate this growth may involve public-private partnerships.

Importance of Bridges to Railroad Companies

In addition to a commitment to safety as their first priority, railroad companies realize that their bridges are perhaps the most critical element in the continuity of a railroad line, and they have every incentive to protect their investment and ability to operate by preventing bridge collapses from occurring.

Authority of Federal Railroad Administration

One question that comes up frequently is why there are no detailed prescriptive Federal Railroad Administration (FRA) bridge standards as there are FRA track safety standards. The primary reason is because the railroads' safety record in this area - zero fatalities since 1957. Although the FRA is now developing requirements for bridge management programs as part of its authority to regulate railroad bridge safety, and has had a Policy on the Safety of Railroad Bridges since 2000, the FRA's investigations into this matter have led to the conclusion that detailed prescriptive federal railroad bridge safety standards would not improve safety. The FRA also has authority to issue emergency orders, and in 1996, 1999 and 2006 issued orders prohibiting operations over shortline railroad bridges that it considered to be unsafe. The shortline railroads are presently cooperating with the FRA in develop bridge management programs to insure that their half century no-fatality record continues to extend far into the future.

There have been many instances where congressional or citizen complaints about railroad bridge conditions have been referred to FRA bridge experts and these investigations have revealed the safety of the bridges despite cosmetic deterioration.

Use of AREMA Recommended Practices

The American Railway Engineering and Maintenance-of-way Association (AREMA) has technical committees dealing with bridges. These committees have chapters in the Manual for Railway Engineering, in which the AREMA recommended practices are published. The material in these chapters is not meant to represent minimum safety standards and takes into consideration, in both design and maintenance procedures, an economically long life. Some major railroad companies have their own bridge standards and procedures.

Strength of Older Bridges

Most older railroad bridges were designed for the heavy weights and high impact loads of large steam locomotives.

The largest steam locomotives in the first half of the 20th century had axle loads higher than those in use on today's locomotives or freight cars. The heaviest normal freight cars in the US have axle loads of about 72,000 pounds, while some steam locomotives had axle loads of 80,000 pounds or more. Some steam locomotives put a static weight of around 480,000 pounds (up to 525,000 pounds on one class of locomotive) on a 40-ft length of track, and over 250,000 pounds in a 12-ft length of track. This is significantly

Ohio River Crossing Photo by Louis Capwell

in excess of modern interchange freight cars. These steam locomotive loads were made far more severe by the impact caused by the heavy reciprocating parts attached to the wheels of the steam locomotives, which could in some cases cause an addition of 100% over the static load.

While the axle loads used today on U.S. railroads have not exceeded those in the past, modern unit trains do have many more axle loads in the higher ranges than typical freight trains in the era of steam locomotives, and freight train frequency on some lines is at an all-time high. Thus railroad bridge engineers are especially alert to the possibility of bridge problems due to fatigue, which is affected by the number of repetitions of a load as well as its size. The use of riveting or bolting instead of welding in older bridges reduces the danger of sudden collapse because a single crack cannot grow across a bolted or riveted connection.

Railroad bridge design has tended to emphasize a high degree of redundancy and avoidance of the type of design detail that was involved in the Mianus River highway bridge collapse in Connecticut. Multiple load paths which would permit the bridge to remain intact despite the loss of an entire member are more frequent in railroad bridge design than in highway design.

