

An Introduction To Historic Bridges



Presented By: Nathan Holth
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An Introduction To Historic Bridges

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An Introduction To Historic Bridges

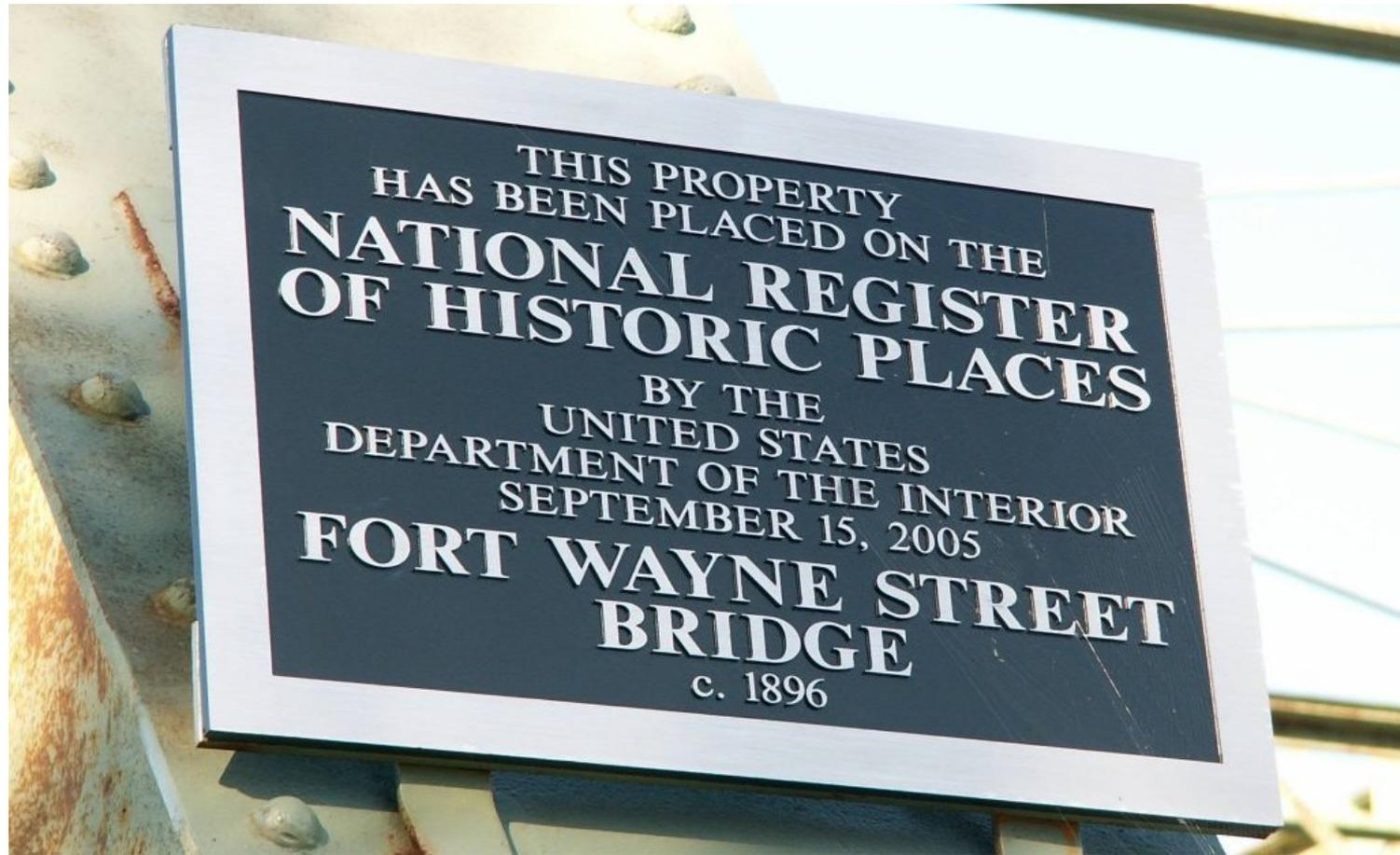
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An Introduction To Historic Bridges

Part 1: Introducing Historic Bridges

What Is Historic?



The United States government defines a historic bridge as one that is both eligible for listing or actually listed in the National Register of Historic Places.

What Is Historic?

This bridge was considered ineligible for the National Register of Historic Places, however bridges like it have not been built for nearly a century.



Such a system helps identify the most important bridges, but that should not mean non-eligible bridges do not deserve preservation or are not worth looking at.

What Is Historic?

A precursor of large-span reinforced concrete bridges, the Arch Bridge is an important milestone in the history of civil engineering in Canada.

il illustre le passage de la pierre au béton. Ce précurseur des ponts en béton armé de grande portée constitue un jalon important de l'histoire canadienne du génie civil.



Historic Sites and
Monuments Board
of Canada

Commission des lieux et
monuments historiques
du Canada

Canada

Aside from the rare “National Historic Site” designation, the Canadian government has no specific country-wide program for designation of historic bridges, also called “heritage bridges” and relies on provincial and municipal designations.

What Is Historic?



HistoricBridges.org will sometimes have bridges not considered eligible for the National Register (or other historic designation) if they retain their original design. Any old bridge will generally tell a story about our past, and at the same time have a higher level of beauty than modern bridges.

Historic Significance Rating (HSR)

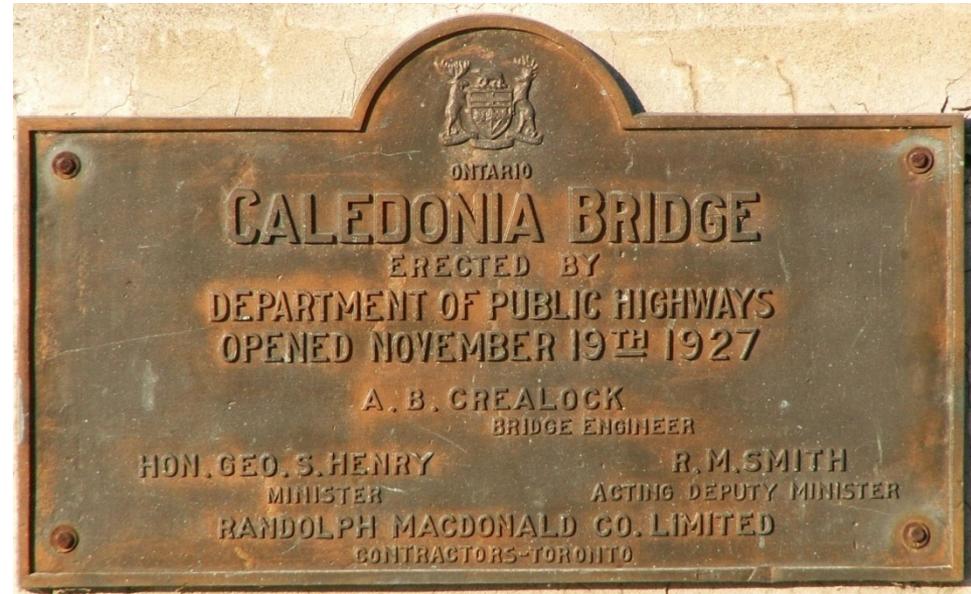


HistoricBridges.org uses HSR, its own rating system. It looks at the value of a bridge on a local scale, and at a nationwide scale. It is a tool to roughly gauge the importance of old bridges.

With a 1-10 scale, it differs from the U.S. government's National Register policy, where a bridge either is or isn't historic.

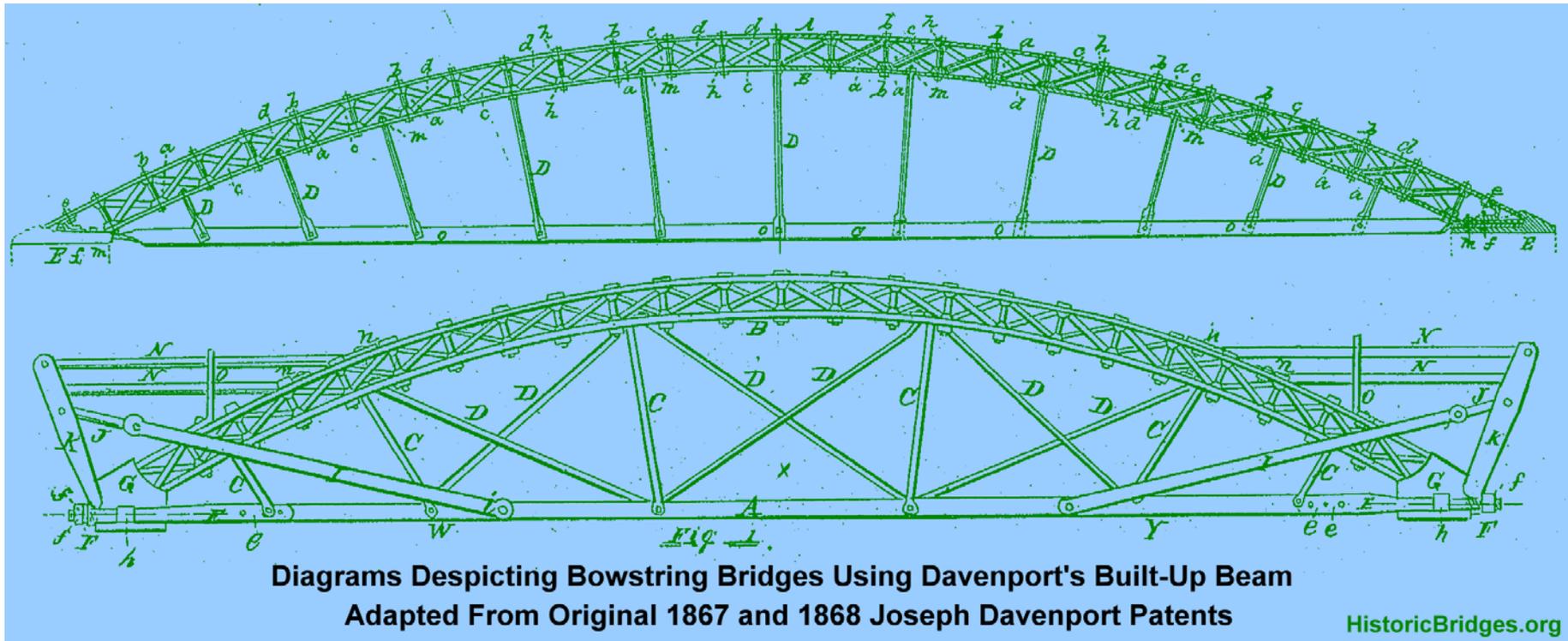
All old bridges have some historic value, even if 1/10!

Evolution of Historic Bridges



Finally, a key overarching fact to note is a transition from roughly the 1850s through the 1910s.

Evolution of Historic Bridges



From the 1850s through the 1870s, bridge companies created and marketed experimental designs, and over time, they developed standard designs by the 1890s.

Evolution of Historic Bridges

Bridges from the earlier era often were prototypes, or otherwise examples of innovative technology of the time, and they are singled out as historically significant.



However, HistoricBridges.org also considers the later standardized bridges that may have not been so innovative to also be historic. They are representative examples from a period in history.

