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Historic Bridge Bulletin

Historic Bridge Foundation

From the Director's Desk

Dear Bridge Enthusiasts,

An unfortunate but common fact is that many of our historic bridges are being replaced. Many of these bridges, however, are being given new life as pedestrian bridges in parks and on hiking trails. On our website, historicbridgefoundation.com, we have a bridge marketing page where details about available bridges can be found.

A notable bridge up for reuse is the Puyallup River Bridge (Meridian Street Bridge) in Washington State. The 1925 bridge is a riveted modified Warren through truss displaying some visual characteristics of the Turner truss configuration. After successful relocation to nearby WSDOT property, the goal is to offer the bridge to a new owner for use as a pedestrian or bicycle facility. Check out the time-lapse video of moving the 379-ton bridge away from the Puyallup River and onto WSDOT right of way: https://www.youtube.com/watch?v=bmzmtlwbDA4 Moving a bridge is not something you see every day!

A new feature to our website is the Bridge Biographies database (found under Resources). The database is a source for information and primary source materials relating to key bridge companies, contractors, builders, and significant bridge engineers. We welcome our readers to share information that will help us expand this resource.

Kitty Henderson

Executive Director

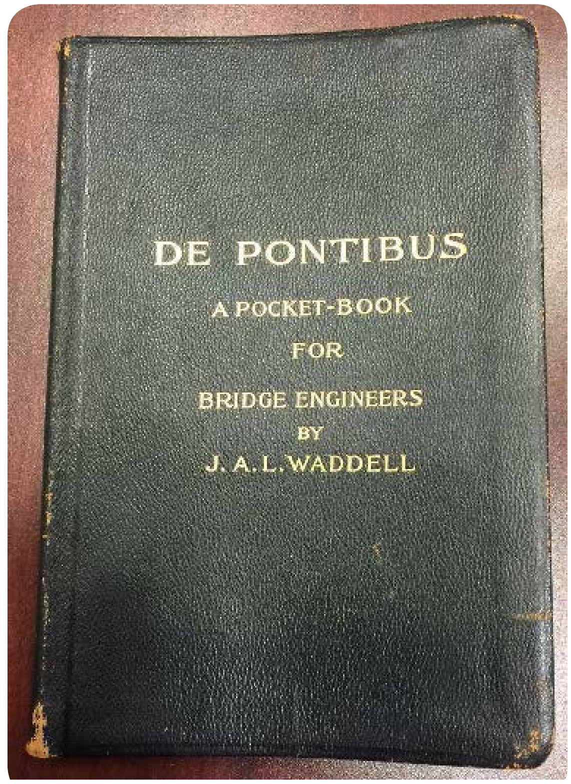
In This Issue:

Meridian Street Bridge over Puyallup River in Washington State. *Photo by Nathan Holth.*

Lessons From Dr. Waddell:
Case Study 1 (Heat Straightening) And Case Study 2 (Laser Scanning)

By Steven A. Olson, PhD, PE

Portrait of Waddell.



Cover of *De Pontibus*..

Introduction

One of the more esteemed bridge engineers of the late 19th and early 20th centuries was J.A.L. (John Alexander Low) Waddell. He would receive several patents associated with bridges and be recognized around the world for his engineering prowess. He authored several books on bridges and his consulting practice would spawn the engineering firms we know today as HNTB and Hardesty & Hanover. In 1890 he authored, "*DE PONTIBUS: A Pocket-Book for Bridge Engineers*". It is still a remarkably relevant document 127 years after its first publication. It contains some of the earliest proposed specifications for highway bridges and railroad bridges. It also contains dozens of design guidelines and principles.

As a practicing bridge engineer it amazes me how pertinent the guidance in this little book is to projects I work on today. While new materials may have characteristics that differ a bit from those in the 1890s, there is much that is the same. We still need to understand the materials we are working with. We need to understand how to design projects that contractors can readily bid and build, and those structures should be durable, cost effective, and aesthetically pleasing for their owners.

> *Waddell Principle V*
> *There are no bridge specifications yet written and there probably never will be any which will enable an engineer to make complete design for an important bridge without using his judgment to settle many points which the specifications cannot properly cover or as Mr. Theodore Cooper put it, the most perfect system of rules to insure success must be interpreted upon the broad grounds of professional intelligence and common sense.*

While today's AASHTO and AREMA Design Specifications contain enormous amounts of technical information and guidance, 127 years after Waddell's text was published it is still true that professional intelligence and common sense need to be brought to bear in the development of bridge projects.

This is particularly true for projects that contemplate the rehabilitation of medium span trusses. Engineers approaching these projects need to have an understanding of the changes in materials and fabrication practices of metal bridges over time. Iron bridges gave way to steel structures. Pin-connected structures gave way to riveted and bolted trusses and, in some cases, welded trusses.

Professional intelligence and common sense allow today's engineers to strengthen, rehabilitate, and repair older trusses with modern materials and details to extend the service life of these bridges subjected to ever-increasing load demands.

This paper presents two truss bridge rehabilitation case studies. The case studies are presented in the context of Waddell principles from *De Pontibus*. Case Study 1 illustrates the successful use of heat straightening to repair a severely damaged end post. Case Study 2 describes the use of laser scanning to collect field data for the rehabilitation of a pair of pony truss spans.