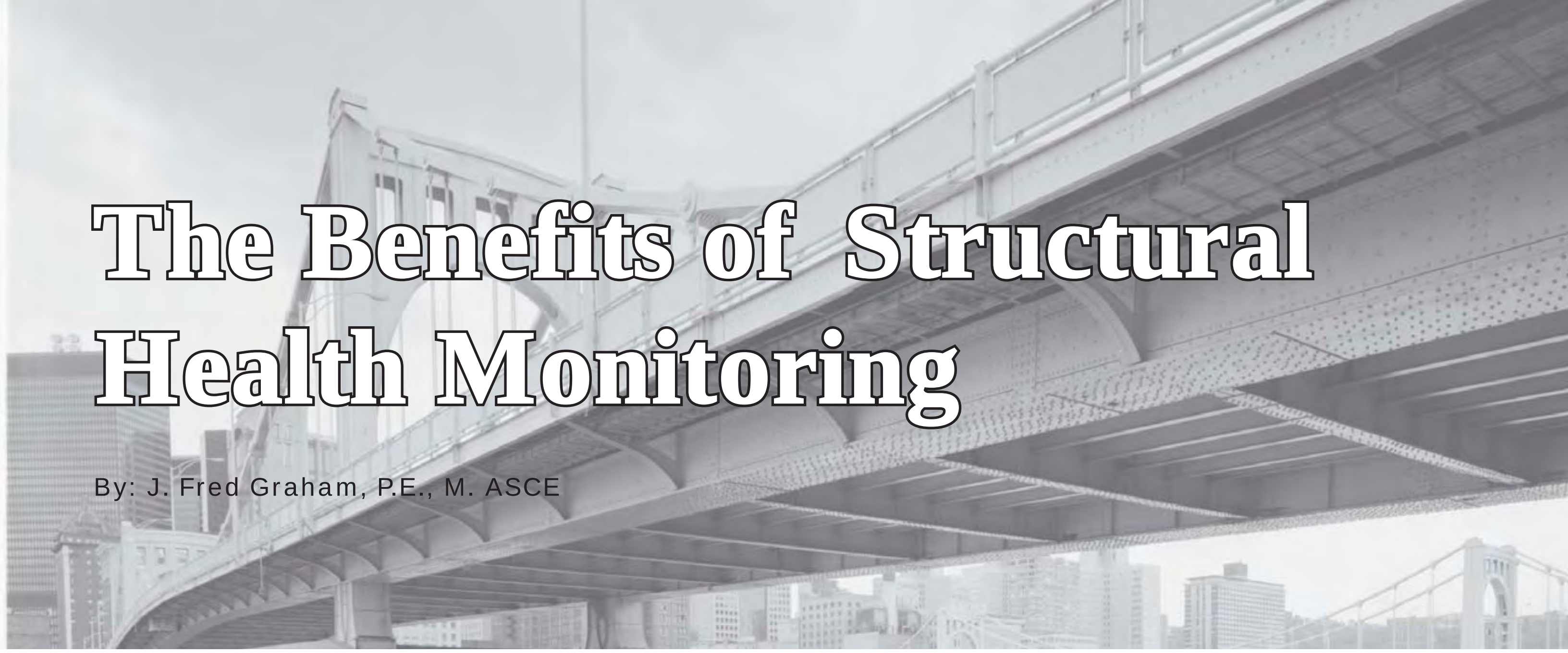
Use of Timber Bridges

Currently about 24% of the total length of bridges on major freight railroads is timber, and about half the total length on shortlines. While those who have worked extensively with timber recognize its virtues as a structural engineering material, there is often a perception among the public that there is automatically something deficient when timber is used. Modern re-treatment techniques, where timber bridges can be retreated with preservative in place, have in some cases made the life of timber bridges comparable with those of steel and concrete. When timber is preserved or not exposed to air, strength can last essentially indefinitely. This is evidenced by untreated timber pile foundations that still support stone bridges carrying road traffic, even though the bridges were built by the Romans more than 1,700 years ago.

In Conclusion

Qualified railroad engineering professionals keep safety first in mind in inspection of railroad bridges - safety of the general public, the railroad's passengers, and railroad employees. History shows what an excellent job the railroads have been doing on bridge safety.

Louis T. Cerny PE, is a Railroad Engineering Consultant from Gaithersburg, Maryland. He may be reached at ltcerny@erols.com



The Benefits of Structural Health Monitoring

By: J. Fred Graham, P.E., M. ASCE

Since the I-35 bridge results have come out, a number of prominent engineers have said that we need more bridge inspections. There will always be a need for visual bridge inspections. But as a previous government engineer, I believe that in many cases we would be much better off with less frequent inspections, in conjunction with readily available smarter and better bridge performance monitoring techniques. This would improve safety and greatly reduce unnecessary bridge repairs and replacements.

In an article in Roads and Bridges, December 2008 edition, Allen Zeyher, Managing Editor, said "The NTSB (National Transportation Safety Board) also wants to see changes made to the way bridges are inspected to identify locations where visual inspections might not detect gusset-plate corrosion and where, therefore, nondestructive evaluation technologies should be used. Bridge inspectors should be trained in techniques and technologies to evaluate gusset-plate corrosion and distortion, since distortion is a sign of an out of-of design condition". It is totally understandable that with only qualitative visual data an engineer will be conservative in determining a bridges condition rating—unless a subtle condition such as a distorted gusset is over looked by the inspector.

