3.0 HISTORIC CONTEXT FOR COMMON HISTORIC BRIDGE TYPES

This Chapter presents the historic contexts for the most common bridge types extant in the United States today. A "common historic bridge type," as defined for the purposes of this study, will possess all of the characteristics below.

1) It is *Common*: a bridge type that is prevalent, i.e., the type is widely represented in extant examples throughout the regions of the United States. (As the discussions of the individual bridge types in this chapter indicate, some types are much less common than others.)

2) It is *Historic*: a type of bridge that meets National Register of Historic Places (NRHP) criteria for evaluation of significance, as outlined in the National Register Bulletin, *How to Apply the National Register Criteria for Evaluation.* This includes types that are more than fifty years of age as of 2005. The date of 1955 was selected as the cut-off date for this study because it covers the period up to the passage of the Federal Aid Highway Act of 1956, which established the Interstate System and which permanently changed highway planning and design. (Since there are few NRHP-eligible or listed examples of types that have developed since 1955, they are not considered both historic and "common.")

3) It is a *Bridge Type*: the primary determinate of "type" is the "form," or manner in which the structure functions. A bridge type is not defined strictly according to materials; method of connection; type of span; or whether the majority of the bridge structure exists above or below the grade of travel surface. (Some patented or proprietary systems are listed in the most common bridge types listed below due to the importance of that system, even though the actual type is covered by a separate "type" designation.)

The list below presents the bridge types that have been identified as both common and historic, using the methodology presented in Chapter 1. They are arranged essentially by categories and then by type, but some types may fit into more than one category. Within each category, the Study Team attempted, when possible, to arrange the types chronologically. The 46 most common historic bridge types discussed in this study are listed below.

CATEGORY 1: TRUSS

- King Post Truss
- Queen Post Truss
- Burr Arch Truss
- Town Lattice Truss
- Howe Truss
- Bowstring Arch Truss
- Pratt Truss
- Whipple Truss
- Baltimore Truss

- Parker Truss
- Pennsylvania Truss
- Warren Truss
- Subdivided and Double-Intersection Warren Truss
- Ventricular Truss

CATEGORY 2: ARCH

- Stone Arch
- Reinforced Concrete Melan/von Emperger Arch
- Reinforced Concrete Luten Arch
- Reinforced Concrete Marsh or Rainbow (Through) Arch
- Reinforced Concrete Closed Spandrel Arch
- Reinforced Concrete Open Spandrel Arch
- Steel Tied Arch
- Reinforced Concrete Tied Arch
- Steel Hinged Arch
- Reinforced Concrete Hinged Arch

CATEGORY 3: SLAB, BEAM, GIRDER & RIGID FRAME

- Timber Stringers
- Reinforced Concrete Cast-In-Place Slabs
- Reinforced Concrete T Beams
- Reinforced Concrete Channel Beams
- Reinforced Concrete Girders
- Reinforced Concrete Rigid Frames
- Reinforced Concrete Pre-Cast Slabs
- Pre-stressed Concrete I-Beams
- Pre-stressed Concrete Box Beams
- Metal Rolled Multi-Beams
- Metal Built-Up Girders
- Metal Rigid Frames

CATEGORY 4: MOVABLE SPANS

- Center-Bearing Swing Span
- Rim-Bearing Swing Span
- Vertical Lift Span
- Simple Trunnion (Milwaukee, Chicago) Bascule Span
- Multi-Trunnion (Strauss) Bascule Span
- Rolling Lift (Scherzer) Bascule Span

CATEGORY 5: SUSPENSION

CATEGORY 6: TRESTLES AND VIADUCTS

CATEGORY 7: CANTILEVERS

For each bridge type, the text in this chapter includes a brief history of the type's development; a description of the type and subtypes; identification of the period of prevalence; and a statement of each type's significance within the context of the most common bridge types identified in this study. This significance evaluation is geared toward the engineering significance of the bridge types, that is, National Register of Historic Places (NRHP) Criterion C.

The evaluation describes the "character-defining" features of each type, i.e., structural elements that are key to conveying the structure's type and construction era. The significance assessment has been derived by the Study Team through consulting numerous historic bridge context studies and comprehensive bridge survey reports and through their cumulative knowledge of historic bridges.

Study users desiring to evaluate a historic bridge can use the guidance presented in this study, but must also consider a structure within its local or state context. Such information is available in comprehensive bridge surveys and the historic bridge contexts that have been prepared by many states. In this study, within the context of the most common historic bridge types in the United States, if a type or subtype is denoted as *highly significant*, it will likely be eligible for the NRHP if it retains a high or medium level of integrity. If a type or subtype is noted as *significant*, it may be eligible for the NRHP if it retains a high level of integrity. Types or subtypes that have moderate significance would need to have a very high level of integrity and may need added elements of significance to be considered NRHP eligible. Example of elements that may increase the significance of a bridge within the context presented in this report, include association with an important designer or historic event. Types or subtypes labeled as having low significance are very common types that either played no important technological role in the context of this study or bridges that are more recent and their relative significance cannot yet be determined because of the limited scholarship on these types.

Study users must also make determinations of bridges that are within NRHP eligible historic districts. For these determinations, its level of significance as presented in this report will not be a deciding factor. If the bridge fits within a district's period of significance and generally retains its character-defining features, it is likely to be considered as "contributing" to the district and thus, NRHP eligible as a contributing element of the district.

Examples of each type are provided; the examples are either listed in or eligible for the NRHP or recorded for the Historic American Engineering Record (HAER). Documentation for the NRHP listed examples is available at the respective State Historic Preservation Offices or at the Office of the Keeper of the Register in Washington, DC The determined eligible examples may also be accessed at the Shops or the transportation departments of the respective states. Often, the comprehensive bridge survey findings of the various states are used as their NRHP Determinations of Eligibility. The HAER documents are available at The Library of Congress in Washington, DC and can be accessed on-line at http://memory.loc.gov/ammem/collections/habs_haer/hhquery.html.

Appendix A provides links to online copies of a number of NRHP historic contexts and multiple property submittals, which provide a wealth of information.

Photographs are included for all of the bridge types, primarily from the HAER collection, and drawings accompany some of the types.

Figure 3-1 illustrates some of the bridge member shapes that comprise the numerous bridge types described in this report. Appendix B contains a copy of *Bridge Basics*, taken from http://pghbridges.com, and used with the gracious permission of Bruce Cridlebaugh, creator of the pghbridges website, “Bridges and Tunnels of Allegheny County and Pittsburgh, PA.” This is a very helpful website. Appendix C contains a copy of *Trusses, A Study by the Historic American Engineering Record*, provided for use in this document by staff of the National Park Service/HAER.

3.1. Trusses

Truss bridges may be built as simple spans, with abutments or piers at either end, or as continuous spans, with intermediate piers, bents or columns supporting the superstructure. A cantilevered truss bridge consists of anchor arms supported by piers, and a suspended span that is supported by the anchor arms.

Truss bridges are usually differentiated by the location of the deck or travel surface in relation to the rest of the superstructure. In a pony truss the travel surface passes between trusses on either side that constitute the superstructure. These trusses are not connected above the deck, and are designed to carry relatively light loads. In a through bridge the travel surface passes through the superstructure, which is connected with overhead lateral bracing above the deck and traffic surface by cross bracing. Through trusses are designed to carry heavier traffic loads than the pony truss and are longer in span, some approaching 400 feet. In a deck truss, the superstructure is entirely below the travel surface of the truss, and the traffic load is carried at or near the level of the top chord. Like the through truss, deck trusses can be designed to carry relatively heavy traffic loads and can have fairly long spans.

Metal truss bridges may also be differentiated by the method of connecting the structural members. The oldest examples were connected by pins. Riveted connections proved to be more stable than pin connections, which were prone to wear at the point of connection. In the twentieth century, welding became a common method of joining structural members.

Refer to Appendices B and C for additional information and drawings of truss types.

In this section on trusses, the first five truss types are commonly found in wood covered bridges, while the last nine are commonly found in metal spans. Figure 3-2 depicts three basic types of truss configurations.

Figure 3-1. Basis shapes of bridge members. From *Bridge Inspector's Training Manual*, U.S. Department of Transportation, 1991.

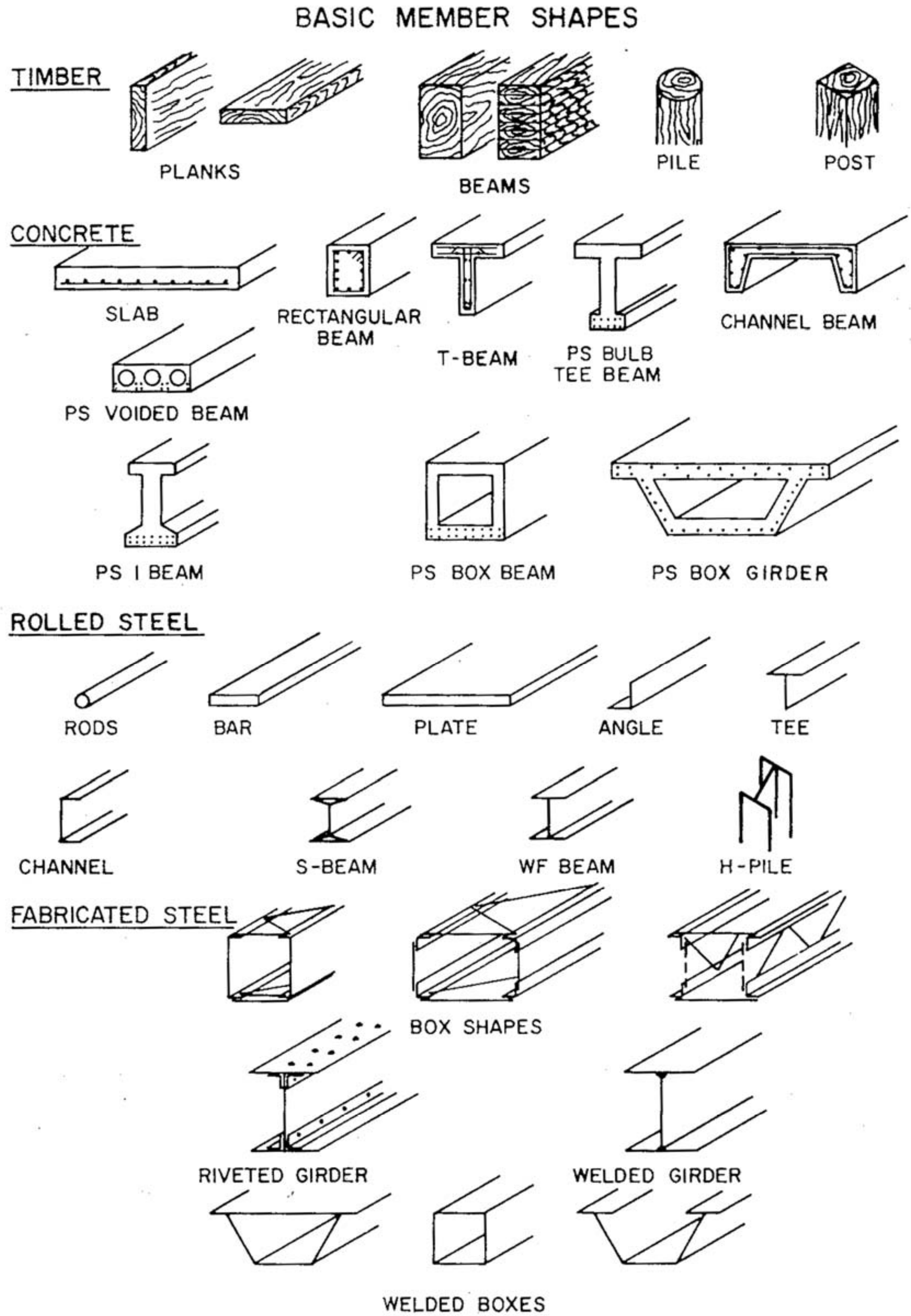
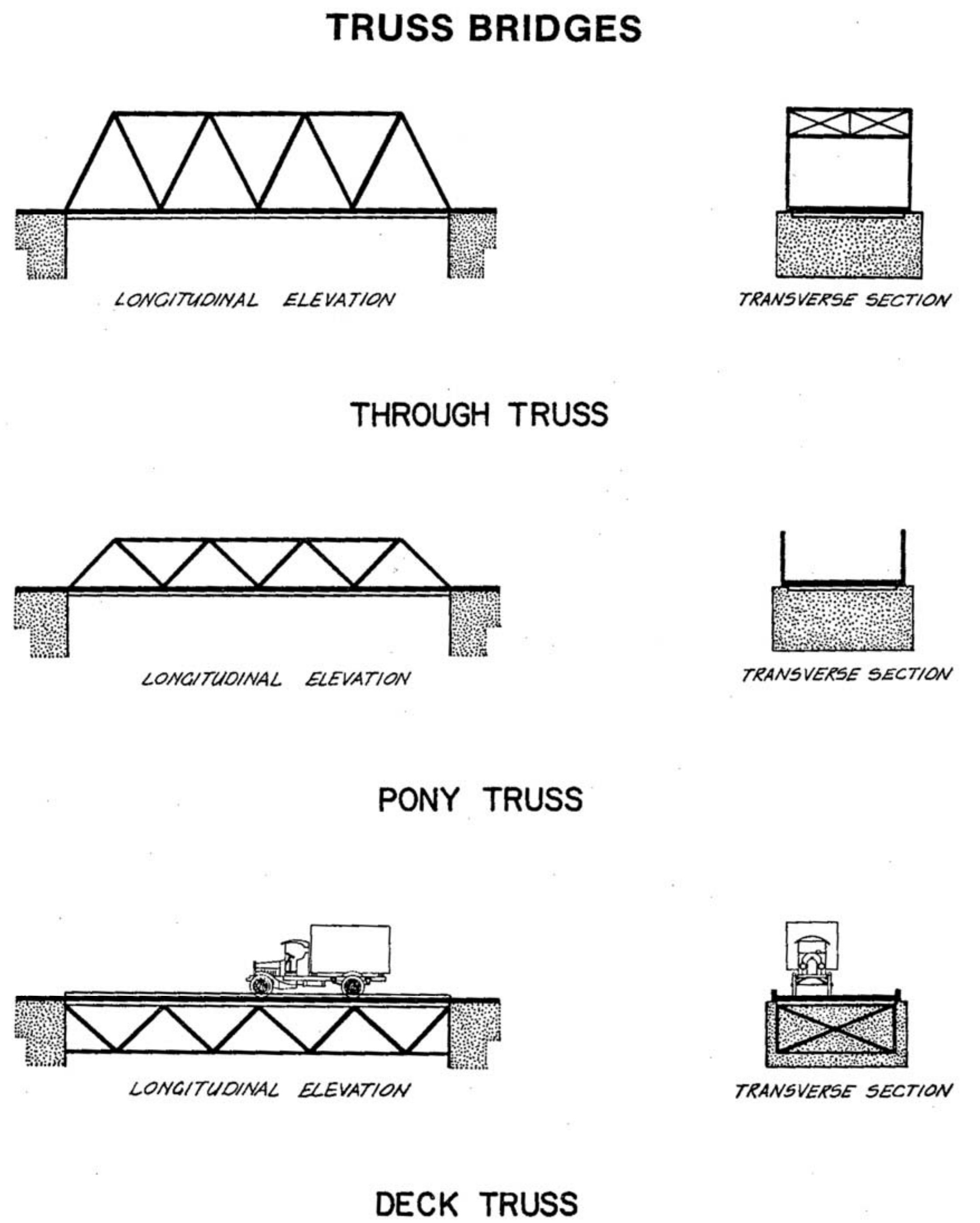