An Introduction To Historic Bridges

Part 2: Bridge Basics

Superstructure, Substructure

Superstructure

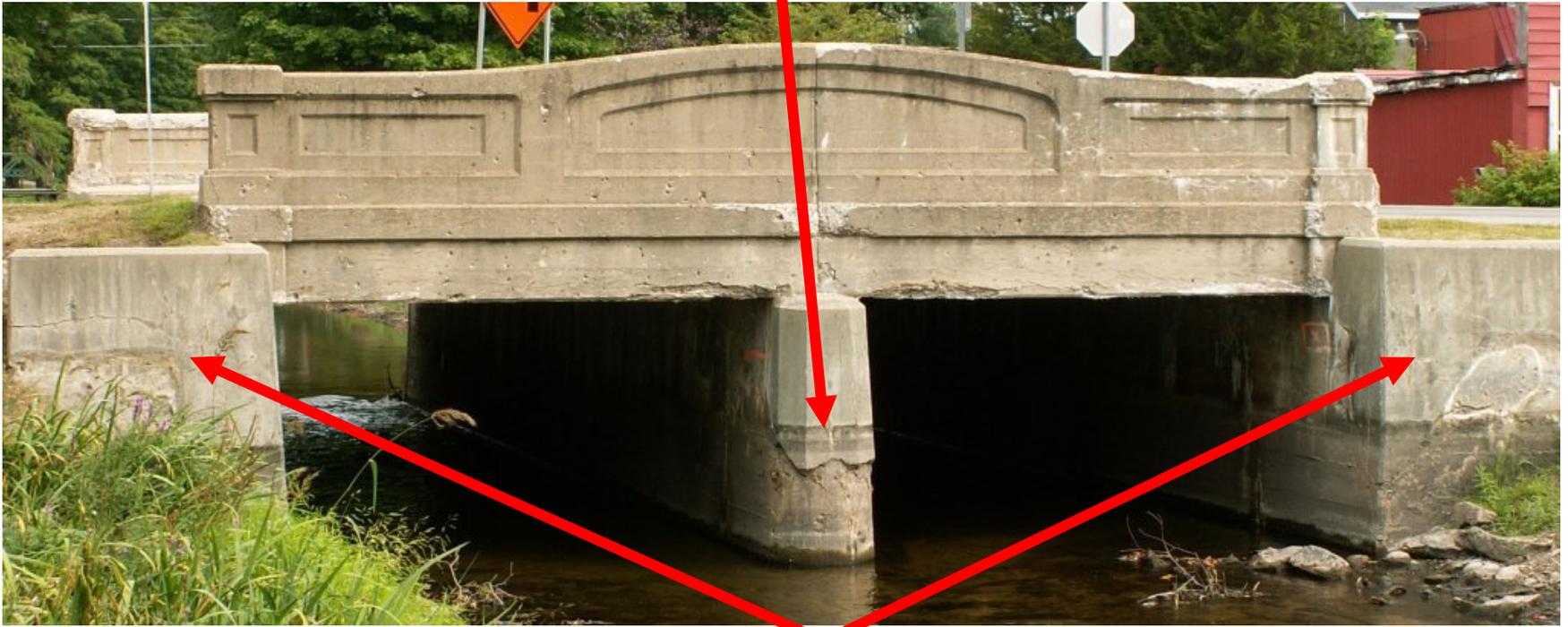


Substructure

The part of the bridge that spans the obstacle is the superstructure. The part of the bridge that holds the superstructure up is the substructure.

Substructures: Parts

Pier



Abutments

The part of the substructure that the ends of the bridge sit on are the abutments. Any supports in between are the piers.



Both piers and abutments can be made of a variety of materials and methods. A few examples follow.

Concrete



Concrete piers come in various shapes and designs. Concrete is also used in abutments. It is a common material for substructures.

Substructures - Caissons



Caissons, also known as “Lally Columns” are metal tubes with a fill inside, such as concrete. They are used as piers, and extend well into the ground. There may be wooden posts or driven piles inside as well.

Refining The Vocabulary: Bent vs. Pier



Bent



Pier

Supports with multiple columns are called bents.

Supports with a single column are simply called piers.

FYI: In casual discussion, bents may still be called piers.

Bents



Metal bents with a complex designs and extensive bracing systems (sometimes called towers) were popular with high level railroad bridges.

Wood Crib



Sometimes wood cribs may be used for piers.



Semi-Coursed Rubble



Random Rubble

Stone abutments and piers can be made of unshaped stones. The layout can be random, or it can be coursed, which means it is lined up in rows. Each row is called a “course”.

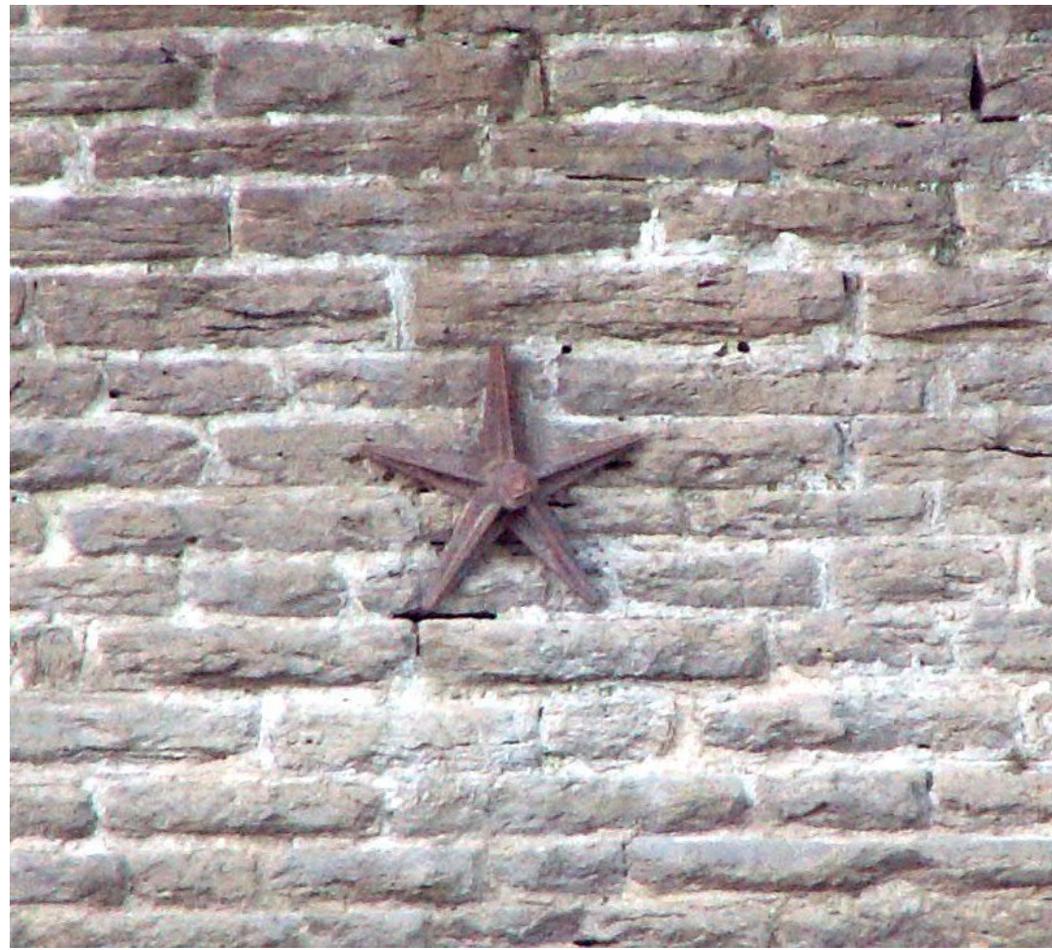
Coursed Ashlar

Ashlar
Includes
First Class
Masonry



Coursed ashlar includes square stones lined up in rows (courses). If the square stones vary in size and do not line up in rows, it is called **uncoursed ashlar**.

Abutments



Stone substructures may have iron or steel tie rods to help hold them together.

Many Designs, Hidden Details



The complexity and appearance of piers, bents, and abutments varies greatly. Further, important design elements may be under ground/water and not visible to the eye, such as whether a substructure extends to bedrock, or has “spread footings.”

Superstructure - Spans



This multi-span bridge has five spans.

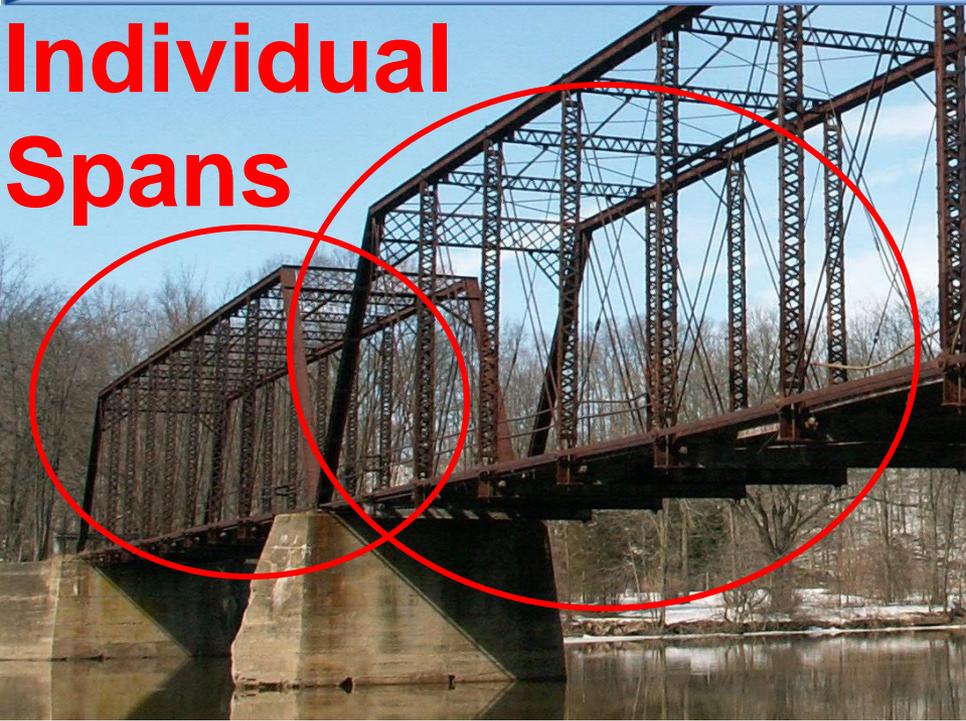


This is a single-span bridge.

Bridges may be single span or multi-span. A span is the distance between each abutment and/or pier.

Superstructure – Span Types

Individual Spans



Simple Spans



Piers

Continuous Spans

Spans may be continuous or simple. Simple spans are essentially a series of single span bridges lined up on piers. Continuous spans are like long single-spans, supported by piers between abutments.

Simple Spans



Simple spans are structurally independent, each physically capable of being its own separate bridge and functioning as such.

Continuous Spans

Continuous Spans



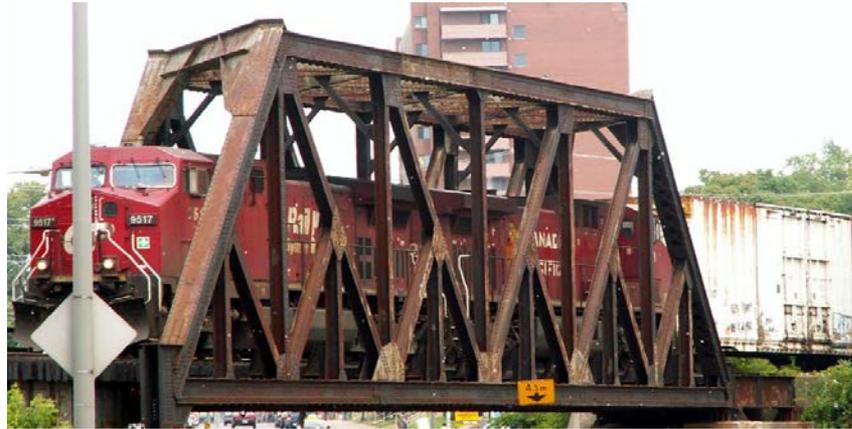
Simple Spans

Pier

Piers

Continuous spans are interconnected with their surrounding spans and require the presence of the surrounding spans to function correctly

Superstructure – Skew



Bridges may be built with a skew, or angle, to them. Skewed bridges required more effort to engineer. They are also interesting to look at. With some bridge types, skew can drastically alter a bridge's appearance. The above bridge illustrates this well.