"...just because a bridge looks okay, it does not mean that is okay"

Despite the delay in readying the (economic recovery) legislation, the measure continues to build support in Congress, even among fiscally conservative members. Senate Budget Committee Ranking Republican Judd Gregg (R-N.H.) said on January 8 "I think we should heavily tilt the stimulus package toward investment-based activities -- bridges, roads, infrastructure, fiber optics." *(ARTBA newsletter, 11/29/09)*.

Over time, I have come to discover that just because a bridge looks okay, it does not mean that is okay; and just because a bridge looks bad, does not mean that the bridge has the potential to fail. This fact is vividly shown by the use of the Structural Health Monitoring (SHM) systems on over 500 bridges, especially our unique, historic bridges worldwide. In about 75% of those cases, weight limits, lowered structural ratings and the need for costly repairs had been imposed based on visual observations when such requirements were not necessary. Instead proper, monitoring showed the structures to be much better than anticipated, allowing the owner to more objectively determine where its limited funds should be spent.

"I strongly recommend that any changes to the AASTO bridge inspection procedures include the allowance for Structural Health Monitoring."

As an example, one column of a very heavily traveled six lane viaduct in New York City was hit by a barge and completely removed. The engineer, because of the concern for safety and liability, suggested that the bridge be closed to make repairs and that the bridge be posted for five (5) tons. The NYC DOT wanted to avoid the resulting massive traffic jams and major repair costs. So instead, they made only minor repairs and had us monitor this bridge to quantitatively measure its performance. By using a SHM system at only a few key locations, the real-time monitoring showed that the bridge was functioning fine due to the redistribution of the load path. That was over five (5) years ago and the bridge is still being monitored with normal traffic and with no subsequent problems. This has allowed NYC to avoid emergency repair costs and to plan for the bridges rehabilitation in a manner that best fits their budgeting allotments.

This example shows why SHM monitoring is usually very cost-effective. The Return-on-Investment can be the highest a bridge owner will ever realize. Because of the major benefit derived by SHM, I strongly recommend that any changes to the AASTO bridge inspection procedures include the allowance for SHM to improve the Engineer's or DOT's conclusions. Also, SHM should be accepted as a means to continuously show the structures performance if safety or large repair costs are of a continuing concern.

Finally, I want to emphasize the SHM systems are far beyond the "research" stage as envisioned by many US engineers.

SHM systems have been successfully used on nearly 1,000 important structures worldwide for more than a decade, including about 30 in the US. Highly reliable and proven SHM is currently available for all owners and DOTs to use immediately.

I have spent most of my adult life attempting to save our engineering heritage, especially our unique, historic bridges. This will help tremendously in extending the life of our bridges.

John F. Graham, Jr., P.E., is a Distinguished Member of ASCE, an Emeritus Member of the Executive Committee of the International Bridge Conference® and Principal in the firm OSMOS USA. 'Fred' is a former Allegheny County (PA) Bridge Engineer, and can be reached at f.graham@osmosusa.com

Seventh Street Bridge–A Short History

HAER PA-40 reports that this is the second bridge at this site. The first bridge was constructed in 1884; at this time in a bid to compete with the popular crossings at Sixth and Ninth streets, the North Side Bridge Company hired famous bridge builder Gustav Lindenthal to design the Seventh Street Bridge. Lindenthal's 1884 structure used a stiffened-chain suspension design. Three towers carried chains supporting two main spans of 320'-0" and two side spans of 165'-0". Rather than calling his design a suspension bridge, Lindenthal referred to it as a "suspended arch bridge". By the early 1900's dangerous conditions developed along the Allegheny River due to swift water, uneven pier locations from adjacent bridges and low clearances. On March 23, 1917, the Secretary of War outlined specifications that the new bridges would be required to meet. In 1923, Engineers prepared several truss options including a continuous-traffic lift design with a variable top chord, a fixed span with parabolic top chord and a cantilever design. After clearing the fixed bridge proposal with the War Department and many other agencies, the county submitted the drawings to the little-known Art Commission "for suggestion and approval." The Commission's veto of the final plans shocked engineers and city leaders. The Commission sent engineers back to the drawing board with instructions for a more attractive bridge that would not mar the downtown skyline with metal structures above the deck – resulting in the splendid "Three Sisters Bridge's that today grace the Allegheny River Shore line. Ed.