Figure 3-2. Three basic types of truss configurations. From Historic American Engineering Record, National Park Service.



3.1.1 King Post Truss

History and Description: The king post form dates from Medieval times, if not earlier. It served as the framework for the basic gable roof. The multiple king post dates from the Renaissance and was first illustrated by Palladio in his classic, *I Quattro Libri dell'Architettura*. After Isaac Ware translated this book into English in 1738, the book was widely distributed and the king post truss came into wide usage.

The king post (or kingpost) truss, the simplest of all truss designs, is now commonly found in covered wood bridges. It is not amongst the most common of the types discussed in this study, but is included because it is derivative. Most of the rectilinear trusses evolved from the king and queen post forms (discussed in Section 3.1.2. The simple form king post truss can be found on country roads or in parks, but it is most commonly found as a multiple kingpost in covered bridges. In the United States, the earliest multiple kingposts were the exposed timber frame bridges built in the first few decades of the nineteenth century by builders such as Timothy Palmer and Theodore Burr. Burr combined the multiple kingpost with the arch resulting in bridges of even longer spans

The king post truss is usually constructed of heavy timbers that form three sides of an isosceles or equilateral triangle, with a metal vertical tie rod or wood post (the king post) extending from the middle of the lower chord supporting the travel surface to the apex of the two diagonal timbers; however, some examples were built with main structural members of metal.

When used in bridge construction, the king post truss could be constructed with the main diagonals above or below the travel surface. Simple king post trusses were used only to span very short distances up to about 30 feet, but occasionally a series of king post trusses were combined to form a long timber bridge. Although the king post truss was often built without any covering or housing, the most common extant king post truss bridges are covered by a roof and siding to protect them from the weather.

A good example of an extant metal king post truss bridge is Bridge No. 1482 (1908), which was moved to its present location in Rock County, Minnesota, in 1990. This bridge has diagonal braces, which make it similar to the Waddell “A” truss. The Waddell “A” truss is a version of the king post truss with diagonal bracing between the main diagonal members and the lower chord, with a vertical tie or strut from the apex of the top members to the middle of the lower chord, and sub verticals from the intersection of the sub-diagonals to the lower chord. Only one Waddell “A” truss in its original location is known to survive in the United States; a span on the Kansas City Southern Railroad Cross Bayou Bridge (1927) near Spring Street in Shreveport, Louisiana.

The multiple king post bridge is essentially composed of a king post truss in the center with multiple panels to either side formed by vertical posts with diagonal counters matching the angle of the diagonals in the center truss, and a horizontal upper chord that is parallel with the lower chord. Three good extant examples are the Blacksmith Shop

Covered Bridge (1881) and the Dingleton Hill Covered Bridge (1882), both over Mill Brook in the town of Cornish, New Hampshire; and the Humpback Covered Bridge over Dunlap Creek in the vicinity of Covington, Virginia.

Below are NRHP listed or eligible and/or HAER-recorded examples of the king post truss type.

Significance Assessment: Few wooden bridges survive from the first decades of the nineteenth century so most bridges of this type will date from the 1840s and 1850s, when other truss forms, such as the Pratt and Warren, supplanted them. However, multiple kingposts persisted until the 1880s.

The king post truss is one of the less common types of the 45 types in this study. King post trusses from the 1840s and 1850s, if they retain their character-defining features, would be considered significant within the context of this study. The character defining features are the structure's triangular shape (either an isosceles or equilateral triangle) and a metal vertical tie rod or wood post (the king post) subdividing the triangle.

Intact late nineteenth century examples of the multiple king post are also considered significant. Twentieth century examples would possess less significance within the context of this study, but examples of king post bridges from this era have been identified as significant, particularly through the Section 106 process and subsequent HAER recordation as a mitigative strategy for proposed demolition.

Examples of King Post Truss

1. Crooks Bridge (1856), Parke County, IN. NRHP listed 1978.
2. Stony Brook Covered Bridge (1899); Washington County, VT. NRHP listed 1974.
3. Waddell "A" Truss Bridge (1898), Originally spanning Lin Branch Creek, Trimble vicinity, Clinton County, MO, moved to Parkville, MO. HAER MO-8.
4. Battle Creek King Post Truss Bridge (circa/ca. 1900), Phillips County, KS. NRHP listed 2003 in Metal Truss Bridges in Kansas 1861-1939 Multiple Property Submittal (MPS).
5. Neal Lane Bridge (1939), Douglas County, Oregon. HAER OR-126.
6. Chow Chow Suspension Bridge (Ca. 1950), spanning Quinault River, Taholah vicinity, Grays Harbor County, WA (Quinault Indian Reservation). HAER WA-51.
7. Humpback Covered Bridge (1857) over Dunlap Creek, Covington vicinity, Allegany County, VA. HAER VA-1.
8. Philadelphia & Reading Railroad, Walnut Street Bridge (no date/n.d.), spanning Reading main line at Walnut Street, Reading, Berks County, PA. HAER PA-119.
9. Bridge over New Fork River (1917), Sublette County, WY. NRHP listed 1984 in Vehicular Truss and Arch Bridges in Wyoming MPS.

Figures 3-3 through 3-5 provide a drawing and examples of the single and multiple kingpost truss.

Figure 3-3. Elevation drawing of king post truss.

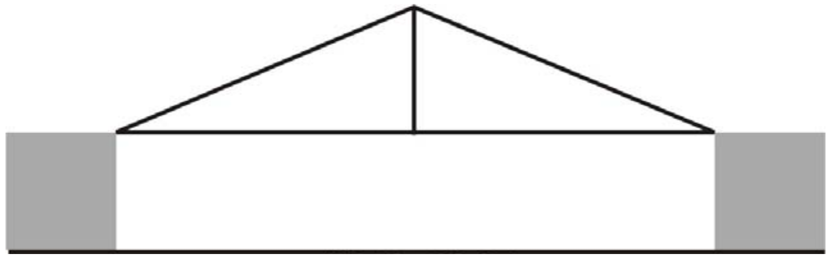


Figure 3-4. Philadelphia & Reading Railroad, Walnut Street Bridge (n.d.) spanning Reading main line at Walnut Street, Reading, Berks County, Pennsylvania. This bridge is an example of a single king post truss.

3-4a. Elevation view.

3-4b. Oblique through view.

Figure 3-5. Humpback Covered Bridge (1857), Humpback Bridge spanning Dunlap Creek, Covington vicinity, Alleghany County, Virginia. This bridge is a good example of a multiple king post used for a covered bridge.

3-5a. Oblique view.

3-5b. Interior view shows king post truss in the center (shown by arrow) with multiple panels to either side formed by vertical posts with diagonal counters matching the angle of the diagonals in the center truss, and a horizontal upper chord that is parallel with the lower chord.

3.1.2 Queen Post Truss

History and Description: Like the king post, the queen post (or queenpost) truss dates to the medieval era, if not earlier. The queen post truss may be thought of as a king post truss lengthened by the addition of a horizontal top chord member, thus creating a rectangular panel between the two triangles that face the center king post in the king post design. Because the rigidity of the center panel suffers without bracing, the middle floor beam was sometimes supported by a tensile member extending from the middle of the top chord, by braces between the corners of the middle panel, or by a pier under the middle of the span. This design enabled the construction of greater span lengths than possible with the king post truss. As with the king post truss bridge, metal versions of the queen post truss were constructed, but extant examples are usually of wood and most are covered. The metal queen post was superseded by the Pratt truss, which was very similar visually but very different in scale and function due to the incorporation of diagonal cross-bracing to handle forces in tension.

Significance Assessment: As illustrated in the examples above, the queen post truss was used through the nineteenth century (primarily the second half) and into the twentieth century. The queen post was a simple, easy-to-frame form that economically addressed the need for short spans of 30 to 40 feet.

Like the king post, the queen post is among the least common of this study's 45 common bridge types. The character-defining feature of the queen post truss is its form, a rectangular center panel with a parallel top and bottom chord, which is flanked by triangular panels with inclined end posts. Queen post trusses from the Antebellum period, if they retain their character-defining features, would be considered significant within the context of this study. Intact late nineteenth century examples of the queen post truss are also considered significant. Twentieth century examples would possess less significance within the context of this study, but examples of queen post bridges from this era have been identified as significant, particularly through the Section 106 process and subsequent HAER recordation as a mitigative strategy for proposed demolition.

Examples of Queen Post Truss

1. Greenbanks Hollow Covered Bridge (1886), Caledonia County, VT. NRHP listed 1974.
2. Copeland Covered Bridge (1879), Saratoga County, NY. NRHP listed 1998.
3. Jediah Hill Covered Bridge (1850, rebuilt in 1956 and 1981), Hamilton County, OH. NRHP listed 1973.
4. North Fork of the Yachats Bridge (1938), Lincoln County, OR. NRHP listed 1979 in Oregon Covered Bridges Thematic Resource Nomination.
5. Mercer County Bridge No. 2631 (circa/ca. 1894), spanning Pine Run at Cribbs Road, Mercer vicinity, Mercer County, PA. HAER PA-225.
6. Hortense Bridge (1880), spanning Chalk Creek on State Highway 162, (1880) Nathrop vicinity, Chaffee County, CO. HAER CO-49.

7. Zurich Road Bridge (1920s, 1940s), spanning Southern Pacific, Chicago & St. Louis Railroad, Joliet vicinity, Will County, IL. HAER IL-130.

Figures 3-6 through 3-8 provide a drawing and photographs of examples of the queen post truss.

Figure 3-6. Elevation drawing of queen post truss.

Figure 7. Hortense Bridge, spanning Chalk Creek on State Highway 162 (1880), Nathrop vicinity, Chaffee County, Colorado. This bridge is an example of a queen post truss built by Denver South Park & Pacific Railroad.

Figure 8. Mercer County Bridge No. 2631 (ca. 1894), spanning Pine Run at Cribbs Road, Mercer vicinity, Mercer County, Pennsylvania. This small structure is a late nineteenth century metal queen post truss.