CASE STUDY 1 – HEAT STRAIGHTENING - THE SALISBURY BRIDGE

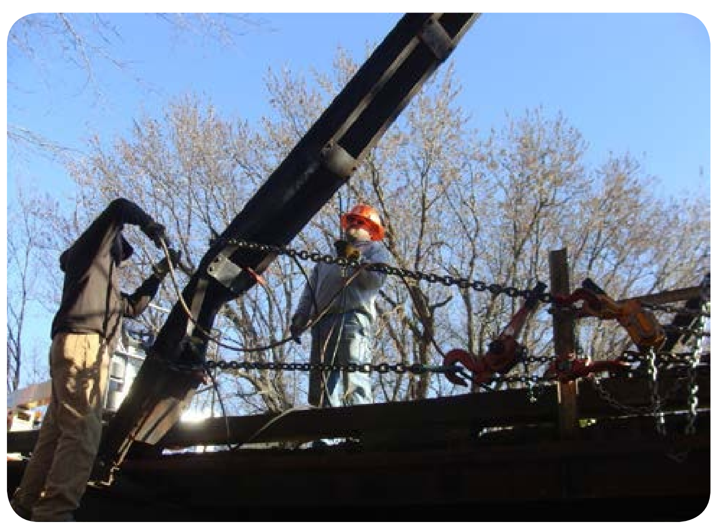
Salisbury Bridge deck.

The Salisbury Bridge is narrow single lane bridge with a timber deck. It has light truss members and only a three-ton load capacity. An errant vehicle on a snowy, icy road impacted the end post of this 1899 through truss over the North Fork of the Crow River near Kingston, Minnesota. The vehicle damage nearly collapsed the pin-connected truss.

Damaged end post.

Waddell Principle I
Simplicity is one of the highest attributes of good designing.

Originally, after we reviewed the bridge in the field, we felt that the lower portion of the end post would need to be replaced to put the bridge back in service, However, the contractor we were working with suggested using heat straightening to return the end post to its original geometry. We agreed to see how the heat straightening worked out. After shoring the hip joint and a week of field work, the heat straighteners were somewhat amazingly able to return the end post to its original alignment. However, longitudinal cracks were observed in the web of the primary channels after heat straightening operations. Due to the cracking and because we were



Heat straightening operations underway.

uncertain of the impacts of heat straightening on the chemistry of the 19th century steel, supplementary plates were bolted to the web of the channels to carry the entire end post load. As a result of this decision, the heat straightened portion of the end post just needed to brace the new supplementary web plates. Construction was simplified because we did not need to develop an end post splice near the lower chord. Consequently, it was a simpler solution to plate the web compared to replacing portions of the channels and splicing new material to the original.

Deteriorated components on the north truss.

CASE STUDY 2 – LASER SCANNING - QUARRY HILL BRIDGE

Repaired end post.

The Quarry Hill Nature Center Bridge carries a trail over Silver Creek in Rochester, Minnesota. The bridge consists of a pair of pony truss spans that were part of an abandoned township road. The city of Rochester eventually acquired the bridge and wrapped it into the trail system at the nature center.

However, by 2011, the structure was showing its age with extensive deterioration of the floor system, the lateral bracing, and the knee bracing.

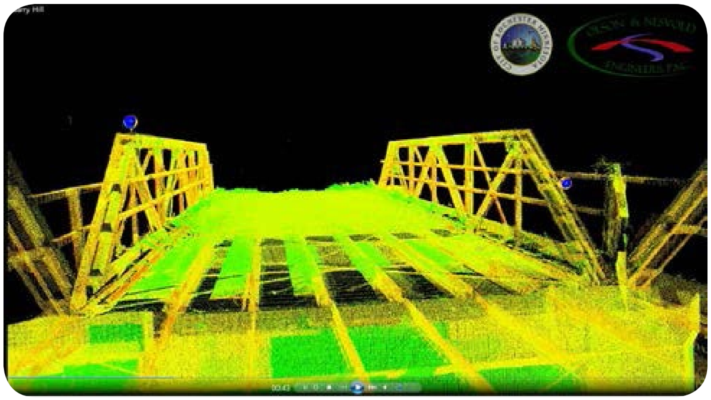
One of the challenges faced by owners of older bridges is to assess the costs and risks associated with bridge rehabilitation versus bridge replacement. A replacement project is often seen as a low risk choice. Owners often understand that it might be a bit more expensive, but at least they will not be caught expending a large sum of money on rehabilitation only to find out later that rehabilitation was not feasible. Owners are rightfully concerned about unforeseen issues that might be discovered during a rehabilitation project that can increase project costs and delay the project schedule.

Another challenge for rehabilitation projects is having accurate geometric information in hand to work with. Many times original plans are not available–and in the cases in which plans are available, it is likely that any alterations to the bridge over the past 50 to 100 years have not been well documented in as-built drawings, inspection, or maintenance files.

> *Waddell Principle XII*
> *Before starting a design, one should obtain complete data for same.*

Laser scanning is an extremely efficient and cost-effective way to collect information. We have used static laser scanning data for our rehabilitation projects for eight years. Not only can member geometry and member sizes be determined, alterations such as railing updates, lighting, and signing can readily be identified. In addition, it is not unusual to have older structures impacted by vehicle hits–or to have substructure units settle and shift with time. These movements can be quantified and extracted from the scan data and included in the design.