Superelevation



Curved bridges have a deck and superstructure that is higher on one side, to provide stability at higher speeds for bridge users. This is called superelevation, and can often result in unusual looking piers and abutments.

↑ Superstructure



← Sole Plate

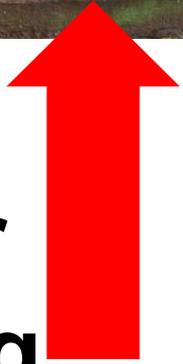
← Bearing

← Masonry Plate

↓ Substructure

Bearings connect the bridge superstructure to the substructure. Bearings may be stationary (fixed) bearings or expansion bearings which give the bridge the ability to make small expansions, contractions, and movements, that occur with a changing environment.

Expansion Bearings



**Pinned
Rocker
Bearing**



**Rocker
Bearing
(No Pin)**

Rocker expansion bearings are common, and often feature a pin above the rocker as well. Some rocker bearings do not have pins, however.

Expansion Bearings



**Roller
Bearing
Nest**



Roller bearing nests, composed of numerous individual roller bearings are another common type of expansion bearings to find on historic bridges. They are very common on older pre-1900 truss bridges.



The surface of the bridge on which traffic is carried is called the deck. Decks come in a variety of materials. Some common types are concrete, wood, and metal grid/grate. The deck may be covered with another material like asphalt for ride quality or sealing purposes. This is called a wearing surface.

Decks: Deck Stringers



Wooden deck

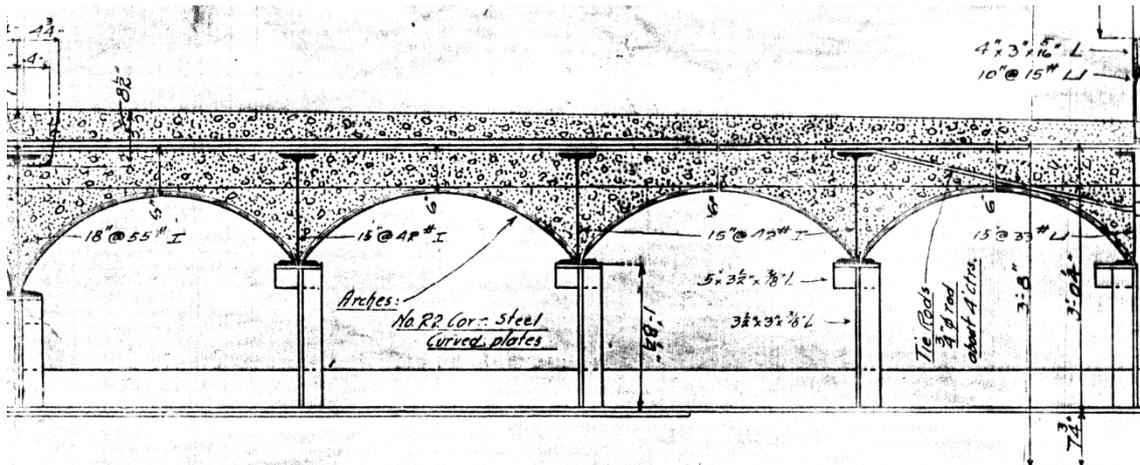
Superstructure

Deck stringers

Some decks may have beams under them whose purpose is to hold the deck in place on the superstructure. These are called deck stringers. The above photo of a deck removal shows the parts.

Decks: Jack-Arch Decks

Sometimes, builders would encase deck stringers inside the deck itself, usually with concrete, making a jack-arch deck. There is often a corrugated sheet metal base that holds the concrete. Most surviving examples date to the early 20th Century and are rare.



Decks: Expansion Joints



Expansion joints are small gaps in the deck that allow for expansion and contraction of the bridge and its deck.

Larger joints may have a more complex finger/tooth design.

Aggregate



Concrete, a substance composed of cement and aggregate, is a common material that can be found in any part of a bridge: substructure, superstructure, and deck.



Although sometimes concrete may not have any reinforcing to strengthen it, or may sometimes have solid steel inside (discussed in the concrete arch section), most concrete found on bridges contains steel reinforcing rods called “rebar” as the deteriorated concrete above reveals.

An Introduction To Historic Bridges

Part 3:

Metal Truss Bridges and the Basics of Iron and Steel

Iron and Steel



Looking at the iron and steel on a truss bridge is a good way to learn about iron and steel on any bridge.

Wrought Iron Bridge



Steel Bridge



Metal is usually steel or wrought iron. Cast iron was used, but is rare. Wrought iron is generally on older truss bridges, and tends to rust very little. Steel is stronger, on newer truss bridges, but more susceptible to rust. Field identification of either may be difficult without tools.

Wrought Iron



Prepared Iron Sample Provided By Vern Mesler

Wrought iron has an interesting appearance when looked at in cross section because it has more slag (waste material) in it. This eye bar was cut in half and you can see the slag appearing like the grain in wood.

American Standard Beams



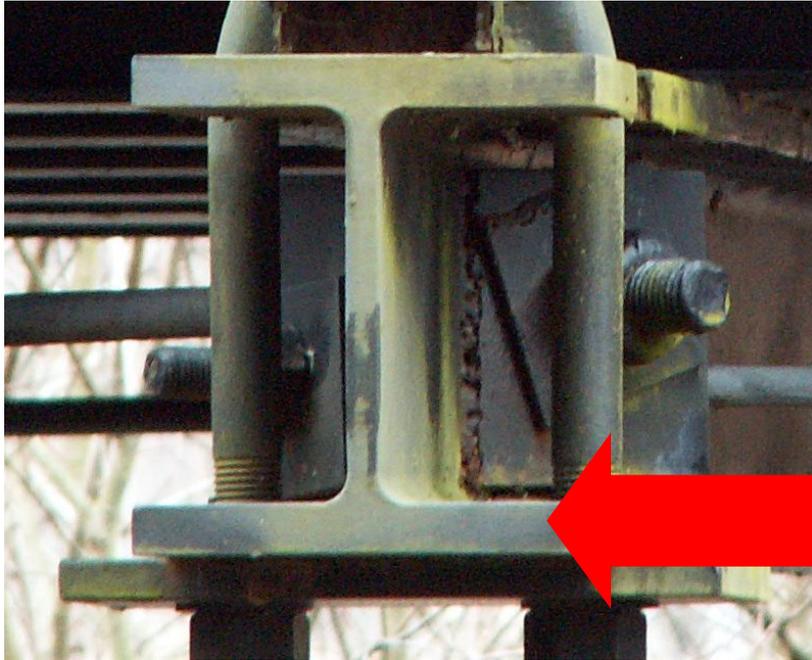
**American
Standard Beams
have a true "I"
shape.**

Sloped Flange



Rolled iron and steel can come in the form of i-beams. The traditional kind, often found on old bridges, is the American Standard Beam, and features an "i" shape. The original designs feature a sloped flange.

Wide Flange Beams



Wide Flange Beams have more of an “H” shape.

No Sloped Flange

The American Standard Beam was later replaced by the Wide Flange Beam. Unless they have been added at a later date, old truss bridges generally should not have these beams, which feature more of an “H” shape. Wide Flange Beams do not have a sloped flange.

Iron and Steel



← Channel



← Bars



↑ Rods



← Plate
Angle



↑ Plate
Angle

Rolled iron and steel comes in other basic forms, including bars, angles, rods, channels, and plates.

Built-Up Iron and Steel



Before the ability to roll larger and stronger beams arrived, iron and steel elements were often riveted together to form larger and stronger beams. Such beams that are formed from smaller elements are **built-up**, sometimes called “**fabricated**” as well.

Built-Up Iron and Steel



battens

V-lacing



Lattice

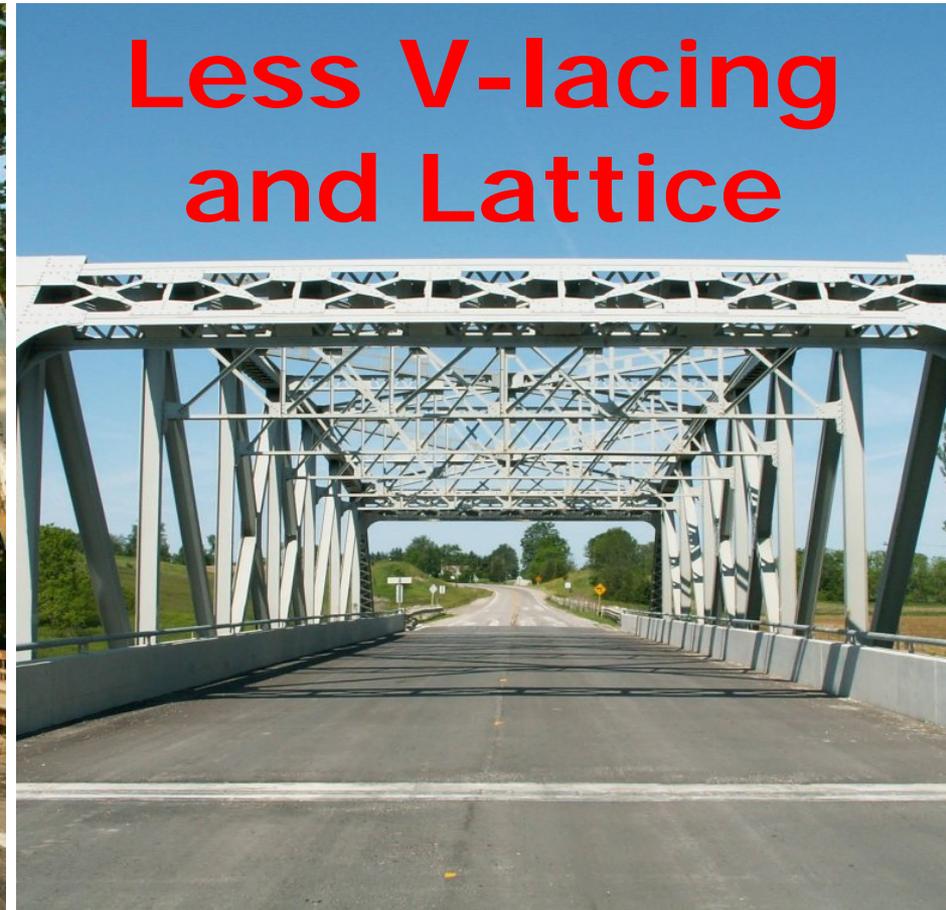


A common way to hold the larger beams such as channels and angles together was to use bars and/or plates to connect them. They are usually connected in one of three ways: with battens, v-lacing, or lattice.