3.1.3 Burr Arch Truss

History and Description: In 1804, Theodore Burr (1771-1822) built a four-span truss bridge with additional arch segments over the Hudson River between Waterford and Lansingburg (now part of Troy), New York. By pegging the arch ribs to the truss, the entire bridge was stiffened throughout its length. This bridge, considered to be Burr's masterpiece, was destroyed by fire in 1909. It is often described as a combination multiple king post truss and arch design, but in fact it had two diagonals in each panel. This arrangement was also illustrated in the Burr patent of 1817, although in practice the Burr arch was usually expressed with a single counter in each panel. The type of truss used was the most variable element in Burr's designs, and not all were of the multiple king post truss type. It was the combination of an arch rib with a truss that was the defining characteristic of the Burr arch. This bridge type was used extensively on highways and railroads primarily during the middle of the nineteenth century. It was suitable for span lengths of approximately 100 to 120 feet.

Significance Assessment: Theodore Burr created a highly successful timber truss system whose most important characteristic, compared to other truss types, was its stiffness. It was used throughout the 1850s, though some examples date from the late nineteenth century, such as the 1892 Raystown Covered Bridge. The Burr arch is considered amongst the highest developed of all-wood bridge types. Today, it is commonly found in wood covered bridges in many regions of the country, particularly in the eastern United States.

Examples of nineteenth century Burr arch bridges are considered significant within the context of this study if they retain their character-defining features. The combination of an arch rib with a truss, the attachment of the arch rib to the truss with pegs, the parallel top and bottom chords of the truss, and the verticals and diagonal members are the primary character-defining features of the Burr arch truss. They may or may not be covered. The roofing and/or exterior covering of a covered Burr arch truss is of secondary importance, since in most, if not all cases, these features are modern replacements. No twentieth century examples of this bridge type were identified during the study process.

Examples of Burr Arch Truss

1. Forksville Covered Bridge (1850), Sullivan County, PA. NRHP listed 1980 in Covered Bridges of Bradford, Sullivan and Lycoming Counties Thematic Resource Nomination.
2. Quinlan's Covered Bridge (1849), Chittenden County, VT. NRHP listed 1974.
3. Perrine's Covered Bridge (1844), Ulster County, NY. NRHP listed 1973.
4. Bridgeton Bridge (1868), Parke County, Indiana. NRHP listed 1978
5. Utica Covered Bridge (ca. 1850), Frederick County, MD. NRHP listed 1978 in Covered Bridges in Frederick County Thematic Resource Nomination.

6. Raystown Covered Bridge (1892), Township Route 418 spanning Raystown Branch, Manns Choice vicinity, Bedford County, PA. HAER PA-351.

Figures 3-9 and 3-10 provide a drawing and an example of the Burr arch truss.

Figure 3-9. Elevation drawing of Burr arch truss.

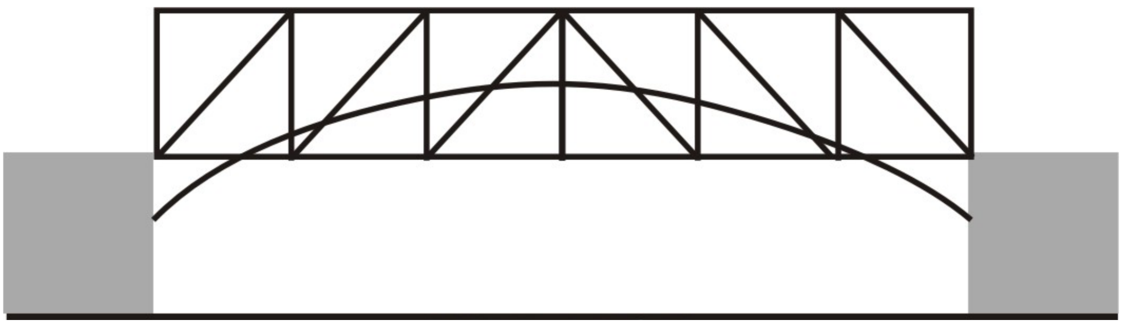


Figure 3-10. Raystown Covered Bridge (1892), Township Route 418 spanning Raystown Branch, Manns Choice vicinity, Bedford County, Pennsylvania. The uncovered sides of this structure reveal the Burr arch.

3.1.4 Town Lattice Truss

History and Description: Connecticut architect Ithiel Town (1784-1844) patented the Town lattice truss in 1820. This type of truss has intersecting diagonals forming a web between the top and bottom chord with no verticals or posts. The diagonals act in compression and in tension. Whereas earlier wood truss designs had relied upon heavy timbers connected with mortise-and-tenon joints, the Town lattice truss used planks cut to standard sizes, connected by round wood pins called “trenails.” Due to the lack of posts and the thinness of the original web design, however, this type was subject to increased twisting of the truss as the length increased. To improve on his design, Town patented a double lattice version featuring a heavier web in 1835 (*1*, p. 40). Town’s system had a number of very appealing features: no preparatory labor; no large timbers or intricate joints; no straps or ties of iron; connections that could all be made with trenails; and chord and web members that could all be made from members of the same size (usually 4-inch x 10-inch planks).

The Town lattice truss was relatively easy to erect and suitable for spans in excess of 200 feet. The longest wood covered bridge in the United States and the longest two-span covered bridge in the world is a Town lattice truss, the Cornish-Windsor Bridge between Cornish, New Hampshire, and Windsor, Vermont. It has a total length slightly in excess of 449 feet, with one span of 204 feet in length and another span of 203 in length. The American Society of Civil Engineers (ASCE) declared it a National Historic Civil Engineering Landmark in 1970.

The type was used extensively for aqueducts, highways, and railroads. The definitive work on the Town lattice is Gregory Dreicer’s dissertation “The Long Span, Intercultural Exchange in Building Technology: Development and Industrialization of the Framed Beam in Western Europe and the United States, 1820-1870,” Cornell University, 1993. It is unknown who, Ithiel Town or a European, first developed the lattice truss (it was known as a trellis in Europe). There is evidence, however, that the Town lattice was taken back to Europe in the mid-1850s and was promoted for use on European railways in iron. Plowden (*1*, p. 40), however, states that the metal lattice truss was invented in Europe and widely used there before appearing in America.

The Town lattice truss is also associated with an important development in business practice as the first bridge design for which licensees wishing to use the type had to pay a royalty to the patent holder. This practice came to dominate iron bridge building a half century later.

Significance Assessment: Most Town lattice trusses are found in wooden covered bridges dating from the 1840s up until the 1870s. In its metal form used by the railroads, bridges would have been built as early as the 1850s, but surviving examples date primarily from the 1890s. Iron and steel lattice trusses for vehicular use are less common. The Upper Bridge at Slate Run, Lycoming County, Pennsylvania, is a wrought iron lattice truss in vehicular service, built by the Berlin Iron Bridge Company, and dating from 1890.

Wooden Town lattice trusses dating from the 1840s up to the period immediately following the Civil War are significant within the context of this study if they retain their character-defining features. The primary character-defining features of this truss are the lattice configuration of the truss (intersecting diagonals forming a web between the top and bottom chord with no verticals or posts), parallel top and bottom chords, end posts and trenail connections. Town lattice trusses may or may not be covered. The roofing and/or exterior covering of a covered Town lattice truss is of secondary importance, since in most, if not all cases, these features are modern replacements. Early metal examples from the Antebellum period are not common and, if intact, would be considered highly significant. Late nineteenth century examples, whether built for the railroad or vehicular use, are more common than the earlier examples, but are still considered significant.

Examples of Town Lattice Truss

1. Cooley Covered Bridge (1849). Rutland County, VT. NRHP listed 1974.
2. Mull Road Covered Bridge (1851). Sandusky County, OH. NRHP listed 1974.
3. Eagleville Covered Bridge (1858). Washington County, NY. NRHP listed 1978.
4. Ashuelot Covered Bridge (1864), Chesire County, NH. NRHP listed 1981.
5. Ashland Covered Bridge (1870), Red Clay Creek-Barley Mill Road, Ashland, New Castle County, DE. NRHP listed 1973. HAER DEL-162.
6. Upper Bridge at Slate Run (1890), spanning Pine Creek at State Route 414, Slate Run vicinity, Lycoming County, PA. HAER PA-460.
7. Cornish-Windsor Covered Bridge (1866), spanning Connecticut River, Bridge Street, between, Cornish, Sullivan County, New Hampshire and Windsor, Vermont. National Civil Engineering Landmark.

Figures 3-11 and 3-12 provide a drawing and an example of the Town truss.

Figure 3-11. Elevation drawing of the Town lattice truss.

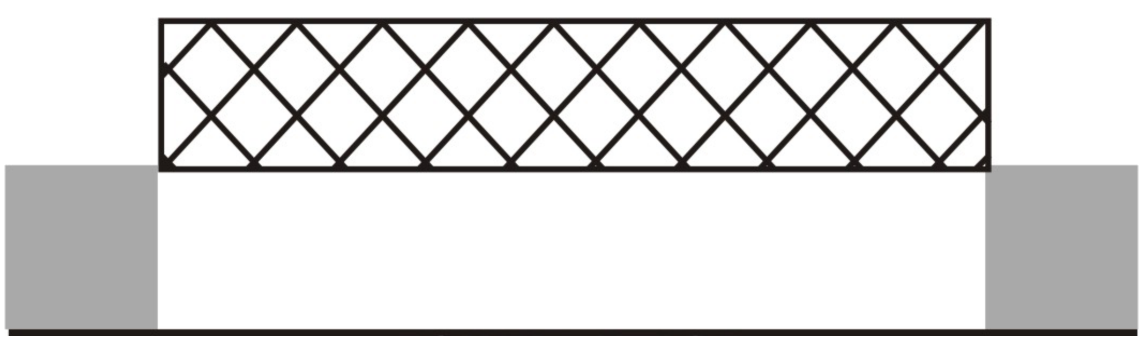


Figure 3-12. Cornish-Windsor Covered Bridge (1866), spanning Connecticut River, Bridge Street, between, Cornish, New Hampshire and Windsor, Vermont. This National Civil Engineering Landmark bridge is an example of the Town lattice truss.

3-12a. Three-quarter view of Cornish-Windsor covered bridge.

3-12b. Interior view of Cornish-Windsor covered bridge showing the intersecting diagonals that form a web between the top and bottom chords.

3.1.5 Howe Truss

History and Description: First patented by Massachusetts millwright William Howe (1803-1852) in July and August of 1840, the Howe truss featured heavy wood diagonal members in compression and lighter, vertical iron members in tension. The use of iron to stiffen parallel chord trusses had been used in Europe as early as 1823, but there is no evidence that Howe knew of this precedent. The use of threaded, adjustable iron tension members, secured at the ends by nuts, was the main difference between the Long truss and the Howe truss. This feature made Howe the first bridge designer to devise a method of adjusting a wood truss, the members of which have the tendency to pull apart under live loads and shrinkage (*1*, p. 57).

Howe arrived at a simple, elegant solution to a problem that had confounded several generations of wooden bridge builders, the solution to joining in tension two wooden members. The classic weakness of a timber truss is not the individual members, but the connections. Tension connections proved particularly difficult to detail to insure minimum joint movement and maximum efficiency in transferring tensile loads to a joint. The genius of the Howe system is that the timber verticals, which pose the most difficult problem in forming an effective connection, were neatly replaced with an iron rod. Eliminating the complex mortise and tenon connection simplified the work of millwrights, resulting in a truss that was not only easy to erect, but could be adjusted and parts replaced while remaining in service.

Like the king post truss, the Howe truss was apparently first used as a roof truss, appearing in a church in Brookfield, Massachusetts. Its first use in bridge construction was in 1838 on the Western Massachusetts Railroad (later the Boston and Albany Railroad) over the Quaboag River in Warren, Massachusetts. In 1839, Howe hired his brother-in-law, Amasa Stone, Jr., as a foreman to oversee construction of several buildings in Warren, Massachusetts. When Howe later won a contract with the Western Railroad Company to bridge the Connecticut River at Springfield using his newly patented truss design, he hired Stone to assist in supervision of bridge construction (*2*). In 1841, Howe revised his patent of the previous year by reducing the diagonals to two in each panel (*3*, p. 61). Soon thereafter, Stone purchased the rights to build the Howe truss in New England and set up a bridge building company with Azariah Boody in 1842 to market the design. In August 1846, Howe won an additional patent for a timber arch design that he hoped would make his basic truss more widely adaptable for use by the railroads.

In 1847, the first company set up by Howe and Stone was reorganized, with Stone retaining the southern New England rights and younger brother Andros claiming the remainder. Along with Boody, Andros established the Stone and Boomer bridge-building partnership with Lucius Boomer of Chicago, Illinois. That company built a large number of Howe trusses for railroads in Illinois, Wisconsin and Missouri, but not always with success. A Stone and Boomer-built Howe truss bridge erected over the Gasconade River in Missouri collapsed in 1855, killing forty-three people and injuring another seventy, including some of the most prominent citizens of St. Louis. The following year, the partners also built the first railroad bridge across the Mississippi River, which was located between Davenport, Iowa, and Rock Island, Illinois. Howe trusses were a prominent feature of this bridge, which was widely reviled by steamboat interests as a hazard to navigation until it burned down shortly after completion.