We have found that collecting scan data for medium sized bridges can usually be accomplished with one day in the field (by a two-person crew) and another day to register the scans into a point cloud. One of the side benefits of scanning is the ability to collect



Point cloud for the bridge.

more information than what is initially expected. It is not unusual to have additional questions or geometric requests arise during design. With scanning, it is likely the geometric information is already available, eliminating the need to conduct multiple follow up trips to the site.

The floor system for the Quarry Hill Nature Center Bridge was rehabilitated by removing the old deck, stringers, and lateral bracing. The new floor system included a cast-in-place slab spanning from floor beam to floor beam.

The floor beam deterioration at the ends of the beams was addressed by sandwiching supplemental web plates on both sides. The new plates arrived at the site with a shop applied zinc primer and were placed against the original web after it was blast cleaned and primed in the field.

One of the benefits of laser scanning the Quarry Hill bridge was identifying some geometry shifts. We were able to see in the scans that the truss spans were no longer rectangular in plan view. Each

New slab floor system.

Supplemental floor beam web plate prior to final paint coats.

span had racked a small amount and turned into a parallelogram. By recognizing this early in the design, we were able to detail the railing to be supported by the curb instead of the distorted trusses.

By adding a small profile to the bridge deck we reduced the amount of drainage washing over the steel bridge components and which will slow the rate of future deterioration. The bridge should be an asset for the City of Rochester for decades to come.

CONCLUSION

Rehabilitated pony truss spans.

Dr. Waddell passed away in 1938. His contributions to the bridge engineering profession were enormous. His projects continue to be assets to people around the world. Today's bridge engineers would be wise to read his books and consider his guidance as they work on projects.

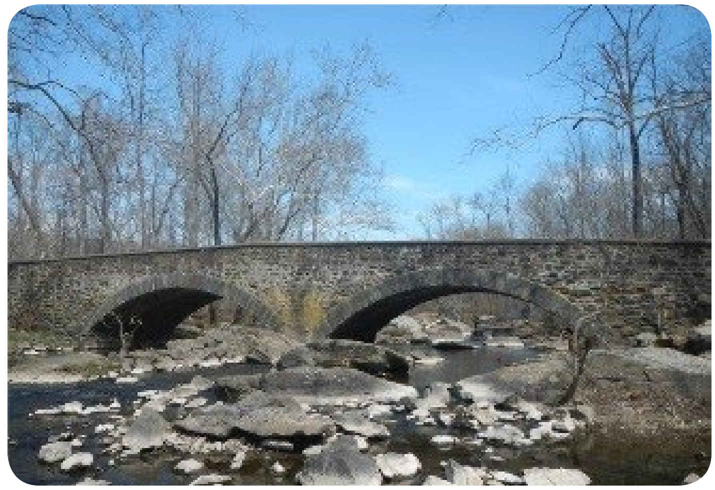
Steve Olson is the principal bridge engineer at Olson and Nesvold Engineers, P.S.C. (O.N.E.) in Bloomington, Minnesota. He received his engineering degrees from the University of Minnesota. Prior to starting at O.N.E., he held engineering positions with Burgess and Niple, Columbus, Ohio; the National Steel Bridge Alliance, Minneapolis, Minnesota; HTNB, Minneapolis, Minnesota; and the Mast Laboratory at the University of Minnesota. He has 32 years of bridge engineering experience.

Guidance for the Treatment of Historic Bridges

By Tyra Guyton

Wherever you travel in Pennsylvania, you are likely to cross a historic bridge. These bridges are an important part of the cultural landscape and a link to Pennsylvania's transportation and engineering history. Eventually these bridges need some level of work to continue providing a safe passage. The best

The Belle Vernon bridge carries I-70 over the Monongahela River, railroads, and roads in Washington County. At least three different bridges can be seen in this photo and illustrates the diversity of bridge types in Pennsylvania. *Photo by Nathan Holth, August 2010.*



The character defining features of this stone arch bridge that carries Price Road over Unami Creek in Marlborough Township in Montgomery County are the voussoirs, arch barrels, and stone construction, including the cut stone and the coursing. *Photo from PennDOT BMS2 Inspection Files, April 2016.*

way to execute this work without diminishing the historic character of these bridges is by consulting and applying the Secretary of the Interior's *Standards for the Treatment of Historic Properties* and relevant guidance.

The Secretary of the Interior is responsible for establishing standards for national preservation programs for historic buildings of different sizes, materials, construction types, as well as the exterior and the interior of the building, the site and location of the building, and related landscape features. The *Standards* are to be applied to specific rehabilitation projects in a reasonable manner, taking into consideration economic and technical feasibility. In addition, the *Standards* guide Federal agencies in carrying out their responsibilities under Section 106 of the National Historic Preservation Act, which requires Federal agencies to consider the effect projects have on historic properties (resources listed in or eligible for listing in the National Register).

These *Standards* offer common sense preservation principles that promote best practices for the maintenance, replacement, and repair of historic materials and the design of new additions and alternative uses for historic properties. The *Standards* offer four approaches to the treatment of historic properties: preservation, rehabilitation, restoration, and reconstruction (https://www.nps.gov/tps/standards/four-treatments.htm).