Built-Up Iron and Steel

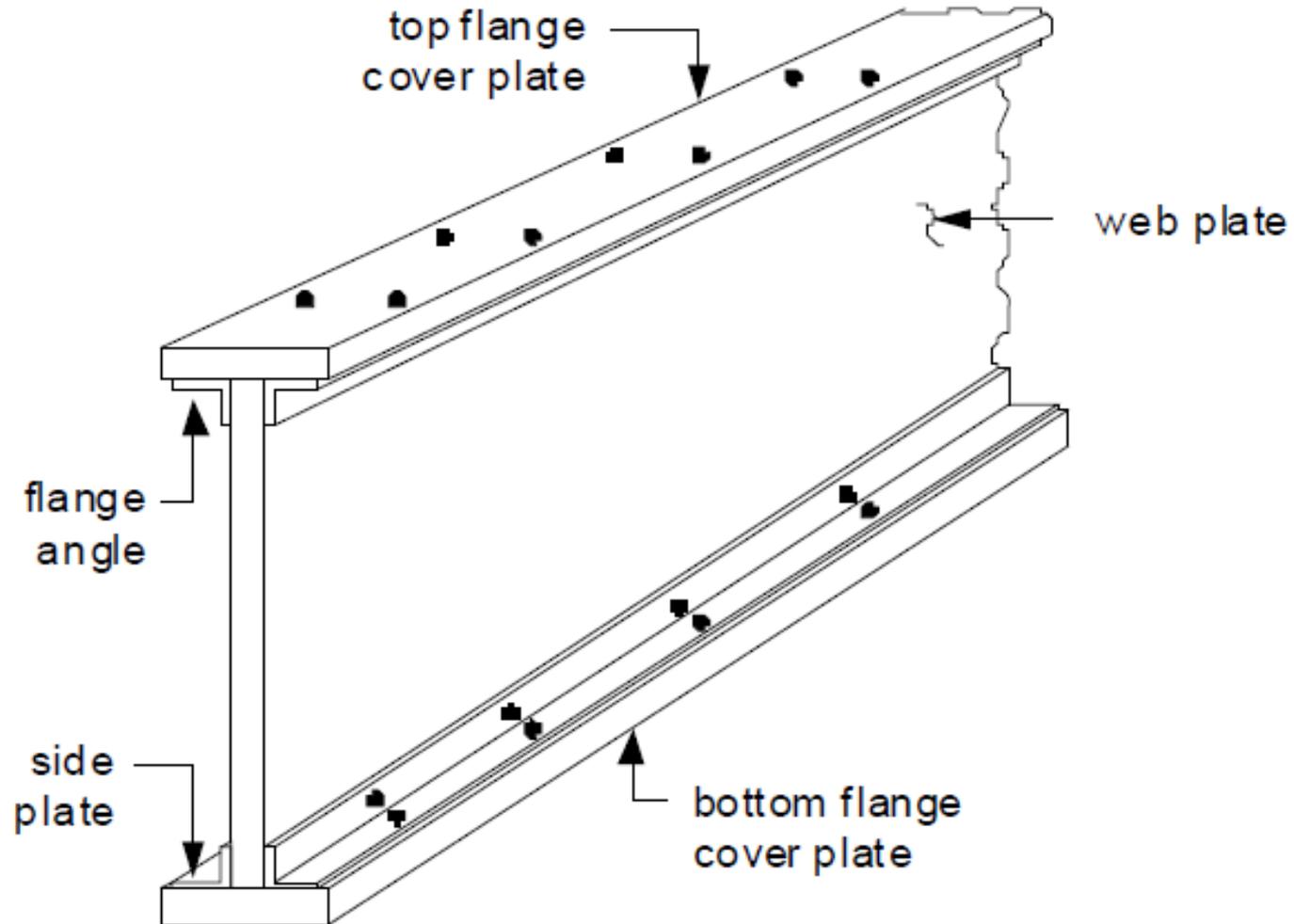
More V-lacing
and Lattice

Less V-lacing
and Lattice



A side effect of v-lacing and lattice is that it adds greatly to the beauty of the bridge, creating an even more defined geometric art and complexity in the truss bridge.

Built-Up Iron and Steel



Parts Composing Built-Up I-beam.

Source: Pennsylvania Department of Transportation



A special type of built-up beam was developed in the 1800s and patented by their respective companies. Many were designed and promoted, but only two major types remain today (both rare) and are called Phoenix and Keystone Columns.

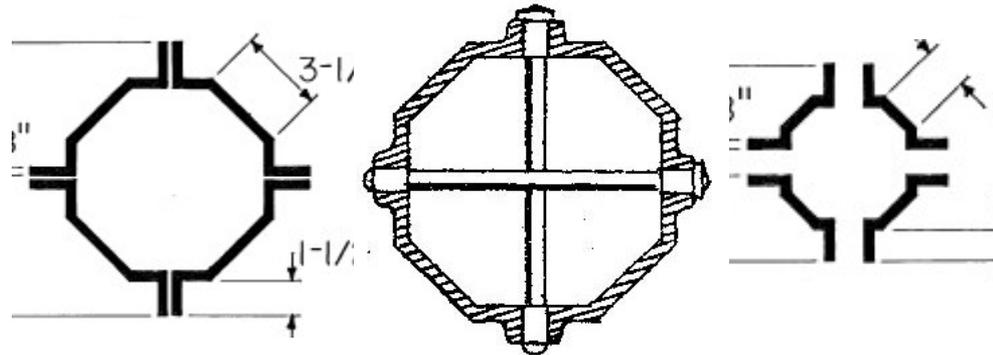
Keystone Columns



One type is the Keystone Column. It is noted for having a polygonal shape with flat sides and not a true circular shape. It was often used as the top chord for bowstring truss bridges built by the Wrought Iron Bridge Company, which will be discussed later.

Keystone Columns

SECTIONS
 of
 BEAMS, CHANNELS, T'S,
 ANGLES, TUBULAR COLUMNS, STRUTS, &C.
 furnished by the
 KEYSTONE BRIDGE CO.
 Pittsburgh, Pa.



CARNEGIE, KLOMAN & CO.
 PROPRIETORS

UNION IRON MILLS,

OF PITTSBURGH, PENNSYLVANIA.

SOLE MANUFACTURERS, UNDER OUR OWN PATENTS, OF

IMPROVED ROLLED-IRON **I** BEAMS AND **C** BARS.

ALSO, MANUFACTURERS OF

BEST QUALITY OF LOCOMOTIVE AND CAR AXLES,

(KLOMAN BRAND.)

ROUND AND OCTAGONAL HOLLOW WROUGHT-IRON COLUMNS
 AND
 UPSET BRIDGE LINKS,

MERCHANT BAR, OF ALL DESCRIPTIONS; HAMMERED AND ROLLED AXLES, FISH-PLATES AND BOLTS TO
 FIT ALL PATTERNS OF RAILS, BRIDGE IRON, BOLTS, &c.

General Office and Works,
 PITTSBURGH, PA.

Western Office,
 211 WASHINGTON AVENUE, ST. LOUIS, MO.
 (44)

New York Office,
 No. 57 BROADWAY.

The inventor of the Keystone Column was Pittsburgh's Keystone Bridge Company and the associated Union Iron Mills of Pittsburgh, an early endeavor of Andrew Carnegie.

Phoenix Columns



The other type is the Phoenix Column. These columns feature a circular shape to them. They were generally used on pin-connected truss bridges, for various members and bracing.

Phoenix Columns



OFFICES:
 410 Walnut St., Philadelphia, 49 William St., New York.

THE PHOENIX BRIDGE CO. OF PA.

Successors to CLARKE, REEVES & CO.,

DESIGN AND CONSTRUCT ALL KINDS OF

IRON RAILWAY BRIDGES, VIADUCTS, ROOFS,

And Similar Structures.

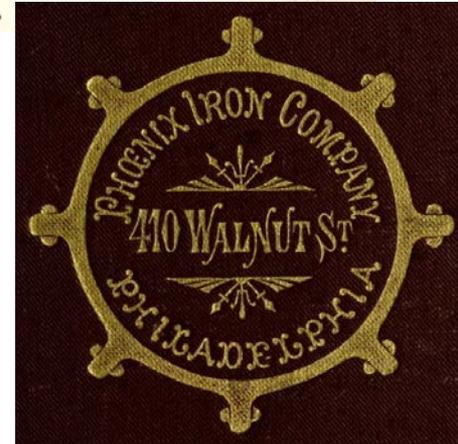
DAVID REEVES, President. ADOLPHUS BONZANO, Vice-President & Chief Engineer
 WILLIAM H. REEVES, General Superintendent.

PHOENIXVILLE BRIDGE WORKS.
 THE PHOENIX BRIDGE-COMPANY.
 SUCCESSORS TO CLARKE REEVES & CO.

ENGINEERS AND BUILDERS OF
IRON BRIDGES, VIADUCTS, ROOFS, TURN-TABLES, Etc.

SPECIALTIES:—Accurate workmanship; the use of double-refined iron; no welds; Phoenix upper chords and posts; the best form of strut known; all work done on the premises, from ore to finished bridge. ILLUSTRATED ALBUM mailed on receipt of 75 cents, at 410 WALNUT STREET, PHILADELPHIA, 49 WILLIAM STREET, NEW YORK, and at WORKS, PHOENIXVILLE, PA.