The Howe truss marked the beginning of the transition from wood to iron as a material for bridge construction, but attempts to express the design in iron structures often met with disaster. In 1876, a cast and wrought iron Howe truss bridge designed by Amasa Stone and built in 1865 at Ashtabula, Ohio, collapsed, killing 85 people. An investigation by the ASCE condemned combination cast and wrought iron bridges in favor of all wrought-iron designs, but the real problem may have been the unsuitability of the Howe truss for all-metal construction.

Bridge scholars generally agree that the wood Howe truss was the crowning achievement of the wood bridge era, and Howe's patent was probably the most profitable wood truss patent ever granted due to the popularity of the type with railroads during a period of great expansion of the nation's rail network. The Howe truss became the most widely used wood type for railroad use and dominated the bridge-building industry until all-iron bridges gained greater popularity in the 1850s. The Howe truss is commonly found in covered bridges in several states. For example, it is by far the most represented type among the covered highway bridges of Oregon.

Significance Assessment: The Howe truss, a composite truss of wooden diagonal compression members, iron junction boxes, and threaded vertical wrought-iron rods to carry tension, was the dominant bridge type during the transition of bridge building materials from wood to iron. As stated above, the Howe truss is considered the crowning achievement of the wooden bridge era and the most profitable bridge patent ever granted. The Howe truss also represents the beginning of the transition from wood to iron.

The Howe truss became the most popular bridge for railroads in American until the appearance of the all-metal bridges in the 1840s and 1850s. Thousands were built until the all-iron truss curtailed its popularity. Highly significant within the context of this study are examples of the Howe truss railroad bridges from the early development period, the 1840s and 1850s, as they are less common and are significant in the evolution of bridge building technology associated with the railroads and with the transition from timber to iron. Wooden Howe truss covered bridges of the second half of the nineteenth century and the first quarter of the twentieth century are relatively common, but are considered significant within the context of this study if they retain their character-defining features. The Howe truss featured heavy wood diagonal members in compression and lighter, vertical iron members in tension. The intersecting wood diagonal members, the vertical metal rods, the parallel top and bottom chords and the struts are the primary character-defining features of the Howe truss. Like the previously discussed timber trusses, the roofing and/or exterior covering of a Howe truss is of secondary importance, since in most, if not all cases, these features are modern replacements.

Examples of Howe Truss

1. Buskirk Covered Bridge (1857), Washington and Rensselaer Counties, NY. NRHP listed 1978.
2. Adams Mill Bridge (1872), Carroll County, IN. NRHP listed 1996.
3. Mt. Orne Covered Bridge (1911), Coos County, NH. NRHP listed 1976.
4. Fisher School Bridge (Five Rivers Bridge) (1919); Lincoln County, OR. NRHP listed 1979 in Oregon Covered Bridges Thematic Nomination.
5. Manning-Rye Covered Bridge (Harpole Bridge) (1928), Whitman County, WA. NRHP listed 1982 in Historic Bridges/Tunnels in Washington State Thematic Resource Nomination.
6. Doe River Bridge (1882), spanning Doe River, Third Avenue, Elizabethton, Carter County, TN. HAER TN 41.
7. Jay Covered Bridge (1857), County Route 22, spans East Branch of AuSable River, Jay, Essex County, NY. HAER NY-170.

Figures 3-13, 3-14, and 3-15 include a drawing and examples of the Howe truss.

Figure 3-13. Elevation drawing of Howe truss.

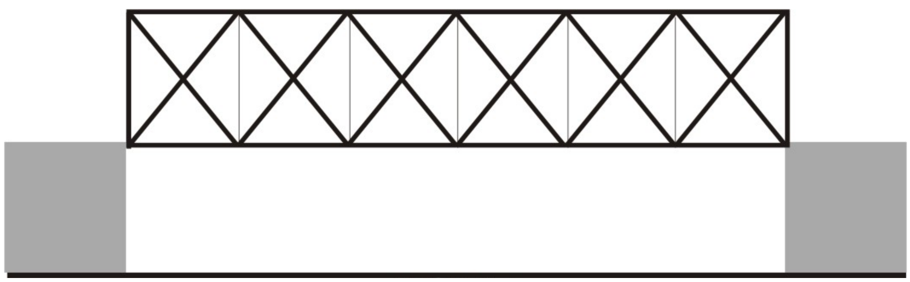


Figure 3-14. Jay Covered Bridge, County Route 22, spans East Branch of AuSable River, Jay, Essex County, New York. This 1857 Howe truss was altered in 1953.

3-14a. Interior of bridge.

3-*14b. Detail of the lower joint of the tension/compression members at the* *cast iron shoe.*

Figure 3-15. Doe River Bridge (1882), spanning Doe River, Third Avenue, Elizabethton, Carter County, Tennessee. This scenic structure is a well-preserved example of a Howe truss covered bridge.

3-15a. Three-quarter view.

3-15b. The interior of the structure. Note the Howe truss's heavy wood diagonal members (in compression) and lighter, vertical cylindrical iron members (in tension).

3.1.6 Metal Bowstring Arch Truss

History and Description: In 1840, Squire Whipple (1804-1888), a graduate of Union College in Schenectady, New York, and a surveyor for railroad and canal companies, built an approximately 82 foot-long, tied-arch "bowstring" truss bridge over the Erie Canal at Utica, New York. It was the second all-metal truss bridge constructed in the United States. The following year he obtained a patent for his design (#2,064), which had arches of cast iron functioning as the primary compression members, and vertical and diagonal rods of wrought iron. The "string" (or lower member) tying the ends of the arch acted in tension.

Even before Whipple's patent expired in 1869, bridge builders copied his design, some with slight variation to avoid infringement, and many without any respect of the patent. This type proved very popular over the next forty years for train sheds, other curved vault structures and short highway and canal spans of 50 to 100 feet, although some bowstring trusses were much longer. During the last quarter of the nineteenth century, it was one of the most generally adapted truss forms in bridge design. Whipple's patent was adopted by Zenas King, David Hammond and other builders who secured patents for the configuration of the upper chord and other details. These men established bridge-fabricating companies to manufacture bridges by the thousands to meet the overwhelming demand for economic, short to moderate span, bridges for burgeoning farm-to-market road systems.

The King Iron Bridge Company of Cleveland (http://www.kingbridgeco.com/) and the Wrought Iron Bridge Company of Canton, Ohio, founded by King and Hammond, were two of literally hundreds of bridge fabricating companies established throughout the east and Midwest to meet demands. The companies employed agents who operated out of larger cities, covering territories and selling their bridges to county commissioners through catalogs, hence the name "catalog" bridges. Whipple himself operated one of the earliest bridge-fabricating companies, building hundreds of iron bridges.

One such example is the Aldrich Change Bridge (1858), formerly at Macedon-Palmyra Creek over the Erie Canal in Wayne County, New York. This span was recently restored to become part of the New York State Erie Canal National Heritage Corridor and the Canalway Trail system, and is now in Wayne County's Aqueduct Park in Upstate New York.

Metal bowstring arch spans from the nineteenth century, whether built of iron or steel (most were iron), may generally be distinguished from steel tied arch spans of the twentieth century by differentiation of historic context. The events, people (designers and builders) and technology for nineteenth-century bridges are far different than those for more modern structures. This reality is reflected by a statement in "Structural Study of Iron Bowstring Bridges," the HAER narrative history prepared as part of the Iowa Historic Bridges Recording Project Phase II in 1996 (*4*, p. 13), which stated that, "the history of the bowstring truss is inextricably linked to the nineteenth century bridge companies." Steel tied-arch spans of the twentieth century, therefore, which may occasionally be called "bowstrings," are examined in the arch category of this study.

Significance Assessment: The number of Whipple bowstring trusses is known, but the number of other surviving bowstring arch trusses is not. The bowstring arch truss is one of the more important nineteenth century bridge forms and dates primarily from the 1870s and 1880s. Bowstring bridges that retain their integrity (i.e., their character-defining features) are highly significant within the context of this study. Character-defining features include a relatively heavy arched top chord, a series of boxed "X" panels, and an outer, basically triangular panel at each end. Character-defining elements include the members that form the 'X's" within each panel and the end panels, the slender vertical rods, the bottom chord, floor beams, and method of connection.

The small number of intact Whipple bowstring trusses that remain possess the highest level of significance within this type.

Examples of Metal Bowstring Arch Truss

1. Whipple Cast and Wrought Iron Bowstring Truss Bridge (1867, moved and re-erected 1900). Albany County, NY. NRHP listed 1971.
2. Mill Road Bowstring Bridge (1870s) Knox County, OH. NRHP listed 1979.
3. White Bridge (1877). Mahoning, OH. NRHP listed 1983.
4. Freeport Bowstring Arch Bridge (1878), Winneshiek County, IA. NRHP listed 1984 in Highway bridges of Iowa MPS.
5. North Platte River Bowstring Truss Bridge (1875), spanning North Platte River, Fort Laramie vicinity, Goshen County, WY. HAER WY-1.

Figures 3-16 and 3-17 depict a drawing and an example of the bowstring arch truss.

Figure 3-16. Elevation drawing of bowstring arch truss bridge.

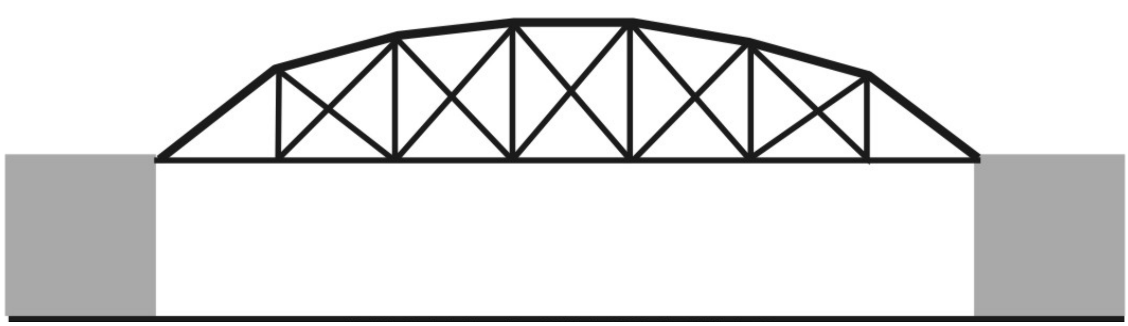


Figure 3-17. Tivoli Island Bridge (ca.1877), spanning the Rock River Channel from the mainland, Watertown, Jefferson County, Wisconsin. The bridge is an example of the metal bowstring arched truss fabricated by King Iron and Bridge Company of Cleveland, Ohio.

3-17a. Three-quarter view.

3-17b. Through view.

3.1.7 Pratt Truss

History and Description: Thomas Pratt (1875), an engineer who studied at Rensselaer Polytechnic Institute in Troy, New York, and worked for the U. S. Army and several New England railroads, designed the first Pratt truss in 1842. In 1844 a joint patent (#3,523) was granted to Thomas and his father, Caleb, a Boston architect. As originally conceived, this design used vertical compression members of wood and wrought iron diagonals in tension, a reverse of the earlier Howe truss, which used diagonals in compression and verticals in tension. The great advantage of the Pratt truss over many earlier designs was the relative ease of calculating the distribution of stress throughout the structure.

Because this design demanded a greater use of the more expensive metal than the Howe truss, it initially was not popular; however, as the nation's railroads gradually began to favor all iron bridges, the Pratt truss became widely adopted (*5*, p. 11). Not only was the design simple, relatively economical, and easily erected in the field, it was also more trustworthy than the Howe. As an iron or steel bridge, the Pratt truss became the post popular span in America in lengths of less than 250 feet for highways and railroads. The Pratt truss was erected in large numbers during the last quarter of the nineteenth century and into the first decades of the twentieth century, when it began to be superceded in popularity by the Warren truss.

The Pratt truss form may be found in through, pony, deck and bedstead spans. Pratt trusses generally have horizontal and parallel chords connected by inclined endposts, but Pratt trusses with vertical endposts were also constructed. In the bedstead variation, the endposts extend below the plane of travel surface, thus serving as components of both the superstructure and substructure. There are a number of Pratt variations, which are discussed as separate truss types in this study (i.e., Whipple, Baltimore, Parker and Pennsylvania).

One popular sub-type of the Pratt is the half-hip pony truss, in which the hip vertical is eliminated and the inclined end post is made more perpendicular to the upper and lower chords, thus requiring less metal. It was limited to lengths of no more than about 60 feet, however. This type was used extensively by county road departments throughout the country for small stream crossings.

Significance Assessment: When fabricated entirely of iron, and later steel, with riveted connections, the Pratt truss became the American standard for bridges of moderate spans well into the 20th century. In 1916, bridge engineer J.A.L. Waddell claimed that the Pratt truss was the most commonly used truss for spans less than 250 feet. Pratt trusses are among the most common nineteenth and early twentieth century bridge types discussed in this study. They are, however, significant in the evolution of bridge technology, particularly the early examples of the type. Early examples of the type that retain their character-defining features are highly significant within the context of this study, while later, more common examples are less significant. The later examples can still be significant if they retain character-defining features and are very good examples of the type.