Because the *Secretary of Interior Standards for the Treatment of Historic Properties* does not relate specifically to bridges, the Pennsylvania State Historic Preservation Office (SHPO) has developed more specific guidance on the consideration and application of the *Standards* to historic bridges in Pennsylvania. By considering historic character and the *Standards* alongside project needs, it is possible to avoid or minimize adverse effect under Section 106.

These heavy timber trusses are among the character defining features of the Burkholder Covered Bridge over Buffalo Creek in Somerset County. *Photo from PennDOT BMS2 Inspection Files, June 2016.*

Standards for Rehabilitation

Treatment of historic bridges falls under the Secretary of the Interior's *Standards for Rehabilitation*. While rehabilitation requires consideration of the retention of historic material, rehabilitation of historic bridges allows more flexibility for the replacement of deteriorated or missing features, while taking into consideration economic and technical feasibility. Of the ten standards found in the *Standards for Rehabilitation* (https://www.nps.gov/tps/standards/rehabilitation.htm), the most relevant to bridge rehabilitation include:

- <u>Standard 2</u>: preservation of distinctive features and finishes that characterize a historic property
- <u>Standard 5</u>: preservation of construction techniques or examples of craftsmanship that characterize a historic property
- <u>Standard 6</u>: preference for repair of deteriorated historic features over replacement

The upper chords of the Ross Fording metal truss bridge in Chester County are Phoenix columns. These columns reflect an important engineering technology. *Photo from PennDOT BMS2 Inspection Files, July 2014.*

Since the goal of the *Standards* is to preserve historic material and the resource's historic character, it's important to understand why a bridge is significant and what features and materials are considered important to conveying significance, also known as character-defining features. Most bridges in Pennsylvania possess individual National Register significance under Criterion C in the area of Engineering (https://www.nps.gov/nr/publications/bulletins/nrb15/nrb15_2.htm). These bridges embody distinctive characteristics of a type, period, or method of construction; are the work of a noted engineer, engineering firm or bridge company; or possess high artistic value. The character-defining features of historic bridges vary by the type and design of the bridge, but are generally those features that convey the structure's type and construction era, such as design features, materials, and decorative detailing. Often the National Register significance and character-defining features of a historic bridge will be found in the documentation that resulted in the structure's listing or determination of National Register eligibility.

Guidelines for Rehabilitating Historic Properties

The Secretary of Interior's *Guidelines for the Treatment of Historic Properties* (https://www.nps.gov/tps/standards/rehabilitation/rehab/guide.htm) provide more specific guidance on how to apply the Secretary of Interior's *Standards for Rehabilitation*. The Secretary of Interior's *Guidelines* specific to rehabilitating historic properties include approaches, treatments, and techniques that are consistent with the *Standards* and include:

- Identify, Retain, and Preserve: Basic to the treatment of all historic buildings, it is necessary to identify, retain and preserve the form and detailing of those architectural materials and features that are important in defining the historic character.
- Protect and Maintain: After identifying those materials and features that are important and must be retained in the process of rehabilitation work, the protection and maintenance of the materials and features should be addressed.
- Repair: Repairing is warranted when the character-defining materials and features warrants additional work. Guidance for the repair of historic materials begins with the least degree of intervention possible. Repairing also includes the limited replacement in-kind–or with compatible substitute material–of extensively deteriorated or missing parts of features. Although the use of like material is preferred, substitute material is acceptable if the form and design as well as the substitute material itself convey the visual appearance of the remaining parts of the feature and finish.
- Replace: Character-defining feature may be replaced with new material because the level of deterioration or damage of materials precludes repair. As with repair, the preferred option is always replacement of the entire feature in-kind, that is, with the same material. Because this approach may not always be technically or economically feasible, provisions are made to consider the use of a compatible substitute material.

This clearance device protects the Mill Road Covered Bridge in Bedford County from being crossed by vehicles that are taller than the portal opening. *Photo from PennDOT BMS2 Inspection Files, February 2017.*

The Pennsylvania State Historic Preservation Office (SHPO) has adapted these guides to more fully address the specific needs in historic bridge rehabilitation:

- Identify, Retain and Preserve: To begin, all character-defining features of the historic bridge should be identified and measures should be taken to retain these features in the process of rehabilitation. If after rehabilitation the bridge still has load and height restrictions, the bridge may be protected by posting a roadway weight restriction or using a headache bar to stop traffic that is taller than the allowable clearance.
- Repair: If features of the bridge need repair, these repairs should be undertaken in a manner with the least intervention, using recognized preservation methods such as splicing, heat straightening, or reinforcing members with additional material.
- Replace: If features of the bridge cannot be repaired, then replacement is allowed. It is preferred to replace the material in-kind using the original material with the same visual qualities. If in-kind replacement is not possible, then substitutions can be used. However, materials must convey the same visual appearance as the original material. Care should be taken to only use substitute materials when necessary since substitute materials can reduce the historic character of a resource. Because most decks are not character defining, traditional wooden decks may be replaced with different materials. In cases where a significant feature in the bridge's historic appearance is missing, the feature should be accurately replicated based on adequate historical, pictorial, and physical documentation with consideration of the size, scale, and material of the bridge.