1884 Advertisement

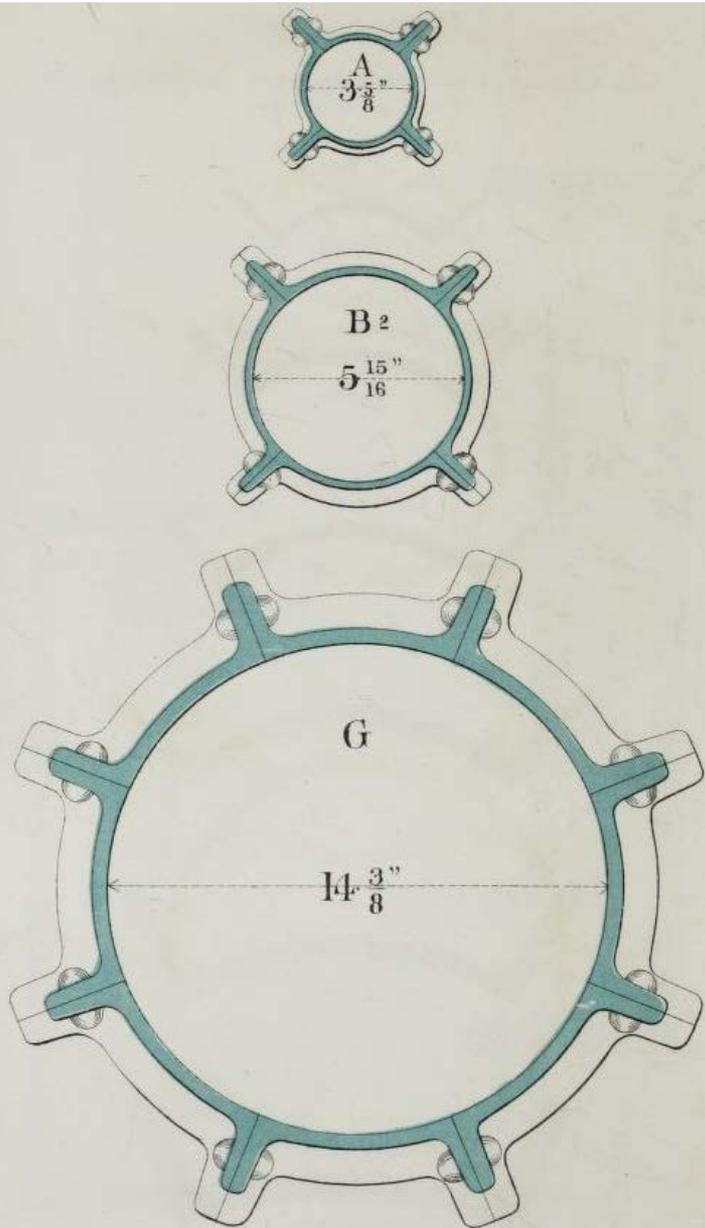
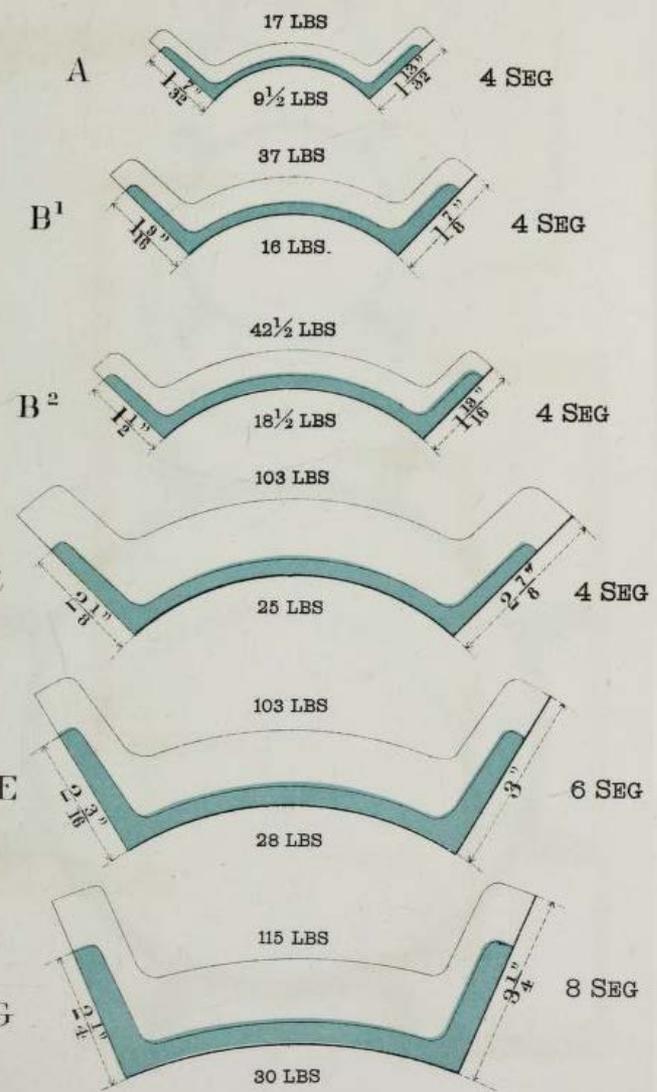


Phoenix Columns were invented and patented by Phoenix Iron Company of Phoenixville and Philadelphia, and the related Phoenix Bridge Company built bridges with them.

Phoenix Columns

COLUMN SEGMENTS.

ANY REQUIRED WEIGHT BETWEEN THOSE SPECIFIED WILL BE ROLLED TO ORDER.



Drawings from a company catalogue show the rolled sections for Phoenix Columns and sample resulting riveted columns.

Eye Bars



**Loop-
Welded**

Has teardrop-
shaped hole.



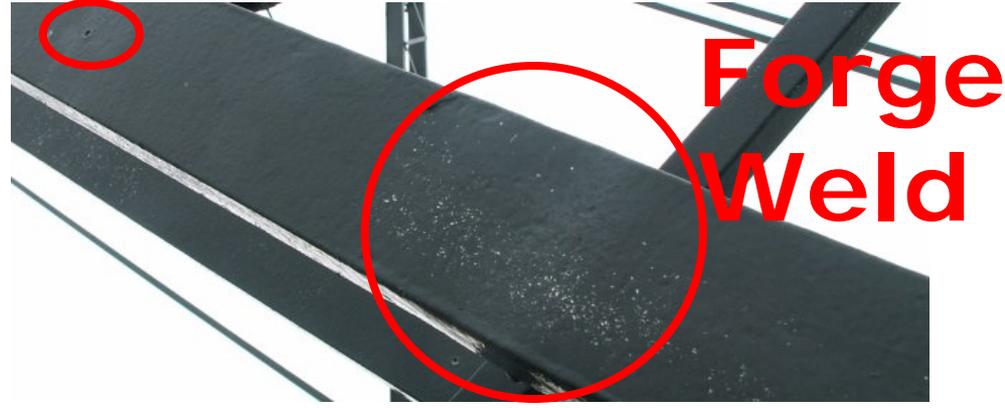
Up-Set

Has circular
hole.



Finally, eye bars may be present on the bridge. They come in two forms, loop-welded and up-set.

Eye Bars



On certain eye bars, generally very long ones, and if they are in good condition, you may be able to find two tiny little indentations at a set distance apart from each other. These were used as measuring points to test the tension of the eye bar (make sure it did not stretch), at a point where two bars were forge-welded together to make it a longer bar. You might feel the slight bulge or see faint hammer marks in between the dots, where the forge weld took place.

Research Credit: Vern Mesler

Steel and Iron Fabricators



Look closely at the iron and steel on bridges and you might find the name of the mill that the metal was fabricated by on it. Common names include Carnegie, Cambria, and Jones and Laughlin (Jones and Laughlins for pre-1905 beams).



Steel and Iron Fabricators

HistoricBridges.org has compiled a special page dedicated to cataloging the various iron and steel brands found on bridges. Since some companies had different years of operation, changed their names at different periods in history, and/or adjusted the font and appearance of their logo, this information can help date iron and steel on a bridge.

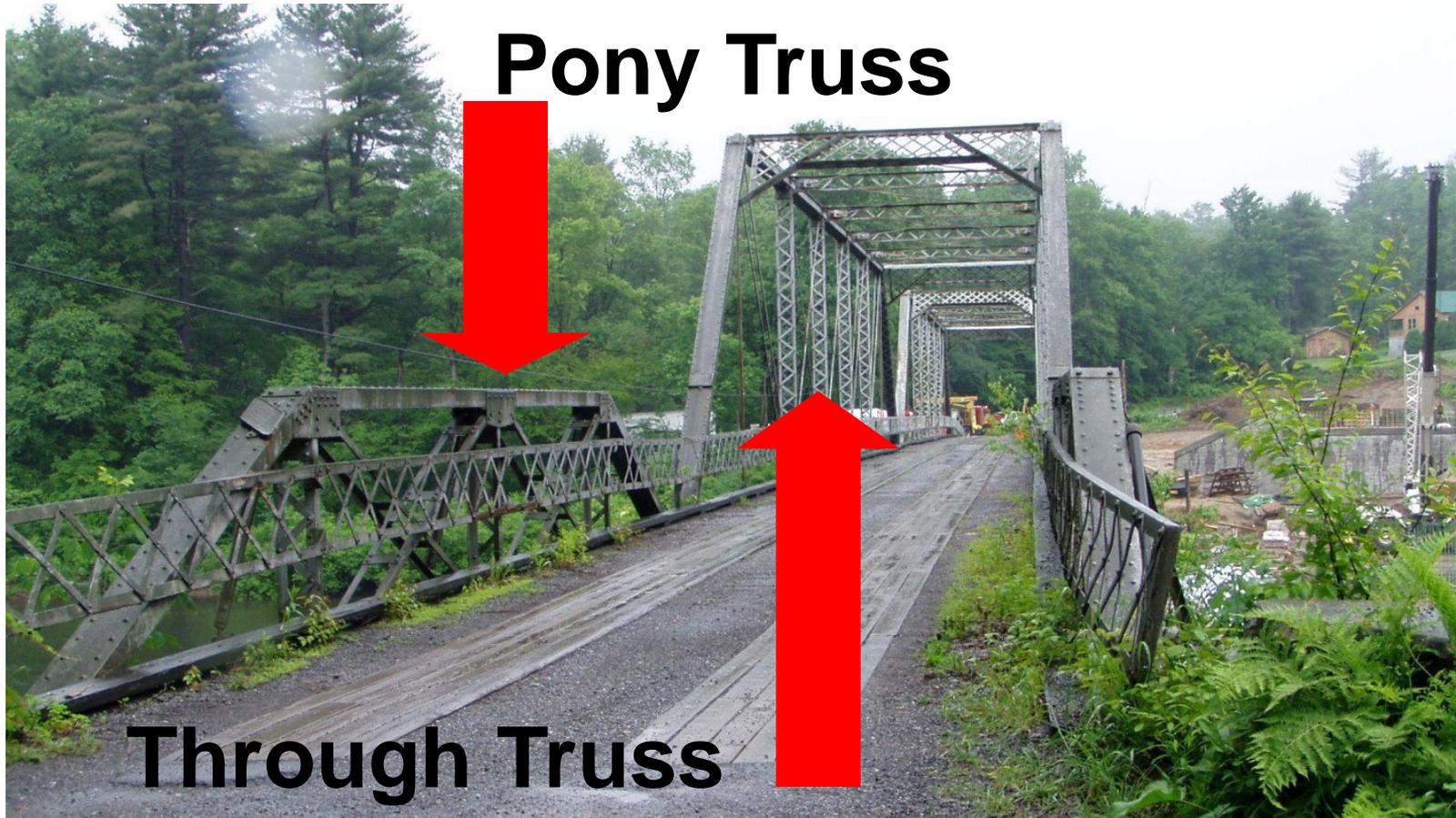
historicbridges.org/info/brands/

Bridge Plaques



Bridge plaques were placed on bridges to identify the builder of the bridge. Plaques may list county commissioners, state, officials, bridge companies, contractors, and engineers. Truss bridge plaques are often very decorative.

If the trusses run beside the deck, with no cross bracing above the deck, it is called a pony truss bridge.



If cross-bracing is present above the deck of the bridge, then the bridge is referred to as a "through truss."