Character-defining features vary, as there are number of different subtypes of Pratt trusses. Because the vertical members and endposts of the Pratt truss handle compressive forces under load, they tend to be relatively heavy and visually prominent, and are usually composed of angles, channels or rolled sections. The diagonal members function mainly in tension and are relatively thin (the ones toward the center handle some compressive forces), and are often composed of square or round bars. The interior diagonals all slant down and in, at a pitch of 45 degrees, the optimal angle calculated by the Pratts, while the inclined end posts slant outward at the same angle. Although the patent drawings illustrate a design option featuring a curved top chord, the basic design was for a truss with a straight top chord, and this became a common characteristic of the Pratt truss. Character-defining features include the truss form, method of connection, top and bottom chords, vertical and diagonal members, floor beams and stringers. For through trusses, the lateral top bracing and features of the portal (e.g., struts, bracing) are also character-defining features.

Examples of Pratt Truss

1. Kennedy Bridge (1883), Blue Earth County, MN. NRHP listed 1989 in Iron and Steel Bridges in Minnesota MPS.
2. Sixth Street Bridge (1886), Grand Rapids, MI. NRHP listed 1976.
3. Raritan Bridge (1886), Somerset County, NJ. NRHP listed 1992 in Metal Truss Bridges in Somerset County MPS.
4. Neligh Mill Bridge (1910), Antelope County, NE. NRHP listed 1992 in Highway Bridges in Nebraska MPS.
5. EDL Peloux Bridge (1913), Johnson County, WY. NRHP listed 1985 in Vehicular Truss and Arch Bridges in Wyoming Thematic Resource Nomination.
6. Daphna Creek Pratt Truss Bridge (1900), State Route 1414, Holly Hill Street, spanning Broadway, Rockingham County, VA. HAER VA-33.
7. Burrville Road Bridge (1887), spanning Toti Creek at Burrville Road, Fort Recovery vicinity, Mercer County, OH. HAER OH-35.

Figures 3-18 through 3-21 depict, respectively, a drawing of a Pratt truss, and examples of the pony, through, and bedstead Pratt trusses.

Figure 3-18. Elevation drawing of Pratt Truss.

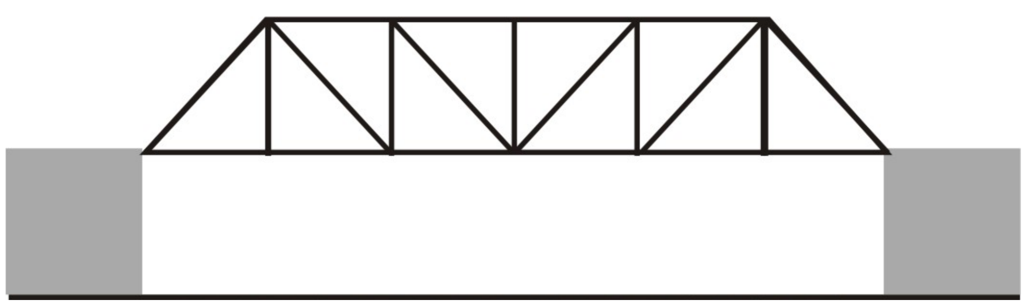


Figure 3-19. Daphna Creek Pratt Truss Bridge (ca. 1900), Rockingham County, Virginia. This Canton Bridge Company structure is an example of the pony Pratt.

Figure 3-20. Runk Bridge (n.d.), Shirleysburg, Huntingdon County, Pennsylvania. This structure is an example of a through Pratt truss.

Figure 3-21. Burrville Road Bridge (1887), spanning Toti Creek Mercer County, Ohio. This structure is an example of the bedstead Pratt truss.

3.1.8 Whipple Truss

History and Description: In 1847, Squire Whipple developed what he called a trapezoidal truss that was similar to a Pratt truss, and has been described as "double-intersection Pratt." He determined that by extending the diagonal members over two panel lengths, the depth of the panel was increased without altering the optimal angle of 45 degrees; thus, the span length could be increased. The first bridge erected of this type was completed in 1853, on the Albany and Northern Railroad (later the Rensselaer and Saratoga Railroad), about seven miles northwest of Troy, New York. The span, of about 146 feet, had a top chord and end posts of cast-iron, while the lower chord was made of wrought iron.

Whipple published his seminal work on scientific bridge design in 1847, *A Work on Bridge Building*. In this and subsequent books, Whipple explained that truss members could be analyzed as a system of horizontal and vertical components whose forces are in equilibrium. His method of analysis permitted the determination of stresses in all truss members, when the two forces are known. In this, he provided a scientific basis for bridge building, a practice that previously had depended on empirical knowledge. His trapezoidal truss was a manifestation of this theory. Although research by former Professor Francis E. Griggs, Jr. and Associate Professor Anthony J. DeLuzio of Merrimack College (*6*) suggested that Stephen Long probably preceded Whipple in developing scientific designs for truss bridges, the impact of Whipple's written work cannot be denied.

Six years after erection of the first Whipple truss, John W. Murphy, chief engineer for the Lehigh Valley Railroad, completed a 165-foot span over a canal near Phillipsburg, New Jersey, in which he substituted wrought-iron pins for the cast iron, oblong trunnions of the Whipple design. This bridge featured wrought iron main web bars and counter bars that were looped at the end. This is considered the first truss bridge in which pin connections were used throughout (*5*, p. 15). The use of pin connections was a major step forward in the advancement of bridge construction practice in the United States, requiring less time, equipment, and skilled labor to erect than fully (shop) riveted connections (*7*). It wasn't until the introduction of reliable and cost-effective pneumatic field riveting equipment at the end of the nineteenth century that the use of pin connections began to fade. The transition from pinned to field-riveted and bolted connections in the first decade of the twentieth century eventually led to the use of heavier and more rigid members than eyebars, which, in turn, led to the use of laced angles for endposts, counters, and lower chord members (*8*, p. 56).

In 1861, Jacob H. Linville, chief engineer for the Pennsylvania Railroad, built a 192-foot Whipple truss bridge over the Schuylkill River, in which forged wrought iron eyebars and posts were used for the first time. Two years later, John Murphy built a railroad bridge over the Lehigh River at Mauch Chunk, in which he used wrought iron for both the posts and top chord members. Even though he also used cast-iron for the joint blocks and pedestals, this is the first pin-connected bridge in which both the tension and compression members were of wrought iron. This was a major step forward in use of materials because cast iron is a brittle metal that has high compressive strength but low tensile strength (it doesn't stretch well) and a lack of ductility (it doesn't react well to shocks). Wrought iron, on the other hand, is equally strong in compression and tension. Changes in temperature affect cast iron more adversely than wrought iron, and the force required to cause rupture of cast iron members is small compared to that for wrought iron. Although wrought iron was the more expensive metal, its use ensured a certain degree of reliability.

The Lehigh River Bridge also featured diagonals that crossed two panels, thus making it a Whipple, or, as some would call it, a double intersection Pratt. This truss type, perhaps best described as a Murphy-Whipple, became very popular for use in long-span, nineteenth-century railroad bridges. Linville used the Murphy-Whipple truss extensively for long-span bridges with top chord and posts of cast iron for the Pennsylvania Railroad, and later with all wrought iron main members for the Keystone Bridge Company. He patented certain design variations that came to be known as "Linville" trusses, although in function these were basically Murphy-Whipple trusses.

Significance Assessment: Also known as a Murphy-Whipple truss when made entirely of wrought iron, the Whipple truss was used from 1860 to 1890 for both rail and vehicular bridges with spans capable of reaching 250 to 300 feet. Whipple trusses are less common than many of the bridge types discussed in this study. (Triple intersection Whipple trusses are rare and possess the highest level of significance within this type. Only one surviving example is known, the Laughery Creek Bridge in Indiana.). When Whipple trusses possess their character-defining features, they are considered highly significant within the context of this study. Whipple's trapezoidal truss was similar in configuration to the Pratt with its parallel top and bottom chords, but had a double intersection web system and inclined end posts as illustrated in Figure 3-22, both character-defining features of the type. Character-defining features include the parallel top and bottom chords, intersecting diagonals, vertical members, method of connection, inclined end post, floor beams and stringers, and portal features (e.g., struts, bracing).

Examples of Whipple Truss

1. O Street Viaduct (ca. 1885), Douglas County, NE. NRHP listed 1992 in Highway Bridges of Nebraska, 1870 – 1942 MPS.
2. Whipple Truss (1875) spanning White Lick Creek south of State Route 36, Hendricks County, IN. Labeled as NRHP candidate in *Iron Monuments to Distant Prosperity* by James L. Cooper, 1987.
3. Laughery Creek Bridge (1878), Dearborn County, IN. NRHP listed 1976. HAER IN-16.
4. Kentucky Route 49 Bridge (1881), Marion County, KY. HAER KY-17.
5. Emlenton Bridge (1883), Venango County, PA. HAER PA-101.
6. Carroll County Bridge No. 119 (Wise's Ford Bridge) (1888), Carroll County, IN. HAER IN-70.

Figures 3-22 through 3-24 provide a drawing and an example of the double and triple intersection Pratt truss.

Figure 3-22. Elevation drawing of double intersection Whipple Truss.

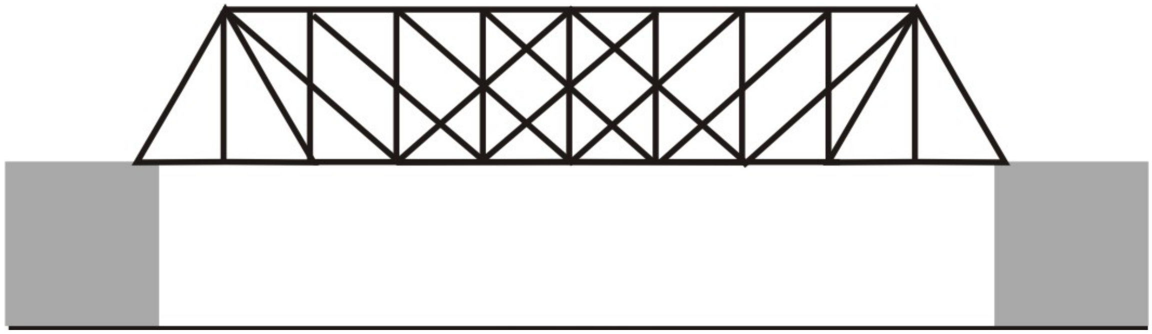
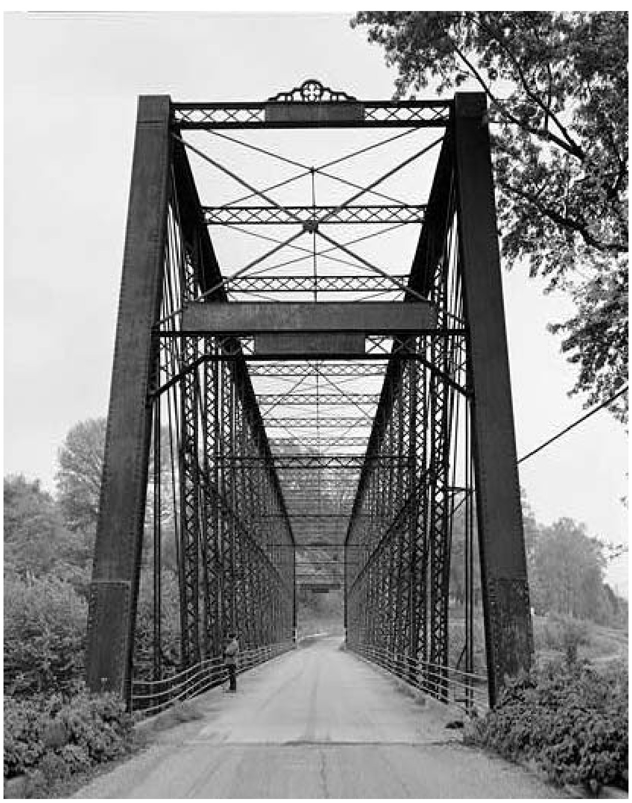


Figure 3-23. Kentucky Route 49 Bridge (1881), spanning Rolling Fork River, Bradfordsville, Marion County, Kentucky. This bridge is an example of the double intersection Whipple truss.

Figure 3-24. Laughery Creek Bridge (1878); Dearborn County, Indiana. This bridge is the only known example of the triple-intersection Whipple truss.

3-24a. Oblique view of bridge.



3-24b. Through View of bridge.

3.1.9 Baltimore Truss

History and Description: This truss (along with Pennsylvania truss) was the product of two of the early eastern trunkline railroads developed during the 1870s for heavy locomotives. The Baltimore truss, specifically, was designed by engineers of the Baltimore and Ohio (B & O) Railroad in 1871.

The truss was adapted for highway use as early as the 1880s, often for spans of modest lengths. When steel replaced wrought iron and rigid, riveted connections replaced pins in the early decades of the twentieth century, the Baltimore truss was used for longer span highway bridges until the 1920s.