Historic Bridge Rehabilitation Considerations

As part of Section 106, a range of alternatives need to be considered by the Federal agency with the goal of meeting project purpose and need while accommodating historic preservation concerns. For historic bridge projects, this includes consideration of rehabilitation for continued vehicular use. Since every bridge and project is different, the Secretary of Interior's *Standards* and *Guidelines* must be applied on a case to case basis The following questions were designed by the Pennsylvania State Historic Preservation Office (SHPO) to guide engineers and historians in the decision-making process. Investigation of these question can also be part of the documentation showing due diligence in the consideration of rehabilitation options.

- Why does the bridge have National Register significance?
- What are the key aspects of integrity that allow the bridge to convey its significance?
- What are the character-defining features that need to be retained for the bridge to convey its significance including distinctive engineering and stylistic features, finishes, construction techniques, and examples of craftsmanship?
- Does the bridge have historic alterations (more than 50 years old) that contribute to the overall significance of the bridge (Standard 4)?
- Are there levels of importance among the character-defining features? If so, what are they? (More significant/distinctive features should receive greater levels of consideration for preservation or rehabilitation.)
- Can the character-defining features of the bridge be preserved while accommodating the project purpose and need and safety requirements (Standard 1)?
- If it is not possible to repair the character-defining features of the bridge, can you replicate historic materials, methods, and construction techniques without affecting the historic character of the bridge (Standard 5)?
- Can the new work on the character-defining features match the old work in terms of size, design, color, texture, architectural detailing, and other visual qualities (Standard 6)?
- For missing features that will be replicated, is there documentary, physical or pictorial evidence (Standard 6)?
- Do new features, such as lighting, railing, or other decorative elements, give a false sense of the bridge's history (Standard 3)?
- If new work is required, such as strengthening or reinforcement, can it be designed not to compromise the historic engineering significance of the bridge (Standard 10)?
- Can the new work be hidden from view?
- Are new features, such as guiderails, differentiated from the old and compatible in terms of massing, size, and scale (Standard 9)?

The Pine Creek bridge in Lycoming County is a rare lenticular truss. An early Inappropriate repair led to the bearings being encased in concrete which caused the bottom chord to buckle over time. In a later rehab, the damaged bottom chord was replaced with high-strength steel, an example of the use of substitute material. *Photo by Nathan Holth, 2016.*

- Would a lay person viewing the bridge after it is rehabilitation be able to understand its original use, design, function, materials, engineering, and/or association (Standard 2)?

If rehabilitation is chosen as the preferred alternative, the successful execution of plans and specifications developed in accordance to the *Standards* is crucial in order to avoid an adverse effect to the historic bridge. Elements critical to a successful execution include the use of qualified construction personnel with demonstrated experience working with the relevant historic material, as well as consistent communication between engineers, historians, and construction personnel and construction monitoring. Through careful planning and collaboration, application of the *Standards* can result in high-quality bridge rehabilitations that enable bridge enthusiasts to continue to enjoy historic bridges.

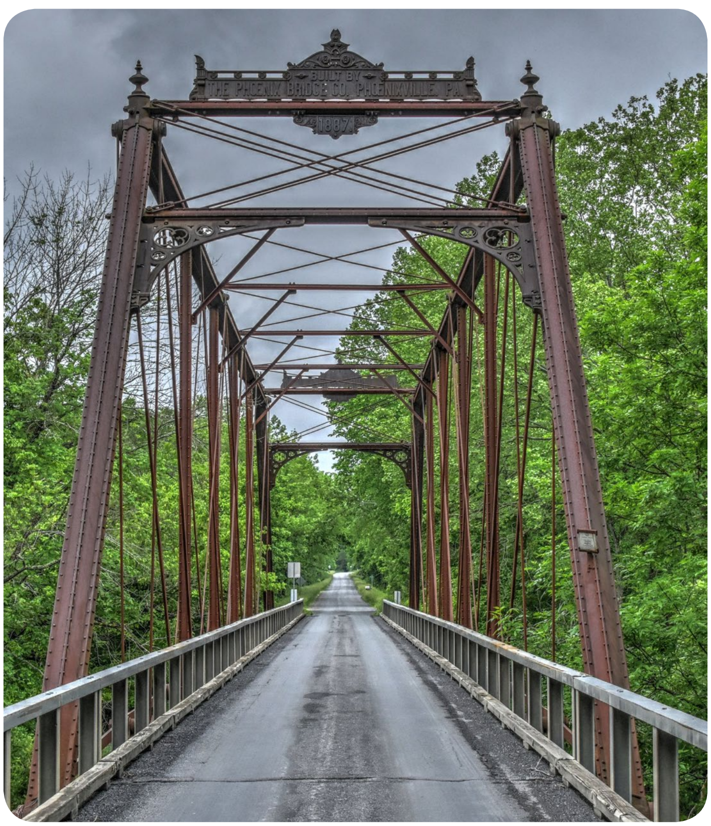
Tyra Guyton is the Transportation Special Initiatives Coordinator in the Pennsylvania State Historic Preservation Office with a special interest in adaptive reuse of historic truss bridges. Through a special funding agreement with PennDOT, she assists PennDOT with management and marketing of their historic truss bridges. She received her Master's degree in Historic Preservation from the University of Maryland.