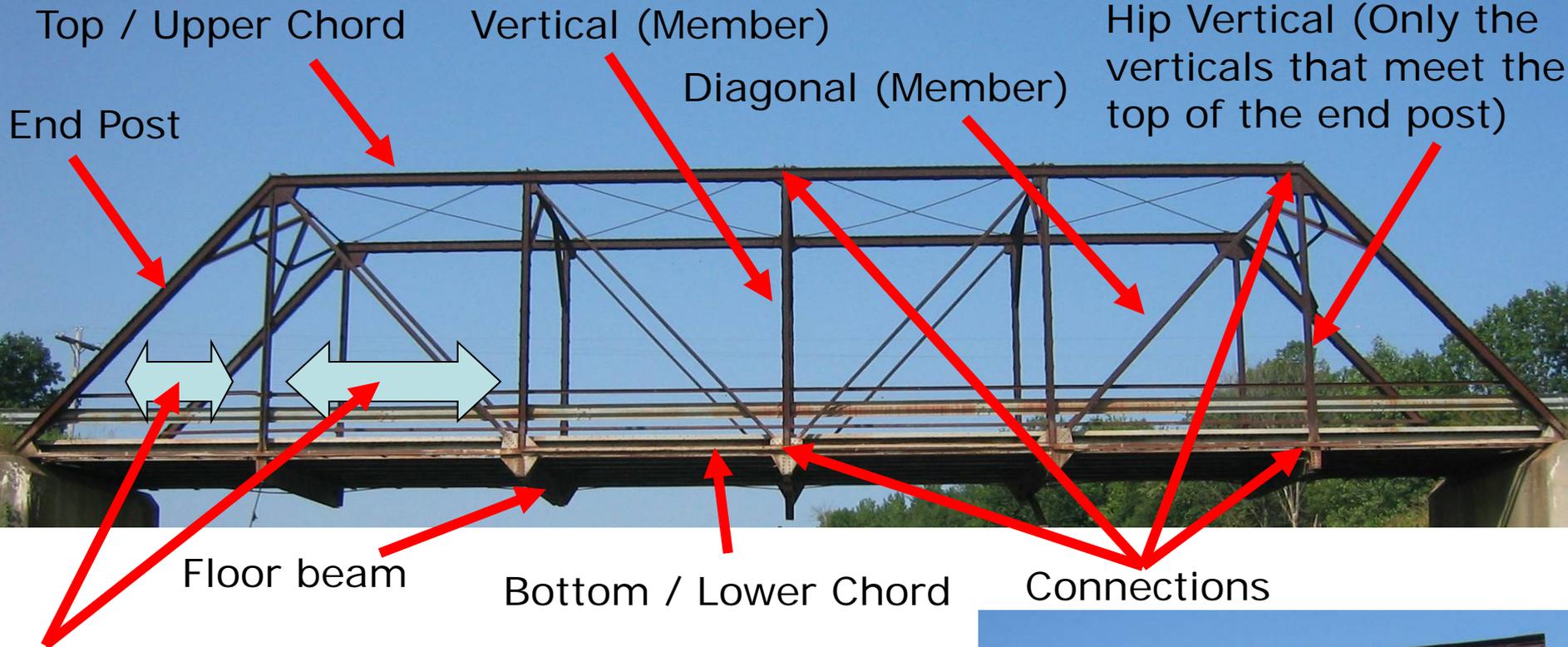
Deck Truss



Trusses may run under the deck: these are called simply Deck truss bridges.

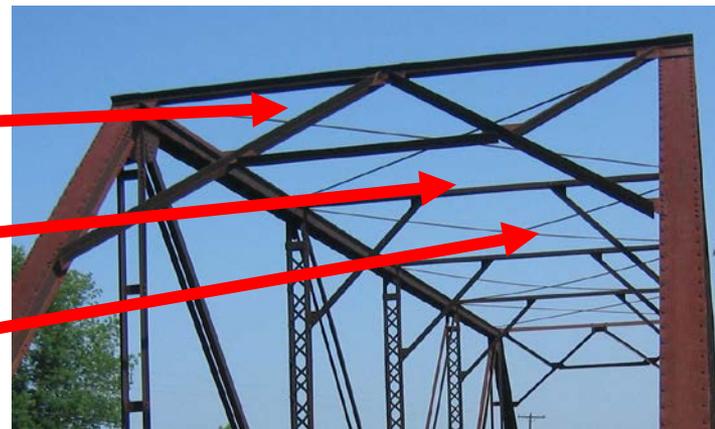
Truss Bridge Parts

The different parts of a truss bridge are all named. Some of the parts:



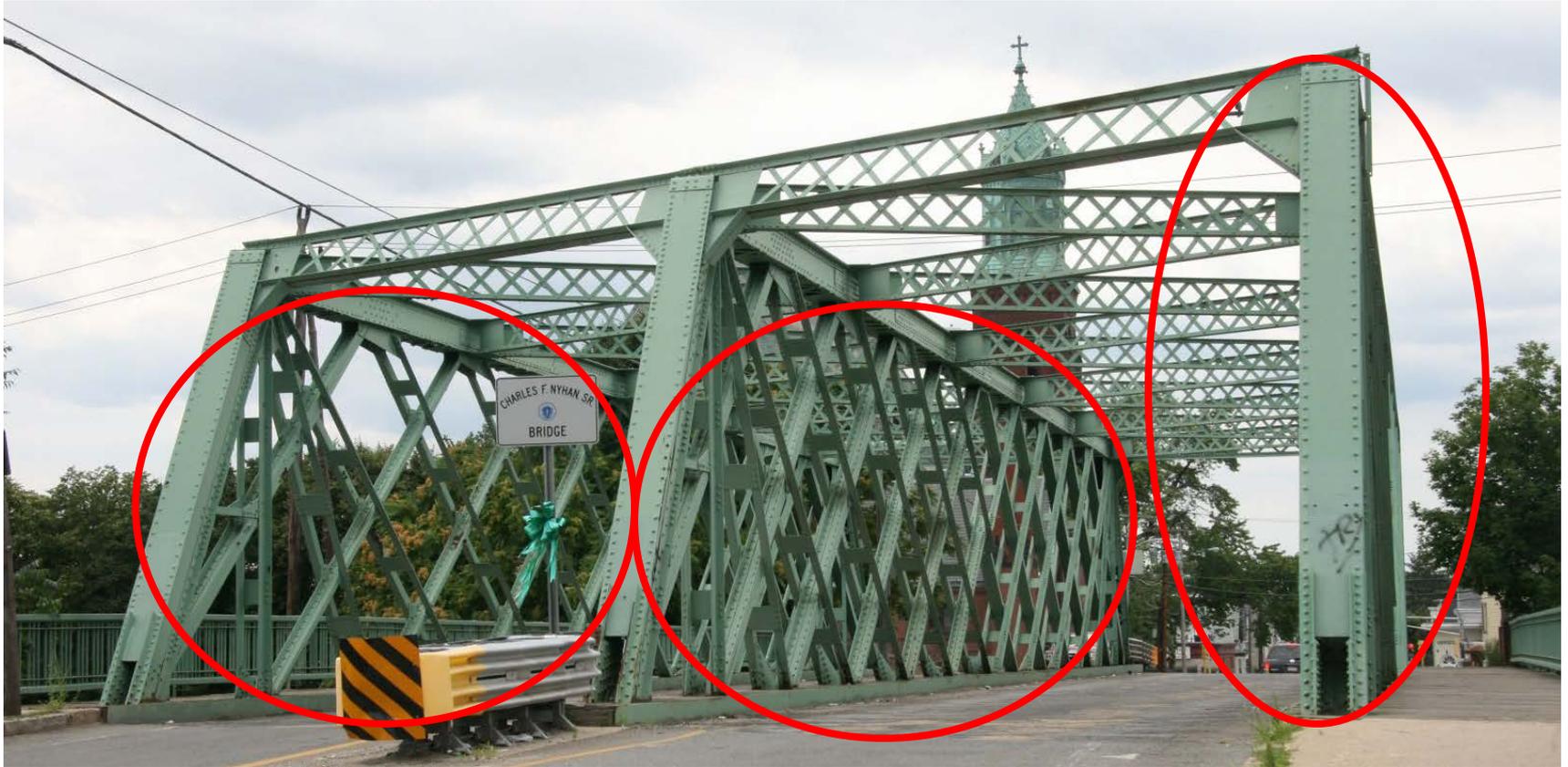
Each space between vertical members and end posts is one *panel*. This bridge has six panels.

Portal Bracing
 Sway Bracing (Upper-most bar sometimes called a "strut")
 Lateral Bracing



Truss Bridge Parts

Truss Webs and Lines

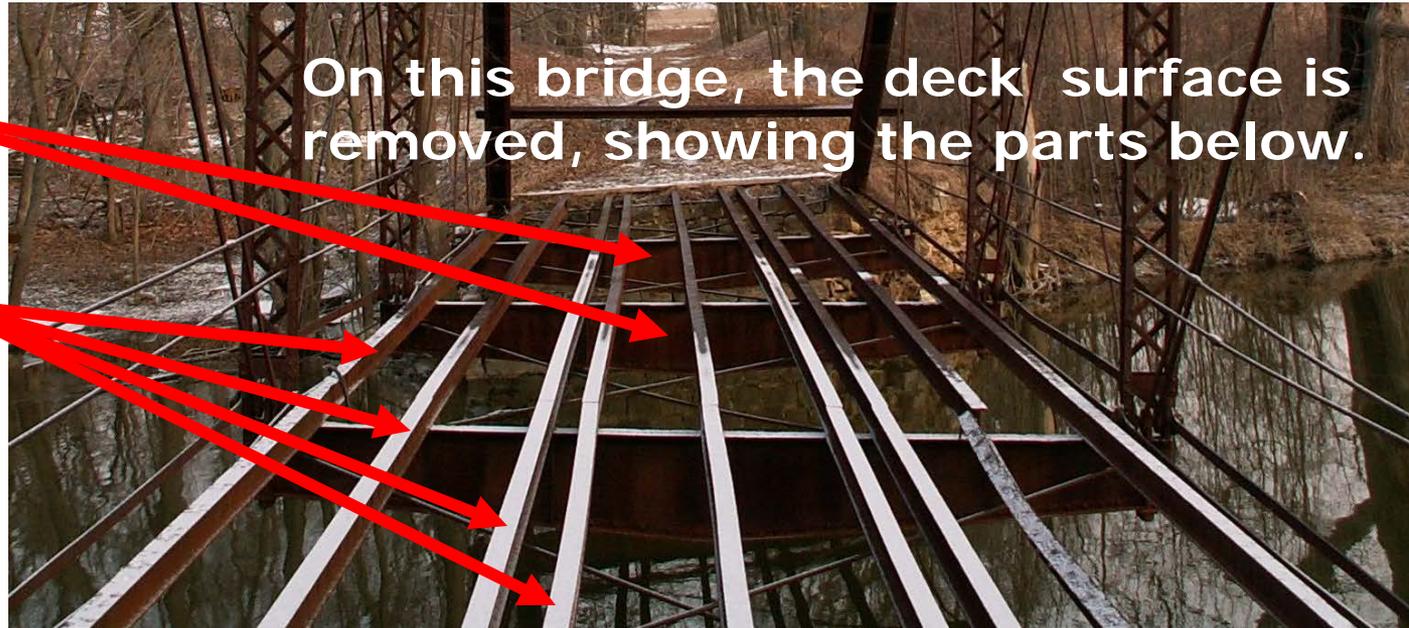


A truss "**web**" consists of all the chords and members that compose one truss "**line**". Most truss bridges have two truss lines, but this bridge has three truss lines.

Truss Deck Elements

Floorbeams

On this bridge, the deck surface is removed, showing the parts below.



Deck stringers

Often, bridges with floorbeams (like truss bridges) have longitudinal "deck stringers" or beams that run between the transverse floorbeams. The actual deck of any variety of materials is placed on top of the deck stringers. Sometimes a "wearing surface" is then placed on the deck to protect it.