The Baltimore truss is basically a parallel chord Pratt with sub-divided panels in which each diagonal is braced at its middle with sub-diagonals and vertical sub-struts. This type is sometimes referred to as a "Petit" truss. The logic leading to subdivided panels stems from the need to maintain an economic spacing of floor beams in longer span bridges. As the distance between chords increases, so does the width of panels. In order to maintain optimum slope of diagonals (45 – 60 degrees) and, an economic spacing of floor beams, the panels were subdivided at intermediate points between the main vertical members. This increases the number of floor beams but reduces the overall cost and weight of the bridge since the whole deck system can be designed with smaller members. Larger members use more metal resulting in an heavier and often more expensive bridge. This is a subtlety of bridge design that is hard to visualize (*8*, p. 68).

Significance Assessment: The Baltimore truss is significant for its association with the railroad. Nineteenth century examples of such bridges are considered significant within the context of this study, and the earliest examples along the B&O Railroad are highly significant. Highway bridges built using the Baltimore truss are not amongst the more common bridge types in this study and are considered significant if they retain their character-defining features. Such features include the elements that comprise its form—basically it is Pratt with parallel top and bottom chords, but with generally wide, sub-divided panels in which each diagonal is braced at its middle with sub-diagonals and sub-struts. The end posts are inclined. Character defining features include its parallel top and bottom chords, verticals and diagonals (including substruts or sub-ties), floor beams, stringers, struts, form of connection, and portal features (e.g., struts, bracing).

Examples of Baltimore Truss

1. Loosveldt Bridge (1888), Sheridan County, NE. NRHP listed 1992 in Highway Bridges in Nebraska MPS.
2. Tippecanoe River Bridge (1890), Fulton County, IN. NRHP candidate in *Iron Monuments to Distant Prosperity* by James L. Cooper, 1987.
3. Walnut Street Bridge (1890), Dauphin County, PA. NRHP listed 1972.
4. Colclessor Bridge #SH00-42 (1888), Sheridan County, NE. NRHP listed 1992 in Highway Bridges in Nebraska MPS.
5. Post Road Bridge (1905), State Route 7A, Havre De Grace Vicinity, Harford County, MD. HAER MD-44.

Figures 3-25 and 3-26 present a drawing and an example of a Baltimore truss bridge.

Figure 3-25. Elevation drawing of a Baltimore truss bridge.

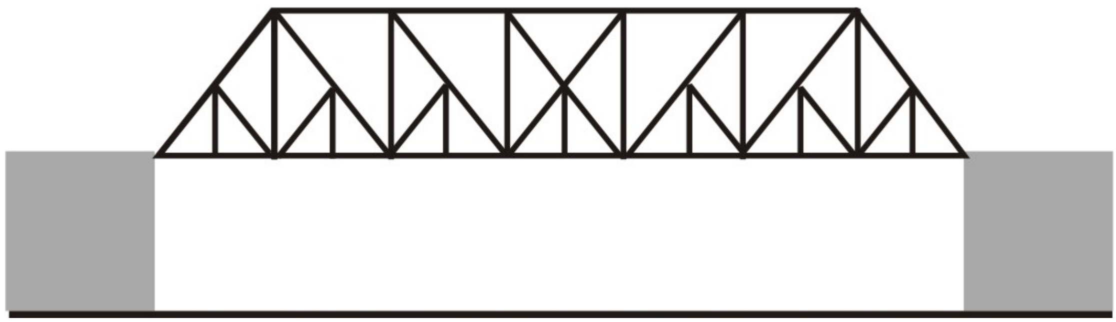


Figure 3-26. Post Road Bridge (1905), State Route 7A, Havre de Grace vicinity, Harford County, Maryland. This bridge is an example of the Baltimore truss type.

3.1.10 Parker Truss

History and Description: On February 22, 1870, Charles H. Parker, a mechanical engineer with the National Bridge and Iron Works of Boston, Massachusetts, was awarded a patent (#100,185) for what was essentially, according to most bridge historians, a Pratt truss with a polygonal or inclined top chord. Parker, it is claimed, recognizing that the depth of truss required at the ends was less than that required at mid-span, simply inclined the top chord, thus also progressively shortening the vertical and diagonal members from the center to the ends of the truss. The Parker truss therefore uses less metal than a parallel chord Pratt truss of equal length, and the longer the span the greater the economy of materials. Unlike the parallel chord Pratt, however, the Parker required different length verticals and diagonals at each panel. This increased fabrication and erection costs. Because bridge prices were usually driven by the weight of the materials used to construct the superstructure, the lighter weight of the polygonal chord truss tended to offset the increased labor costs for spans over a certain length.

According to bridge engineer and historian Victor Darnell, however, the Parker design could not claim the curved top chord as a feature because it was already in common use. Even Thomas and Caleb Pratt, who illustrated a curved top chord in their truss patent of 1844, could not claim a curved top chord as a feature of their patented design. The Parker patent claimed three improvements over earlier designs. The first claim was that minor changes in bridge lengths could be accommodated by changing the slope of the inclined end post or extending it to the top chord to a point behind the first vertical web member. Second, the design of the top and bottom connections of the web posts to the chords was new. And third, the casting at the bottom of the end post simplified the connection joining the top and bottom chords (*10*, p. 12). What set the Parker truss aside from earlier designs was not so much the continuously sloping top chord, but the use of simple, cast iron connections and the inclined end post. Yet, the Pratt patent also had inclined end posts, although these were placed very near the verticals of the end panel and did not function in the same way as in the Parker design.

In 1998, Darnell could only find one extant bridge that was built according to the original design patented in 1870; the Vine Street Bridge (1870) in Northfield, Vermont. This bridge has all the characteristics evident in the 1870 patent application: sloping wrought iron endposts, continuously curved wrought iron top chord, wrought iron I-beam web posts, cast iron web post connections, and a bottom chord that forms a loop around the endposts. The trusses that we now commonly identify as “Parkers” use inclined endposts, but generally have inclined top chords composed of straight members, with the degree of inclination changing at the panel points. Virtually all of these bridges are constructed of steel.

In the highly competitive bridge market, the economy of materials directly affected profit, and the Parker trusses superseded Pratt trusses for long span bridges after the turn of the century, as less materials were needed in their construction. The form was adopted by highway departments as standard designs for pony trusses (30 to 60 feet) and through trusses (100 to 300 feet).

The camelback is a variation of the Parker truss. Most camelback trusses are essentially Parker trusses with exactly five slopes in the upper chord and end posts.

Significance Assessment: A selection of wrought iron Parker pony trusses with pinned connections survive from the nineteenth century, but the majority date from the twentieth century. The Parker pony truss was built as late as 1950. These bridges are characterized by rigid riveted connections and steel construction.

Parker trusses are significant within the context of this study. At the highest level of significance within this type are nineteenth century, pin-connected Parker trusses, as the numbers of these bridges are dropping as they are replaced with modern structures. A well-preserved twentieth century Parker truss that exemplifies a standard bridge type of a state department of transportation also is significant within the context of this study. Examples dating after the first two decades of the twentieth century are substantially less significant than the above-discussed examples, possessing low to moderate significance. Primary character-defining features include the polygonal top chord; inclined end posts; diagonals in each panel; and different length verticals, shortening in length outward from the central panel. Other character-defining features include the floor beams, stringers, struts, method of connection and portal features (e.g., struts, bracing)

Examples of Parker Truss

1. Bridge No. 5721 (1890, 1937), Koochiching County, MN. NRHP listed 1998 in Iron & Steel Bridges in Minnesota MPS.
2. Walnut Street Bridge (1891), Chattanooga, Hamilton County, TN. NRHP listed 1990.
3. Rifle Bridge (1909), Garfield County, CO. NRHP listed 1985 in Vehicular Bridges in Colorado Thematic Resource Nomination.
4. Gross State Aid Bridge (1918), Knox County, NE. NRHP listed 1992 in Highway Bridges in Nebraska MPS.
5. Enterprise Bridge (1924-25), spanning Smoky Hill River on K-43 Highway, Enterprise, Dickinson County, KS. HAER KS-5.
6. Sparkman (Shelby) Street Bridge (1907-09), spanning the Cumberland River, Nashville, Davidson County, TN. HAER TN-38.

Figures 3-27 through 3-29 include a drawing and examples of the Parker truss.

Figure 3-27. Elevation drawing of Parker truss.

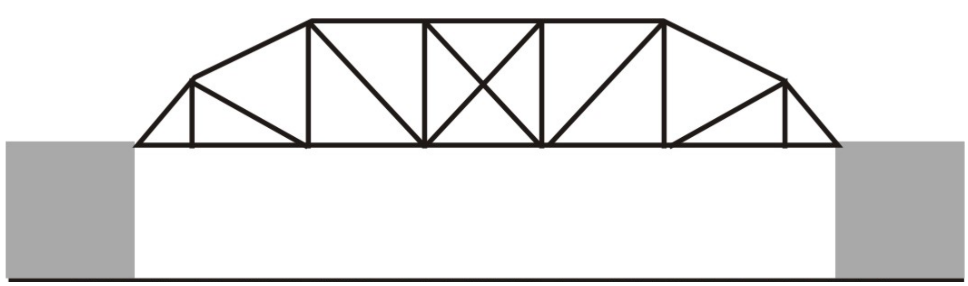


Figure 3-28. Enterprise Bridge (1924-25), spanning Smoky Hill River on K-43 Highway, Enterprise, Dickinson County, Kansas. This structure is an example of a Parker truss.

Figure 3-29. Sparkman (Shelby) Street Bridge (1907-09), spanning the Cumberland River, Nashville, Davidson County, Tennessee. This span is an example of the camelback variation of the Parker truss. Note the characteristic five slopes in the upper chord and end posts.

3.1.11 Pennsylvania Truss

History and Description: The Pennsylvania truss, like the Baltimore truss sometimes referred to as a "petit," was developed by engineers of the Pennsylvania Railroad in 1875. The Pennsylvania truss (along with the Baltimore truss) was the product of two of the early eastern trunkline railroads developed during the 1870s for heavy locomotives. This truss is similar to the Baltimore truss in that it has sub-divided panels, but it also has a polygonal or inclined top chord.

As with the Baltimore truss, the Pennsylvania truss was originally developed for use in relatively long span railroad bridges, but became a common type for shorter span lengths. The truss was adapted for highway use as early as the 1880s. When steel replaced wrought iron and rigid riveted connections replaced pins in the early decades of the 20th century, the Pennsylvania truss was used for longer span highway bridges until the 1920s.

Significance Assessment: The Pennsylvania truss is significant for its association with the railroad. Nineteenth century examples of such bridges are considered significant within the context of this study, and the earliest railroad-built examples are highly significant. Highway bridges built using the Pennsylvania truss are not amongst the more common bridge types in this study and are considered significant if they retain their character-defining features.

This truss is a form of the Pratt, similar to the Baltimore truss in that it has sub-divided panels, but unlike the Baltimore truss, it has a polygonal top chord. This heavy top chord and the panel configuration, as shown in Figure 3-30, comprise the primary character-defining features of this type. Character-defining features include the top and bottom chords, vertical and diagonal members (including sub struts or sub ties), floor beams, stringers, struts, method of connection and portal features (e.g., struts, bracing).

Examples of Pennsylvania Truss

1. Leaf River Bridge (1907), Green County, MS. NRHP listed 1988 in Historic Bridges of Mississippi MPS.
2. Rifle Bridge (1909), Garfield County, CO. NRHP listed 1985 in Vehicular Bridges in Colorado Thematic Resource Nomination.
3. Third Street Bridge (1910), Goodhue County, MN. NRHP listed 1989 in Iron and Steel Bridges in Minnesota MPS.
4. Four Mile Bridge over Big Horn River (1927-28), Hot Springs County, WY. NRHP listed 1984 in Vehicular Truss and Arch Bridges in Wyoming MPS.
5. Old Colerain Pennsylvania Through Truss Bridge (1894), spanning Great Miami River at County Route 463, Ross vicinity, Hamilton County, OH. HAER OH-54.
6. Scioto Pennsylvania Through Truss Bridge (1915), spanning Scioto River at State Route 73, Portsmouth, Scioto County, OH. HAER OH-53.

Figures 3-30 and 3-31 include a drawing and an example of the Pennsylvania truss.

Figure 3-30. Elevation drawing of a Pennsylvania truss.