Phoenix Bridge builder plaque. *Photo by Nathan Holth.*

Railroad Heritage on Virginia Highways

By Nathan Holth

The vast majority of historic bridges can typically be divided into three major categories: railroad bridges, highway bridges, and pedestrian (foot) bridges. Differences between these groups extends beyond the difference in the traffic on the bridge, including ownership (and public accessibility), project funding and government regulations, as well as structural differences in bridge design to serve these different traffic needs. On occasion, these groups can become mixed when a bridge's original traffic function changes, either through relocation of the bridge or through conversion of the facility the bridge carries. The most common changes in function are from vehicular to pedestrian use (often to preserve a historic bridge), and from railroad to pedestrian (typically as part of a rails-to-trails project). Less common is a transition from railroad to vehicular use. However, Virginia has several noteworthy former railroad bridges that were converted for use by vehicular traffic.



Phoenix Bridge portal. *Photo by Nathan Holth.*

Phoenix Bridge

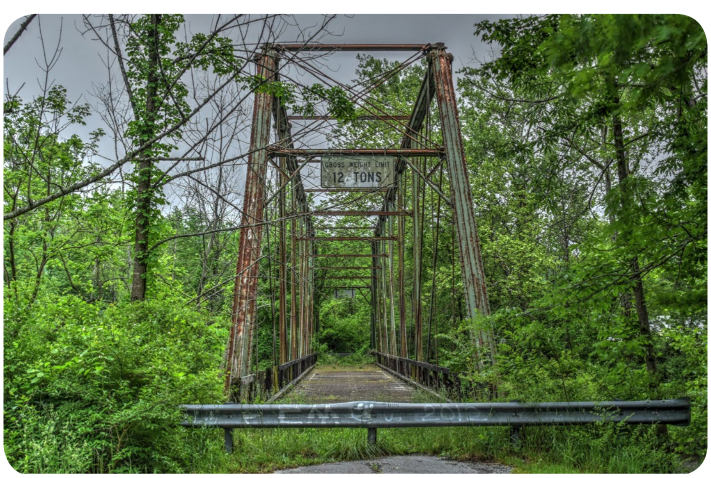
Metal truss bridges that made use of patented Phoenix columns are held in high regard by bridge historians because they are rare and represent a unique patented approach to the fabrication of iron members for bridges and buildings. A number of patents were issued in the 1800s for patented cast and wrought iron columns to be used in bridges and buildings. Only two enjoyed a brief period of common use: Keystone columns by the Union Iron Mills (and the related Keystone Bridge Company), and Phoenix columns by the Phoenix Iron Works of Phoenixville, Pennsylvania. The Phoenix Iron Works produced columns for buildings, but also for its related bridge building interest, the Phoenix Bridge Company, which was originally called Clarke, Reeves, and Company.

Looking up at the Phoenix Bridge, with the deck truss approach span shown to the right. *Photo by Nathan Holth.*

End post, cast iron shoe, and bearing for Rocky Gap Bridge. This detail photo shows the rounded Phoenix sections making up the end post. *Photo by Nathan Holth.*

Located in Botetourt County, the Phoenix Bridge crosses Craig Creek on Ball Park Road (Route 685). The Phoenix Bridge as seen today was a replacement for a previous bridge built ca. 1891 to serve the Craig Valley Line of the Chesapeake and Ohio (C&O) Railroad. In 1903, this bridge was replaced with two truss spans that were reused from an unknown location. One span is a pin-connected Whipple through truss with Phoenix columns and built by the Phoenix Bridge Company in 1887. The other span is a rivet-connected Warren deck truss built in 1888. The Phoenix Bridge Company had supplied the C&O Railroad with a number of 150-foot truss spans. Therefore, it is not certain where this span originally came from. The original location of the Warren truss span is also unknown, as is the builder for that span.

While the Phoenix column through truss span is by far the most beautiful span, both spans enjoy a high level of historical significance. Any surviving truss bridge that includes use of Phoenix columns is both rare and historically significant for the use of this noteworthy patented column. However, this bridge’s through truss span stands out among such bridges for several reasons, including its use of the uncommon Whipple truss configuration. This bridge also stands out among similar bridges for its nearly complete lack of alteration. Most amazingly, all the ornamentation on the portal including builder plaques, date plaques, finials, and portal bracing knees survive largely intact. This is extremely rare among bridges with this type of ornamentation. Additionally, this bridge is unusual among Phoenix column bridges with surviving builder plaques because its plaque actually bears the name of the Phoenix Bridge Company. Many of the surviving truss bridges with Phoenix columns were erected by Dean and Westbrook of New York, New York, and these bridges bear plaques with the Dean and Westbrook name, not the Phoenix Bridge Company.



Rocky Gap Bridge. *Photo by Nathan Holth.*

Other Phoenix Column Bridges

While the aforementioned Phoenix Bridge stands out as the most noteworthy in Virginia, there are several other outstanding truss bridges with Phoenix columns in the state. The bridge over Wolf Creek at Rocky Gap (Bland County) is one example. The National Register of Historic Places Nomination Form states that the bridge was built in 1912, referencing the years in which the New River, Holston, and Western Railroad Company extended its line to Rocky Gap. Although erected here to serve this new section of the New River, Holston, and Western Railroad, the Phoenix columns and Whipple truss configuration

The Gleaves Road Bridge. *Photo by Nathan Holth.*

suggest the trusses are much older. Most likely, this bridge was a ca. 1890 bridge that was relocated to Rocky Gap (from an unknown location) for reuse in 1912. In 1946, this bridge was converted into a highway bridge, allowing it to serve Route 61 until 1987 when a new highway bridge was built on a nearby realignment of the highway. Today, the truss bridge sits abandoned. The combination of wrought iron's resistance to deterioration from rust, as well as paint surviving on most of the bridge, appear to have kept this bridge in excellent condition even in its abandoned state.