Pony Truss: Outriggers (Buttresses)

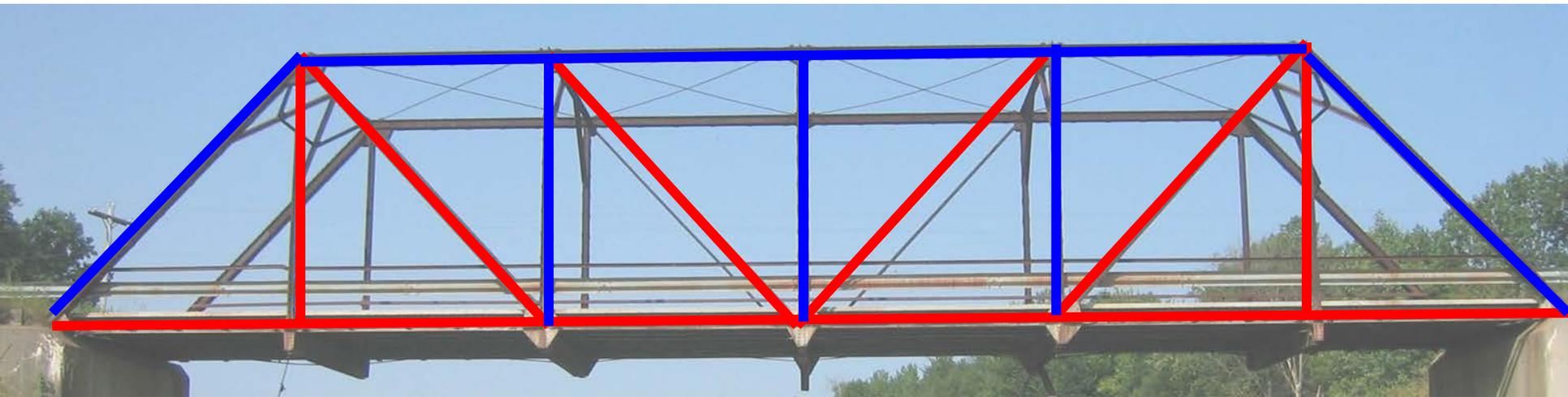


Pony trusses may have a vertical member that extends or angles out beyond the edges of the bridge. These are to stabilize the bridge and are called **outriggers** or sometimes **buttresses**.

Truss Bridge Forces

— Compression —

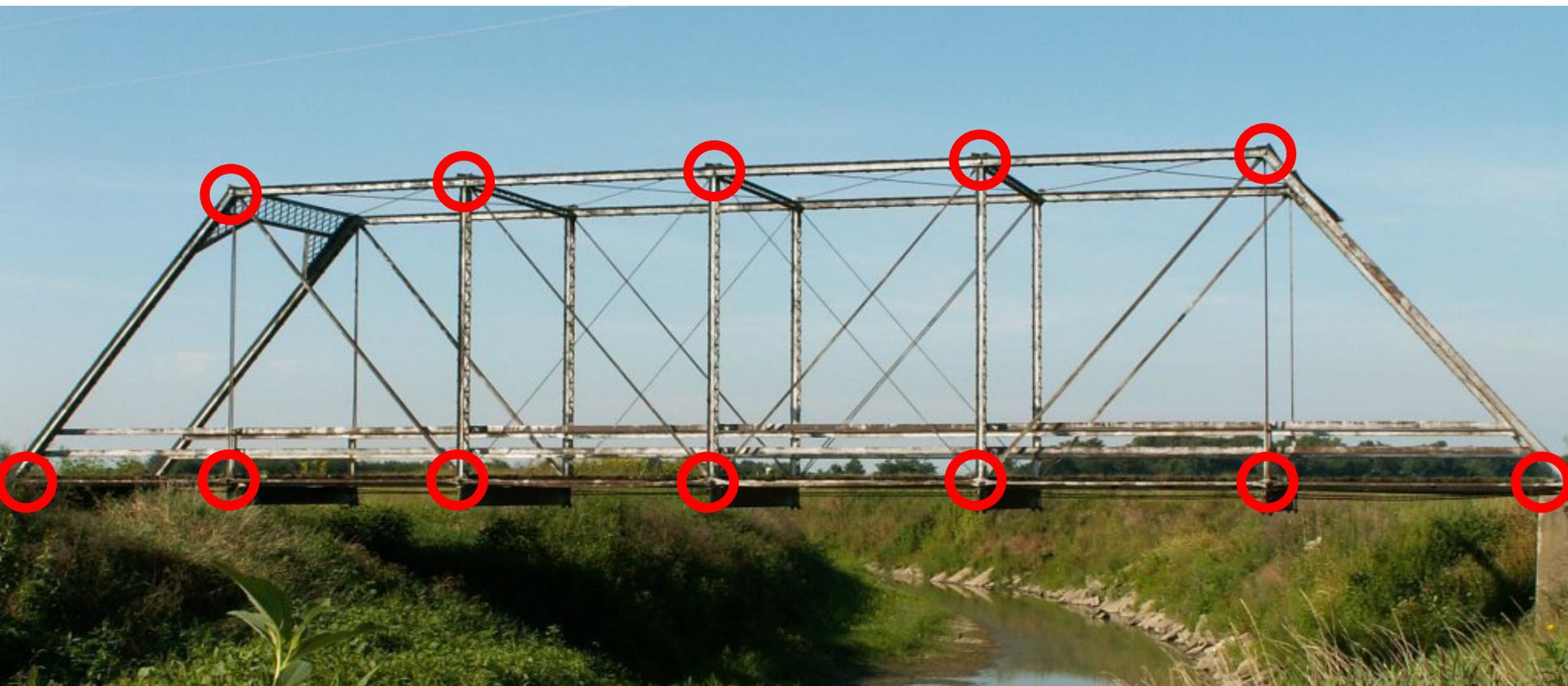
— Tension —



The chords and members of a truss bridge experience strain in the form of tension (stretching apart) and compression (squeezing together). Engineers often picked different types of materials and designs for the different parts of a bridge based on these forces. An example is shown above.

Truss Bridge Connections

The pieces of the framework of a truss bridge are held together by **connections**, sometimes also called joints. Most connections on historic bridges are either riveted or pinned, but can also be bolted or welded.



Pinned Connections



Pinned connections can be identified by the threaded bolt-like rod/cylinder called a **pin** going through loops or holes of the members. They tend to show up on bridges from the first half of the truss bridge era.

Riveted Connections



Riveted connections are identified by a “**gusset plate**” which diagonals and vertical members are riveted to, and no pin is present. These connections tend to show up in the second half of the truss bridge era.

Bolted and Welded Connections



Bolted



Welded

Welded and bolted connections are similar to riveted connections, and generally are only found on newer bridges or altered old bridges, although there are some exceptions.

Threaded Rod With Nut Connections



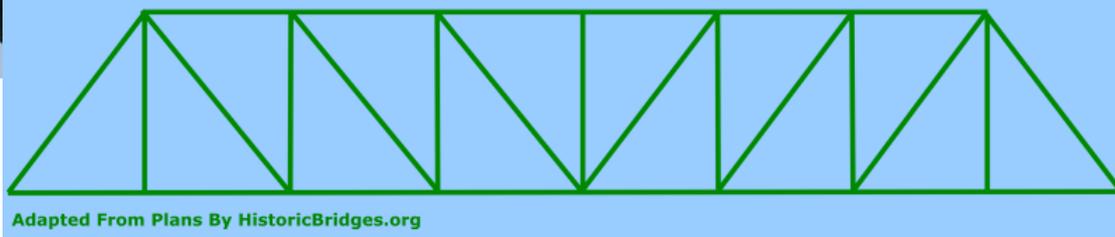
Threaded rod and nut connections are an unusual type of connection that generally is seen on very old truss bridges. These are called rod-nut connections by HistoricBridges.org for ease of categorization.

An Introduction To Historic Bridges

Part 4: Truss Bridge Configurations

Truss Configurations

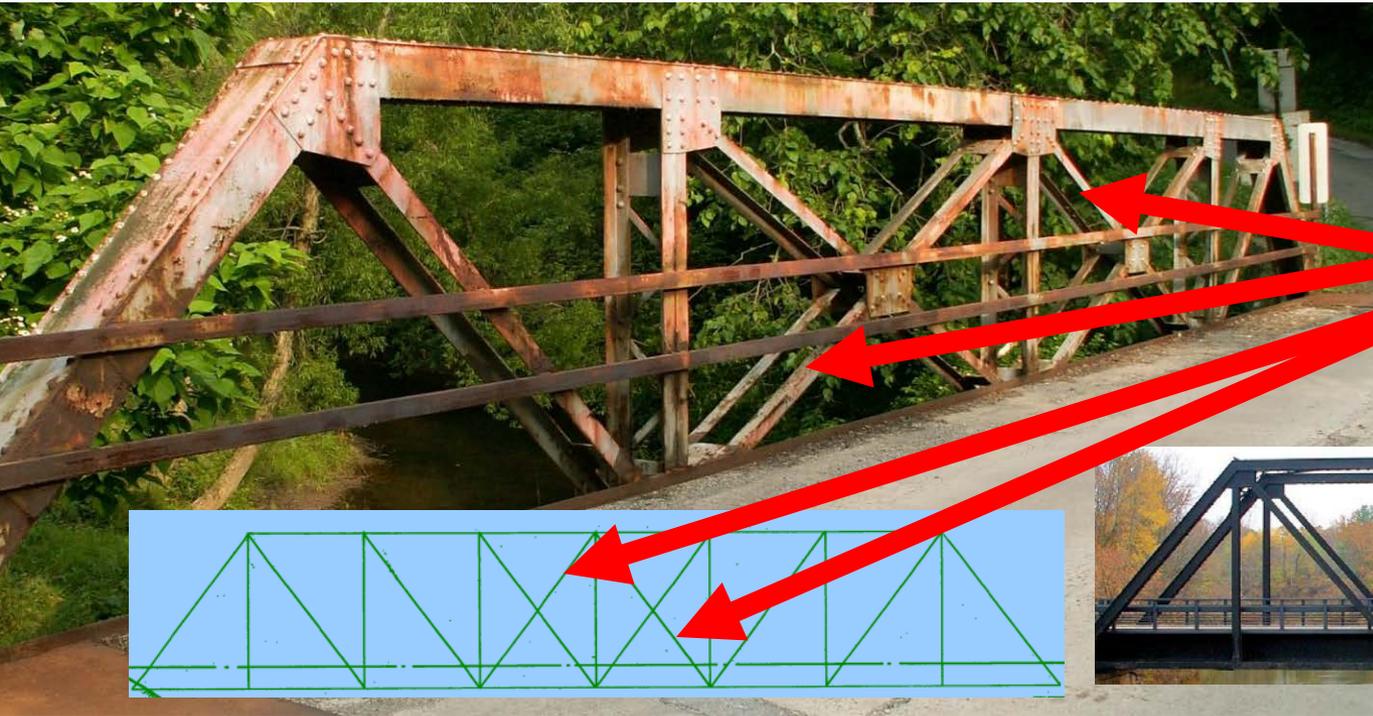
Pratt



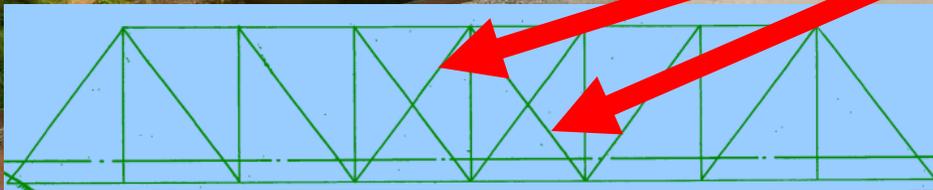
Overview: One of the two most common configurations, it tends to occupy the earlier half of the truss bridge era, but was used throughout. Originally developed by Thomas and Caleb Pratt in 1844.

Appearance: Diagonal members angle toward the center and bottom of bridge.

Pratt – Additional Notes



Counters



A Pratt may have additional diagonals called “counters”, sometimes of a smaller size, that do not follow the standard pattern to form an “X” shape on panels, usually toward the center, and may have turnbuckles.