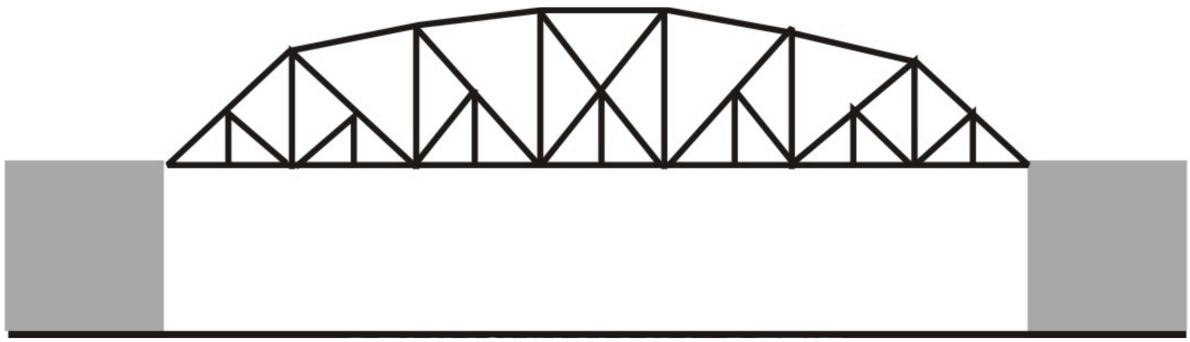
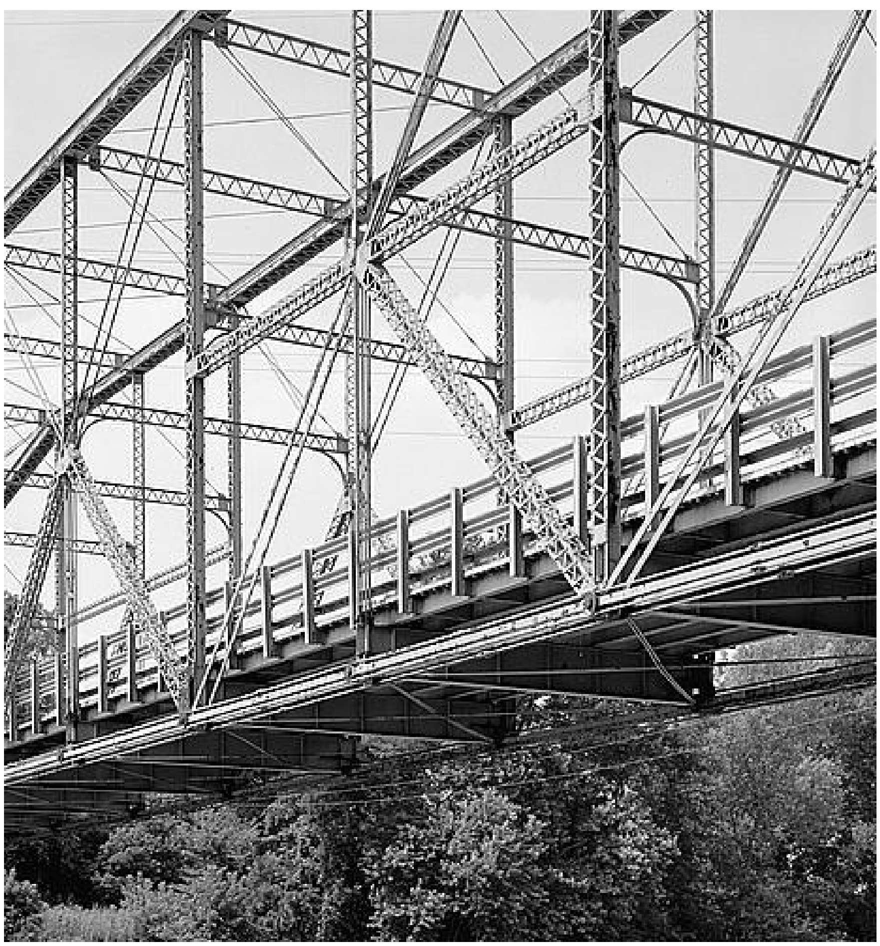


Figure 3-31. Old Colerain Bridge (1894), spanning Great Miami River at County Route 463, Hamilton County, Ohio. Detail of panel configuration, bottom chord, floor beams, and stringers of Pennsylvania truss bridge.



3.1.12 Warren Truss

History and Description: The Warren truss is a highly efficient form developed by an obscure Belgian engineer named Neville and a British engineer named Francis Nash. The form has only diagonal members connecting the two chords, with no verticals. The basic design is based on combining a series of equilateral triangles to form an efficient truss in which the diagonals act in compression and tension. Usually this truss type was altered by the addition of verticals or additional alternating diagonals. The main diagonals, endposts, and top or bottom chord members tend to be thick and visually prominent. Verticals or additional diagonals, when present, are much thinner. As was the case with the Pratt truss, the distribution of stress throughout the structure was easily analyzed in the Warren truss by mathematical calculation.

The Warren truss was theoretically a rational design. Since the structure's diagonals took both tensile and compressive stresses, they were constructed of wrought iron, thus introducing all wrought-iron bridge construction to Europe. In the Warren truss, every part of the truss equally bears its share of the stresses, while in the lattice, Pratt and other truss forms, stresses in the members vary, hence differently sized members.

As a pin-connected iron truss, this type was never very popular, either as a railroad or a highway bridge. Many steel, field-riveted or bolted Warren pony trusses, however, were erected by counties throughout the country beginning in the 1890s, by state highway departments in the 1920s and 1930s, and by railroads into the 1930s. Warren trusses were also built, occasionally, with polygonal top chords as a through or pony truss; with vertical endposts as a pony truss; or as a bedstead pony truss.

Significance Assessment: Few Warren trusses survive from the nineteenth century, but the form dominated twentieth century bridge design, used in many different configurations by highway departments for short span pony trusses and through trusses for intermediate spans, from the 1900s to the present.

The Warren truss is significant within the context of this study if they retain their character-defining features, which include parallel top and bottom chords, inclined end posts (or vertical end posts for bedsteads), diagonals, floor beams, stringers, method of connections, and for through trusses, struts and portal features (e.g., struts, bracing). Intact nineteenth century examples are the most significant within this type as they are no longer common. Most significant amongst the twentieth century examples are the bridges built by state departments of transportation according to their standardized plans. Warren trusses built after the first two decades of the twentieth century are substantially less significant than the aforementioned significant examples, possessing low to moderate significance.

Examples of Warren Truss

1. Clear Creek Bridge (1891), Butler County, NE. NRHP listed 1992 in Highway Bridges in Nebraska MPS.
2. Bridge No. 12 (1908), Goodhue County, MN. NRHP listed 1989 in Iron and Steel Bridges in Minnesota MPS.
3. Romness Bridge (1912), Griggs County; ND. NRHP listed 1997 in Historic Roadway Bridges of North Dakota MPS.
4. ERT Bridge over Black's Fork (1925), Unita County, WY. NRHP listed 1985 in Vehicular Truss and Arch Bridges in Wyoming Thematic Resource Nomination.
5. Williams River Bridge (1929), Windham County, VT. NRHP listed 1991 in Metal, Truss, Masonry and Concrete Bridges in Vermont MPS.
6. Virgin River Warren Truss Bridge, spanning Virgin River at Old Road, Hurricane vicinity, Washington County, UT. HAER UT-76.
7. Boylan Avenue Bridge (1913), Raleigh, Wake County, NC. HAER NC-20.
8. Fifficktown Bridge (1910), spanning Little Conemaugh River, South Fork, Cambria County, PA. HAER PA-233.
9. Spavinaw Creek Bridge (1909), Benton County Road 29 spanning Spavinaw Creek, Gravette vicinity, Benton County, AR. HAER AR-29.

Figures 3-32 through 3-36 show, respectively, a drawing, and examples of the through, pony, deck and bedstead Warren trusses.

Figure 3-32. Elevation drawing of Warren truss.

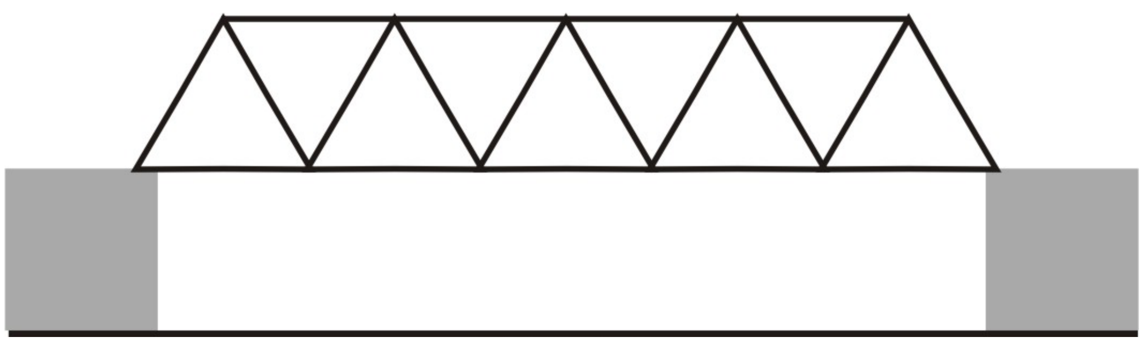


Figure 3-33. Boylan Avenue Bridge (1913), Raleigh, Wake County, North Carolina. This through Warren truss serves as a grade separation.

Figure 3-34. Virgin River Warren Truss Bridge, spanning Virgin River at Old Road, Hurricane vicinity, Washington County, Utah. This undated pony Warren truss bridge is in Zion National Park.

3-34a. Oblique view.

3-34b. Side panel.

Figure 3-35. Fifficktown Bridge (1910), spanning Little Conemaugh River, South Fork, Cambria County, Pennsylvania. This structure is an example of the Warren deck truss.

Figure 3-36. Spavinaw Creek Bridge (1909), Benton County Road 29 spanning Spavinaw Creek, Gravette vicinity, Benton County, Arizona. This structure is an example of the Warren bedstead truss.

3.1.13 Subdivided and Double Intersection Warren Truss

History and Description: An adaptation of the Warren truss is the double intersection Warren, also called a quadrangular, or multiple-intersection Warren truss. It has a distinctive crosshatched appearance, and when viewed in profile it seems that one triangular web system has been superimposed upon another. This type of truss may have verticals but usually does not. The main structural members act in compression and in tension (depending on specific configuration). The purpose of overlapping the diagonals was to increase stiffness and load carrying capacity.

The quadruple intersection Warren through truss is sometimes called a “Hilton” truss, after bridge designer Charles Hilton, an apprentice of Howard Carroll, a builder of riveted metal lattice truss bridges for the New York Central Railroad. The “lattice” truss of Carroll appeared similar to the quadruple Warren truss when viewed in profile, however, Hilton extended and adapted the system that he had learned under Carroll to create a design suitable for longer span lengths. Hilton’s longest bridge was the seven span, 180-foot long bridge over the Connecticut River at Springfield, Massachusetts, completed in 1874 (*5*, p. 16). He is also known for having developed bridge specifications for the Lake Shore and Michigan Southern Railway in 1877 (*9,* p. 29). A good extant NRHP example of the quadruple intersection Warren truss bridge is the Rice Farm Road Bridge (1892) in Windham County, Vermont.

Significance Assessment: Few subdivided or double intersection Warren trusses survive from the nineteenth century. Extant subdivided, double intersection, and quadruple intersection Warren truss bridges have been identified during the last twenty years in North Carolina, Colorado, Kansas, Oklahoma, Connecticut, Vermont, Ohio, Pennsylvania, and West Virginia. Subdivided, double intersection, and quadruple intersection Warren truss bridges are among the least common bridge types in this study and examples that retain their character-defining features are highly significant within the context of this study. Character-defining features include the parallel top and bottom chords, diagonal members, floor beams, stringers, struts, method of connection and portal features (e.g., struts, bracing). Vertical members are an additional character-defining feature of the subdivided Warren truss.

Examples of Subdivided and Double Intersection Warren Truss

1. Georgetown Loop Railroad Deck Truss Bridge (ca. 1870s): Clear Creek County, CO. NRHP listed in 1970 as part of Georgetown Loop Railroad, Structure #70000909.
2. Rice Farm Road Bridge (Green Iron Bridge) (1892); Windham County, VT. NRHP listed in 1995 in Metal Truss, Masonry, and Concrete Bridges in Vermont MPS.
3. Tauy Creek Bridge (ca. 1895); Franklin County, KS. NRHP listed in 1990 in Metal Truss Bridges in Kansas 1861-1939 MPS.

4. Norwalk River Railroad Bridge (1896); Fairfield County, CT. NRHP listed 1987 in Movable Railroad Bridges on the Northeast Corridor in Connecticut Thematic Resources Nomination.
5. Blackledge River Railroad Bridge (ca. 1907); New London County, CT. NRHP listed 1986. HAER CT-7.

Figures 3-37 and 3-38 present a drawing and an example of the subdivided and double intersection Warren truss.

Figure 3-37. Elevation drawing of the subdivided Warren truss (with verticals).