The Gleaves Road (Route 619) Bridge over Cripple Creek in Wythe County is a 128-foot Pratt through truss with Phoenix columns. This bridge continues to carry vehicular traffic on a highway that was originally part of the Speedwell Extension of Norfolk and Western Railway. This railroad line was built ca. 1903, and this bridge was erected to serve the railroad line. Like the bridge at Rocky Gap, this bridge's design suggests the truss span is a relocated and reused bridge originally dating to the ca. 1880-1890 period. The Speedwell Extension was abandoned in 1938 and later converted into a highway ca. 1948. This bridge has changed little from its original design.

Lastly, a small 80-foot Pratt through truss with Phoenix columns in the city of Covington is worth mention. This bridge was constructed ca. 1885-1890 and potentially relocated to its current location on Hawthorne Street over the CSX Railroad in the early 20th century. While a more detailed history was not researched, clues seen while visiting this bridge suggest an interesting history. The use of Phoenix columns support the reported construction date. However, unlike the other Phoenix column bridges in Virginia, this bridge does not use Phoenix columns for the overhead struts and portal bracing, and the portal bracing also lacks the ornamental cast iron bracing knees found on other Phoenix column bridges. Instead, these parts of the bridge are composed of traditional riveted angles, channels, and battens. Also noteworthy is the bridge's 21-foot roadway, which is quite wide for a 19th century truss bridge. The wide roadway, and overhead bracing design suggest this bridge was widened at some point during its history. If the truss was widened, the original bracing would not have been long enough and would have required replacement or alteration. The fact that the bracing on the bridge is riveted suggests that the bridge was widened during the period where rivets were still in use, which would be any time before ca. 1970. It may date to the assumed relocation of the bridge in the early 20th century. In its more recent history, this bridge was rehabilitated in 2006. The rehabilitation replaced the deck, stringers, and floor beams of the bridge. The work was notable for the use of a fiber-reinforced polymer composite cellular deck system to replace the former traditional concrete deck. The new deck was much lighter and reduced the bridge's dead load, enabling a greater posted weight limit for vehicles.

Oak Ridge and Aden Road Bridges

What is today the Norfolk Southern Railway has two similar highway overpass bridges in Virginia that bear mention. One carries Aden Road in Prince William County, while the other carries Wilson Road in Nelson County. Constructed in 1882, both are early surviving pin-connected Pratt through truss bridges,


Oak Ridge Bridge. *Photo by Nathan Holth.*

The Aden Road Bridge before the 2017 project began. *Photo by Rick McOmber.*

and both were built by the Keystone Bridge Company of Pittsburgh, Pennsylvania.

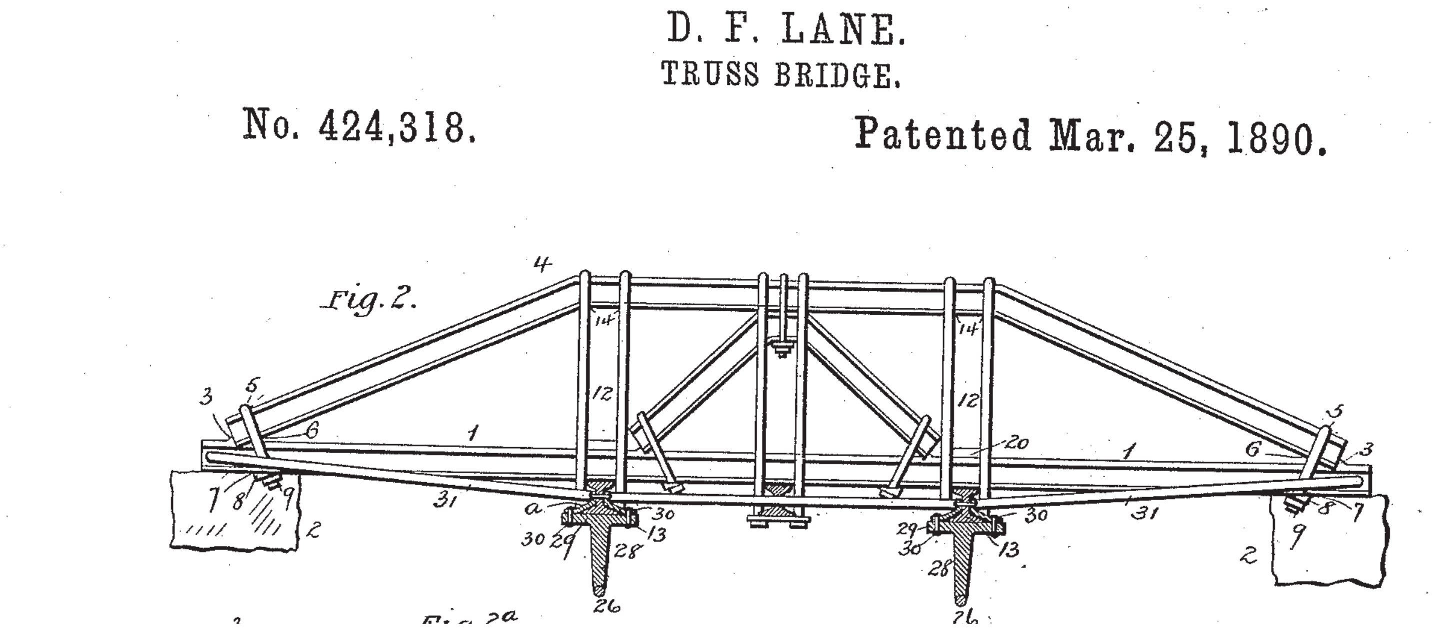
The exact history of the bridges is not known, but it is assumed that they share a similar history. The bridges were originally built to carry railroad traffic on unknown parts of the Virginia Midland Railroad. Likely in 1904-1905, when this railroad line was converted into a double-track line, the bridges were relocated to their present locations where they were converted for use as vehicular bridges.