Seventh Street Bridge, in Pittsburgh, PA is owned by The County of Allegheny
Photo courtesy of HAER Photographic collection

Answers to Bridge Quiz

Answers to Bridge Quiz

(From Page 3)

A, B, C, and D are ALL correct. On the Pittsburgh side (facing three rivers Stadium in this 1970's photo) shown kneeling on either side of the Arms of the City of Pittsburgh, are Christopher Gist, pioneer and companion to George Washington, and Chief Guyasuta, a local Seneca Indian and also companion to George Washington. The Northside portal depicts Joe Magara, the mythical steel worker and Jan Volkanik, the mythical coal miner. The bronze sculptures now stand outside the Children's Museum (former Post Office) on Pittsburgh's North Side.

IBC 2009 BRIDGE AWARDS PROGRAM

By Carl Angeloff, P.E.

The International Bridge Conference in conjunction with Roads and Bridges Magazine, Bayer Corporation and bridge design and engineering Magazine, annually awards five medals and one student award 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, champion of the student award's program and friend to the bridge community at large.

John A. Roebling Medal

The John A. Roebling Medal recognizes an individual for lifetime achievement in bridge engineering. We are pleased to recognize Harold R. Sandberg as, P.E., S.E. the 2009 recipient. As the first employee and Chairman Emeritus of Alfred Benesch & Company, Mr. Sandberg is well known in the engineering community. His many contributions to the industry have garnered numerous prestigious awards. As an honorary member of ACI he was given the Henry Crown Award in 2005 and the Alfred E. Lindau Award in 2006. As a strong advocate of redundancy, he presented papers at meetings of the IBC. In 1982 he testified before the House Congressional Sub-Committee regarding failures in public structures. At 89 Mr. Sandberg continues to be active in several professional committees.

George S. Richardson Medal

The George S. Richardson Medal, presented for a single, recent outstanding achievement in bridge engineering, is presented to recognize the I35W Bridge over the Mississippi Bridge in Minneapolis, Minnesota. After the Aug. 1, 2007 collapse, the new segmental girder structure was designed, constructed, and opened to traffic at 5 a.m. on Sept. 18, 2008. The award celebrates the accomplishments of the government, contractors and consultants who were focused on delivering a complex project within extremely tight time constraints.

Gustav Lindenthal Medal

The Gustav Lindentahl Medal, awarded for an outstanding structure that is also aesthetically and environmentally pleasing, will be presented to recognize the Woodrow Wilson Bridge, south of Washington D.C. linking Virginia and Maryland. The fixed span and bascule bridge features an aesthetic appearance and integrated state of the art environmental measures to preserve underwater vegetation and protect fish during foundation installation.

Eugene C. Figg Jr. Medal

The Eugene C. Figg Jr. Medal for Signature Bridges, recognizing a single recent outstanding achievement in bridge engineering, which is considered an icon to the community for which it is designed, will be presented to recognize the Sanhao Bridge over the Hunhe River in the Northeastern city of Shenyang, China. This artistic bridge expresses a new structural form that will give identity and distinction to the connecting communities.

Arthur G. Hayden Medal

The Arthur G. Hayden Medal, recognizing a single recent outstanding achievement in bridge engineering demonstrating vision and innovation in special use bridges, will be presented to recognize Seattle's Museum of Flight Pedestrian Bridge. This bridge, sculptured to represent the wisps of an airplane's contrails, provides a visually interesting invitation to the Museum of Flight.

James C. Cooper Student Award

The James D. Cooper Student Award recognizes undergraduate and graduate students who demonstrate an interest and passion for bridge engineering. The award is presented to winners of a student competition for technical writing and engineering insight. The 2009 award will be presented to Michael Loy of Oregon Episcopal High School for his paper entitled Developing a Novel pH Buffer Methodology to Inhibit Concrete Corrosion. The awards committee judged this paper to be superior all other undergraduate student and graduate student entrees, quite an accomplishment for a high school senior.

Carl Angeloff, P.E. is a member of the Executive Committee of the International Bridge Conference® and the Chairman of the IBC Awards Committee. Carl works for Bayer MaterialScience, headquartered in Pittsburgh, PA

For up-to-the-minute updates on the 2009 International Bridge Conference®, visit our web site at www.eswp.com/bridge. The 26th Annual International Bridge Conference® is proudly sponsored by the Engineers' Society of Western Pennsylvania

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