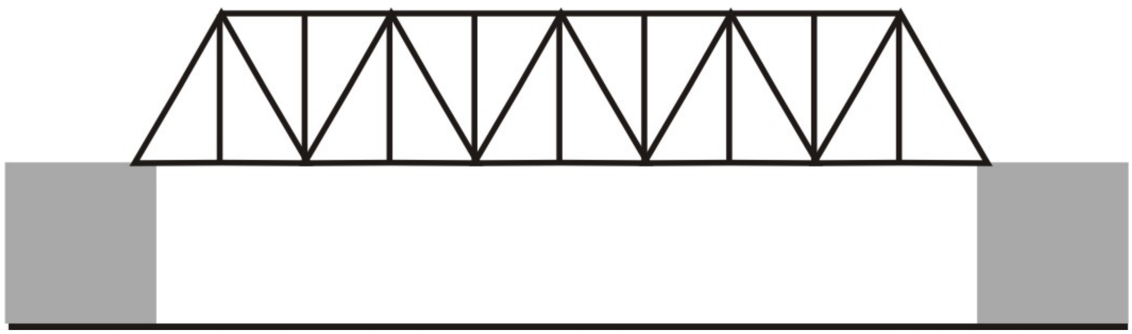


Figure 3-38. Bridge spanning Blackledge River (1907), Solchestes, New London County, Connecticut. This abandoned railroad bridge is an example of a double intersection Warren truss.

3.1.14 Lenticular Truss

History and Description: The lenticular truss may be thought of as a Pratt truss with the top and bottom chords curved over the entire length of the structure, thus creating the appearance of a lens. This type of truss is sometimes referred to as a "parabolic" truss.

Friedrich August von Pauli, a German engineer, patented the lenticular form in 1856, twenty-two years before William Douglas received his United States patent in 1878. We have no evidence whether Douglas knew of von Pauli's precedent. Historically, the lens-shaped profile probably was derived from Laves beam. The earliest parabolic can be traced back as far as Faustus Verantius who in 1617 published MACHINAE NOVAE, a review of the structural arts at the end of the Renaissance where he discussed and illustrated several concepts that later become standard bridge designs: the tied arch and the lenticular truss in wood, a form that recognized the concept of bending. In 1820, a French engineer named Debia designed bridges with a curved top chord and an iron-chain bottom chord with vertical and diagonal bracing in the web attempting to equalize the stresses in the upper and lower chords.

Known as the Pauli truss in Europe and as the "lenticular truss" in the United States, the Berlin Iron Bridge Company of Connecticut adapted it as a standard design. Except for the Smithfield Street Bridge in Pittsburgh, Pennsylvania (1883), all of the lenticular trusses built in the United States were fabricated by the Berlin Iron Bridge Company of East Berlin, Connecticut, or by its predecessor company, the Corrugated Metal Company. Although this company built other types of trusses, it is best known for proliferating the lenticular design patented by William O. Douglas in 1878. From that date to about 1900, the company erected hundreds of bridges in the Northeastern and Midwestern states. A smaller, but significant number of bridges were also erected in California, Montana, Kansas, Texas and Virginia. Foreign sales included Germany, Mexico, Haiti, and much of South America (*11*, p. 10).

Significance Assessment: There are fifty-five known lenticular truss bridges in the United States today, which have been identified through the research ("Lenticular Truss Bridges of Massachusetts") of Allen Lutenegger, a professor of civil engineering at the University of Massachusetts-Amherst. His research paper on lenticular truss bridges can be found at http://www.ecs.umass.edu/cee/cee_web/bridge/1.html. This type is one of the least common types in this study and is highly significant. Lenticular bridges have been identified in Massachusetts (9), Vermont (2), New Hampshire (4), Connecticut (11), New York (13), New Jersey (2), Rhode Island (2), Pennsylvania (5) and Texas (9). Character-defining features of this truss are its parabolically curved top and bottom chords, its vertical and diagonal members, floor beams, stringers, and method of connection. For through trusses, the portal elements (e.g., struts, bracing) are also character-defining features.

Examples of Lenticular Truss

1. Washington Avenue Bridge (ca. 1880); New Haven County, CT. NRHP listed 2001. HAER CT-18.
2. Smithfield Street Bridge (1883); Allegheny County, PA. NRHP listed 1974.
3. Nicholson Township Lenticular Bridge (1881), spanning Tunkhannock Creek at State Route 1029, Nicholson vicinity, Wyoming County, PA. HAER PA-468.
4. Lover's Leap Lenticular Bridge (1895), spanning Housatonic River on Pumpkin Hill Road, New Milford, Litchfield County, CT. HAER CT-17
5. Neshanic Station Bridge (1896); Somerset County, NJ. HAER NJ-31.

Figures 3-39 through 3-41 depict, respectively, a drawing of a lenticular truss and an example of a through and pony lenticular truss.

Figure 3-39. Elevation drawing of the lenticular truss.

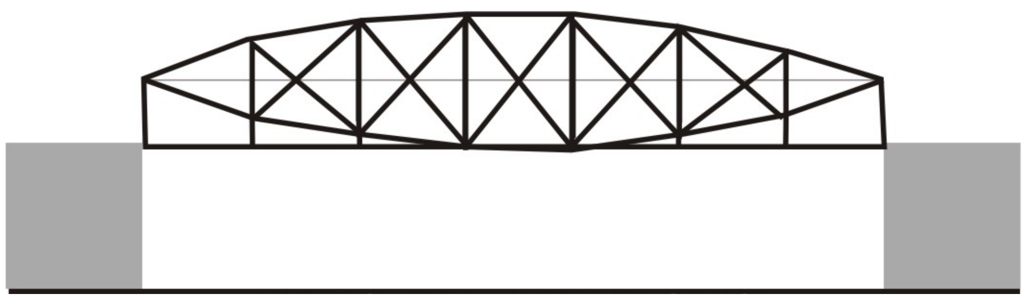


Figure 3-40. Nicholson Township Lenticular Bridge (1881), spanning Tunkhannock Creek at State Route 1029, Nicholson vicinity, Wyoming County, Pennsylvania. This bridge is an example of the through lenticular truss.

Figure 3-41. Nicholson Bridge (1888), Cemetery Road spanning Black Creek, two miles Southwest of Salem, Washington County, New York. This bridge is an example of the pony lenticular truss.

3.2 Arch Types

The types of arch bridges may be differentiated by the location of the deck or travel surface in relation to the rest of the superstructure. In a deck bridge the superstructure is entirely below the travel surface of the bridge. In a through-arch bridge the travel surface passes through all or a portion of the superstructure, which is sometimes connected above the deck and travel surface by cross bracing.

3.2.1 Stone Arch

History and Description: The immigrants who settled America came from European countries where masonry arch bridge construction was well established. Though our earliest stone arch bridge dates from 1697, and there is a scattering of early stone arch bridges in the original thirteen colonies, consistent stone arch construction did not appear until the third decade of the nineteenth century and was limited to major public work projects such as the canals, turnpikes, railroads and water supply systems.

Our most distinctive collection of stone arch bridges are found on the early, eastern trunkline railroads such as the B&O (Thomas Viaduct) and Erie (Starrucca Viaduct) railroads, and intrastate railroads such as the Providence & Boston (Canton Viaduct). These railroad structures are the American equivalent of Roman stone arch aqueducts.

Early turnpikes such as the National Road had impressive stone arch bridges in Maryland. Along the road in Ohio, the famous S-bridges were built.

Canals such as the Erie and the Chesapeake & Ohio had stone arch aqueducts. Early water supply systems such as the Croton Aqueduct (1837 - 1842) had stone arches carrying the conduit over roads in Westchester County, New York, including the massive Croton Aqueduct High Bridge over the Harlem River between the Bronx and Manhattan. America's greatest stone arch is the 220-foot span Cabin John Aqueduct Bridge (1864) over Cabin John Creek in suburban Maryland outside Washington, DC. It was the longest arch bridge in the world until 1905.

Masonry arch bridges can be composed of either stone or brick, or both, but most are entirely of stone, and the oldest extant vehicular bridge type in the United States is likely the stone arch. Stone and wood were often the most readily available building materials for bridges long before fabricated metal was introduced towards the middle of the nineteenth century, and of the two, stone was by far the preferred choice where durability and permanence were required. The technology of stone arch construction is ancient, and from the seventeenth century through the early nineteenth century, the skills necessary for erection of falsework to support arch construction (carpentry) and for the laying of stones (masonry) were commonly found within the local labor pool, although this was somewhat truer of Colonial America and the new Republic than it was for the railroad-expanded nation of the mid-to-late 1800s.

Stone arch bridges were generally more expensive to build than were timber bridges, but their use for roads and highways was favored for heavily traveled routes or locations of high visibility and importance; otherwise, the cost savings of timber bridges tended to offset their relative lack of permanence.

The oldest known stone arch highway bridge in the United States is the Frankford Avenue Bridge in Philadelphia, Pennsylvania, which crosses Pennypack Creek. Built in 1697 as part of the King's Road, this National Civil Engineering Landmark has been extensively altered through the years and has suffered considerable loss of its original integrity (*1*, p. 10). A better example of an early stone arch structure is the Choate Bridge (1764), spanning the Ipswich River in Ipswich, Massachusetts. Although widened in 1838, this two span, 75 foot-long bridge is listed in the NRHP and is the oldest known extant bridge in the state. This important structure was documented by the Historic American Buildings Survey (HABS) and the Historic American Engineering Record (HAER), respectively, in 1934 and 1986.

Increased use of metal truss bridges on highways from the late 1800s into the early twentieth century, coupled with a decrease in the number of skilled masons, and advancements in reinforced concrete construction technology in the early decades of the twentieth century, led to a decline in stone arch bridge construction. A brief resurgence in construction of this type occurred during the Great Depression due to the availability and low wage rates for both skilled masons and unskilled labor.

One good example of a masonry arch bridge built during the later stages of this period is the Possum Kingdom Bridge, constructed across the Brazos River on State Highway 16 near the town of Graford, Texas. This eighteen-arch bridge was built by the Works Progress Administration between 1940 and 1942, using unemployed coal miners who had acquired stone cutting skills in the underground mines. It is the longest and most substantial masonry arch bridge in Texas, and like many earlier masonry highway bridges built in the 1800s, it was constructed to withstand floodwaters from an upstream dam.

Some states have an abundance of stone arch highway bridges, while others do not. For example, the NRHP Inventory—Nomination Form for "Masonry Arch Bridges of Kansas" (*12*) states that "stone arch bridges were popular in Kansas for many reasons, a major one being that the stone was often available locally." The NRHP Multiple Property Documentation Form for "Minnesota Masonry Arch Highway Bridges, 1870-1945" (*13*) similarly found that there were 45 masonry arch bridges in the state, all of which appeared to be constructed of local stone. In contrast, the NHRP Multiple Property Documentation Form for "Historic Highway Bridges of Michigan, 1875-1948" (*14*) states that "despite an abundance of stone in various forms through the state and an indigenous tradition of masonry construction, stone bridges were never built in abundance in Michigan." The NRHP Multiple Property Documentation form for "Highway Bridges in Nebraska: 1870-1942" (*15*) noted that stone arch bridges were never popular in that state, and lists only two bridges of that type as possibly eligible for the NRHP. However, despite variation in frequency from state to state and region to region, stone arch bridges were constructed in most states, even if there are only a few extant examples in any one state.

The strength and durability of stone arch bridges made them popular for non-highway transport systems, such as canals, aqueducts, and railroads. Although stone arch canals and aqueducts no longer exist in great numbers, there are a number of stone arch railroad bridges, including grade separation structures, still scattered about the country. The oldest stone arch bridges are viaducts, which are addressed in Section 3.6.

Significance Assessment: Generally, stone arch bridges built during the nineteenth century are found today in areas where good stone was available. Stone arches were common in the first half of the nineteenth century, and a number of these structures still exist. There were flourishes of stone arch construction in the late nineteenth and early twentieth centuries, as in park bridges built during the City Beautiful movement and in the work projects of the Great Depression.

Stone arch bridges from the late eighteenth and first half of the nineteenth century are highly significant within the context of this study if they retain their character-defining features. Character-defining features include the arch ring with keystone, barrel, spandrel wall, parapet, headwalls and abutments/wingwalls. Piers may also be a character-defining feature.

Many of these stone arch structures possess both engineering and historical significance, the latter for associations with early and important infrastructure projects, such as the turnpikes, railroads and canals. Also significant are the Depression-era stone arch bridges, constructed up to the early 1940s by government work programs. The structures may possess both engineering and historical significance for their associations with the work programs of the Great Depression of the 1930s. Bridges associated with parks may be significant. Stone arch bridges that do not fit within these areas (early, Depression-era, association with parks) generally possess less significance, but are still significant within the context of this study.

Examples of Stone Arch

1. Goose Creek Stone Bridge (Ashby’s Gap Turnpike Bridge) (ca. 1810s), Loudoun County, VA. NRHP listed 1974.
2. Wade Park Avenue Bridge (1899), Rockefeller Park, Cleveland, OH. NRHP listed 1982.
3. Park Avenue Bridge (1907), El Paso County, CO. NRHP listed 2000 in Vehicular bridges in Colorado Thematic Resource Nomination.
4. Cedar Creek Bridge (1935), Conway County, AR. NRHP listed 1990 in Historic Bridges of Arkansas MPS.
5. “S" Bridge (first quarter nineteenth century), West of Cambridge, Cambridge vicinity, Guernsey County, OH. HABS recorded 1933.
6. Cabin John Aqueduct Bridge (1853-1864), MacArthur Boulevard, spanning Cabin John Creek at Cabin John, Montgomery County, MD. HAER MD-51.