Both the Oak Ridge and Aden Road Bridges are noteworthy for their association with the Keystone Bridge Company, which was a business associated with Andrew Carnegie. Further, because these bridges were originally railroad bridges, they are early surviving examples of iron railroad bridges.

The Stokesville Bridge as seen in 2017. *Photo by Nathan Holth.*

Railroad bridges of this vintage are uncommon today because their lightweight construction rapidly became insufficient in the early 20th Century and most bridges from this era were replaced. These two bridges survived because of their conversion to highway use, where load and width requirements were not as high. However, after over 100 years of service, the Aden Road Bridge nevertheless became insufficient for the needs of the highway. As of 2017, a project to

This historical photo of the Stokesville Bridge shows it as a railroad bridge with tracks and train station clearly visible.



A portion of D. F. Lane’s patent for a truss bridge composed of railroad rails shows a general design drawing.

create a one-way couplet of bridges is underway. The trusses of the Aden Road Bridge will no longer serve a structural function, but will be placed on one of the two one-way bridges as decorations.

Wallens Creek and Stokesville Bridges

Virginia has two highway bridges that were originally railroad bridges and are rare examples of pin-connected Warren truss bridges. Warren truss bridges typically have riveted connections.

The bridge in Lee County over Wallens Creek on County Road 616 was built at an unknown date, but has the appearance of a 19th century truss bridge. Its deep, heavy floorbeams, which also have unused brackets (likely for the railroad deck stringers which no longer exist) and empty rivet holes, hint at this bridge’s presumed railroad past. The bridge’s unusually composed built-up beams and connection details, which differ from typical highway truss design, further suggest railroad origins for this span.

The Stokesville Bridge in Augusta County is another pin-connected Warren through truss that is better documented and more clearly indicates its railroad origins. A rather late example of the uncommon pin-connected Warren truss design, this bridge was built ca. 1901. It displays design and fabrication details typical for this period with the exception of its truss configuration. The bridge today carries Stokesville Road (Route 730) over North River, but the bridge and the road it carries was originally the Chesapeake

The Stokesville train station as seen today, with some salvaged railroad equipment on display to the left. *Photo by Nathan Holth.*

The Crab Run Bridge trusses. *Photo by Nathan Holth.*

The Crab Run Bridge trusses. *Photo by Nathan Holth.*

and Western Railway. Immediately southeast of this bridge, the Stokesville Railroad Depot remains standing. Historical photos provide further proof of this bridge's railroad past.

Crab Run Lane Bridge

The Crab Run Lane Truss Bridge in Highland County was never a railroad bridge, but it bears mention because it has an unusual connection to railroads: the truss was built using railroad rails as structural members! Daniel F. Lane owned the Lane Bridge Company in Painted Post, New York. In 1890, Lane patented a unique pony truss design (#424,318), and improved upon this patent in 1894 (#531,048). His patent was specifically for a truss bridge fabricated using railroad rails, and also claimed the many unusual details that Lane had designed to accommodate this atypical structural member.

The Crab Run Bridge was built in 1896 using the Lane Patent, although by a different company, the West Virginia Bridge Works of Wheeling, West Virginia, manufactured this bridge. Typical of patented truss designs, the actual bridge varies in some details from the drawings shown in the actual patents. Moreover, this bridge more closely resembles the details shown in the 1890 patent, rather than the 1894 improved patent. The bridge is composed of a top chord rail, which bends at the ends to become the inclined endposts. A second rail inside the truss is bent to form an inverted "V" giving the truss an appearance similar to a Howe truss. The unusual vertical members are paired rods that literally wrap around the top chord and run at angles into the floorbeams.

The Crab Run Bridge was bypassed by a modern realignment of the main highway, which had originally been part of the Staunton and Parkersburg Turnpike, and is today US-250. The bridge has been closed to vehicular traffic, but left in place for pedestrian use. Interpretive signs describing the history of the bridge, turnpike, and surrounding area are present next to the bridge.

Conclusions

While uncommon, highway bridges with railroad heritage can be found across the country. Virginia stands out however, not only because it has several good examples of these types of bridges, but also because these bridges stand out as some of the most significant historic bridges in the state of any kind. These bridges are significant for their railroad heritage, as well as their design and materials. Because railroad bridges were typically of heavier design than highway bridges of the same age, these bridges also may offer unique preservation opportunities, whether for continued vehicular use, or perhaps for another conversion, such as for pedestrian use.