Truss Configurations

Pratt - Half-Hip



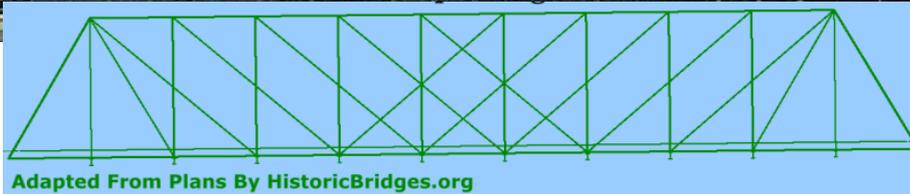
Full-Slope



Half-Hip

Some smaller pony truss bridges may not feature a hip vertical member, and they are called half-hip Pratt pony truss bridges. Those that feature the hip vertical may be called full-slope Pratt pony truss bridges.

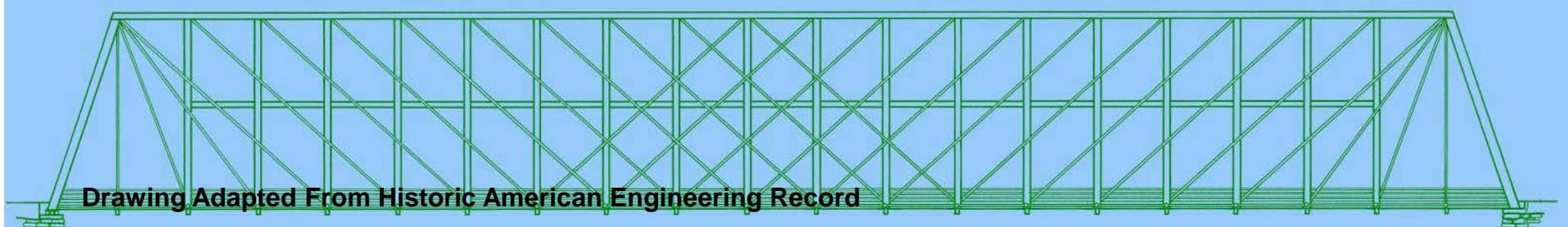
Whipple (Double-Intersection Pratt)



Overview: The Whipple truss is also known as the double-intersection Pratt truss. It was patented by Squire Whipple in 1847 as a stronger version of the Pratt truss.

Appearance: Similar to the Pratt truss, but the diagonals pass through two panels before reaching the bottom chord. They tend to show up on longer spans built in the first half of the truss era, and with pinned connections.

Triple Intersection Pratt



Drawing Adapted From Historic American Engineering Record

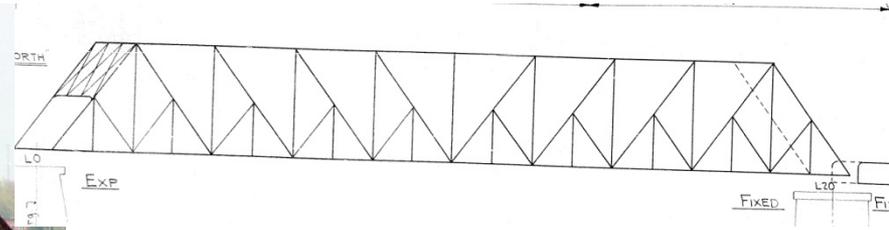
Overview: Also called the Triple Whipple, this truss configuration was never employed very often, and was used for very long spans. Only one such example is known to remain today.

Crossing Laughery Creek in Indiana, this bridge is known as the Triple Whipple Bridge.

Appearance: The diagonals pass through three panels instead of two as in the Whipple.

Truss Configurations

Baltimore



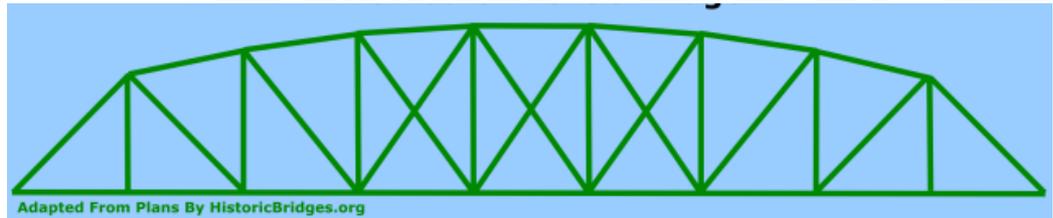
Overview: The Baltimore Railroad designed a truss configuration that eventually found use on both railroads and highways. It is a Pratt truss with additional members added for additional strength.

Appearance: Characterized by a Pratt configuration with extra smaller members branching off of the diagonals, which subdivide the panels.

Truss Configurations

Overview: Charles H. Parker modified the Pratt design to create what became known as the Parker truss configuration. This design allowed one to use less materials to get the a similar load capacity. The downside was the more complex design.

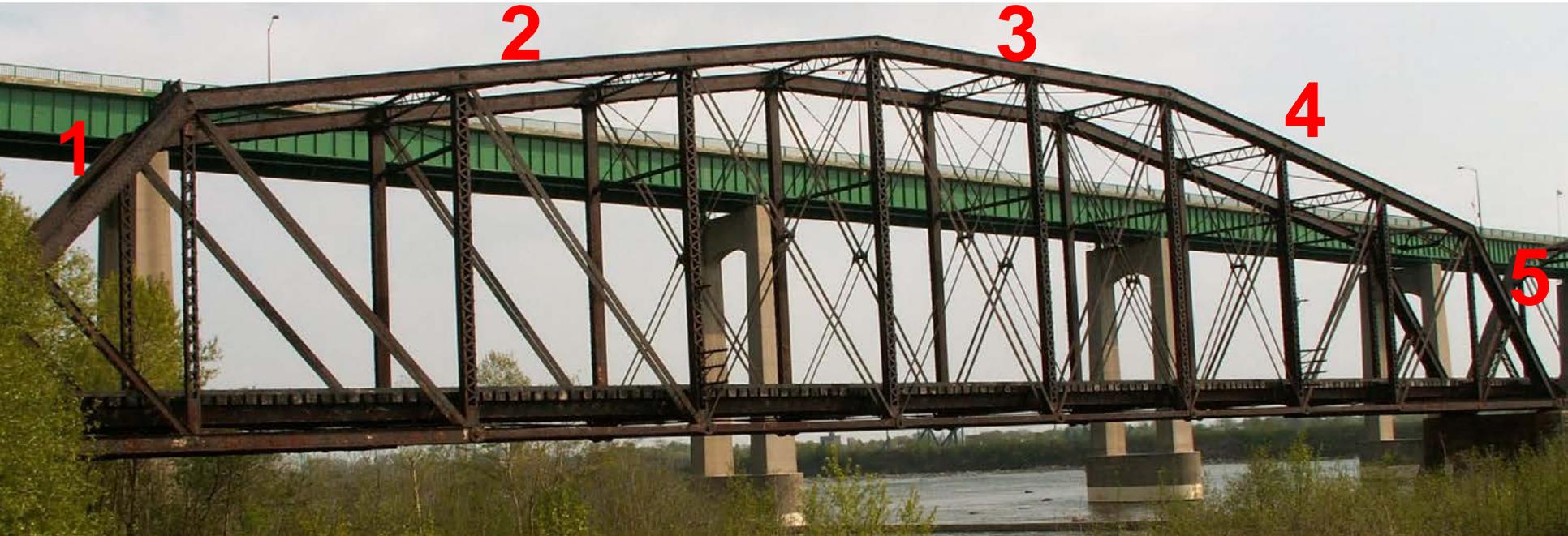
Parker



Adapted From Plans By HistoricBridges.org

Appearance: Characterized by an arch-shaped (polygonal) top chord, with diagonals that follow the Pratt configuration.

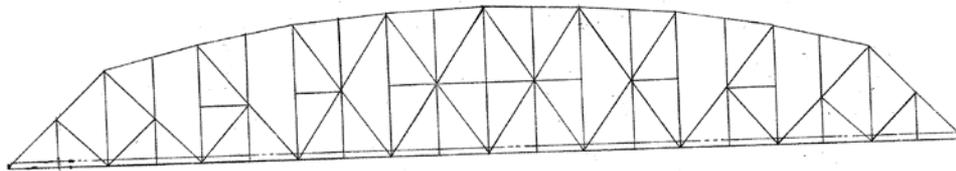
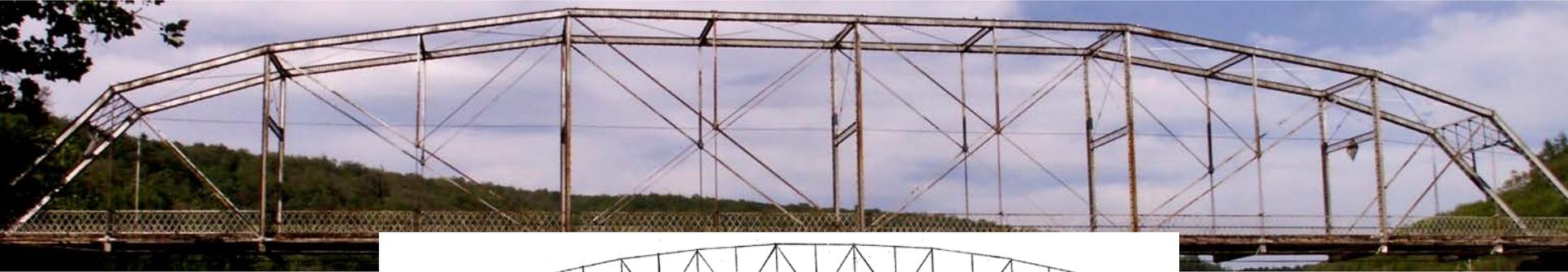
Camelback



Overview: Some bridges that appear to be simple Parker truss bridges but have exactly five sections of top chord are referred to more specifically as a Camelback truss.

Appearance: Characterized by exactly five different angled sections of top chord, with a Pratt layout of the diagonals.

Pennsylvania



Overview: Sometimes called the Petit truss. Designed by the Pennsylvania Railroad, this configuration combines the engineering ideas behind the Baltimore with those of the Parker or Camelback. Those with the 5 slopes like a Camelback are sometimes called “Pennsylvania Camelback” truss bridges.

Appearance: Features an arch-shaped (polygonal) top chord with a diagonal arrangement like the Baltimore, which subdivide the panels.

Warren



Overview: The other most common truss configuration, this design tended to be used in the second half of the truss bridge era, and with riveted connections. Originally developed in 1848 by James Warren and Willoughby Monzoni.

Appearance: Alternating diagonal members form a repeating “V” shape. A true Warren does not have vertical members.

Warren: With Verticals



Most Warren truss bridges do in fact feature vertical members. They may be referenced generally as “**Warren with verticals**” truss bridges. Vertical members may occur at each connection, or every other connection.

Double-Intersection Warren



Overview: Often called simply the Double Warren, this is an uncommon truss configuration. Bridges with this configuration often have riveted connections.

Appearance: Looks like two Warren trusses offset and superimposed on each other, forming a repeating “X” shape.

Lattice Truss



Overview: An adaptation of Warren truss technology that tends to show up on railroad bridges and with riveted connections. This category includes any multi-intersection Warren, generally beyond Double-Intersection (ie triple, quadruple, quintuple)

Appearance: Multiple Warren trusses offset and superimposed on each other, forming a lattice pattern.

Lattice Truss: Quadruple Intersection Warren



Overview: The Quadruple Intersection Warren, sometimes called a “Warren Quadrangular truss” is the most common form of lattice truss.

Appearance: Four Warren trusses offset and superimposed on each other, forming a lattice pattern.

Lattice Truss: Triple Intersection Warren



Overview: The Triple Intersection Warren is much less common than the Quadruple Intersection Warren truss.

Appearance: Three Warren trusses offset and superimposed on each other, forming a lattice pattern.

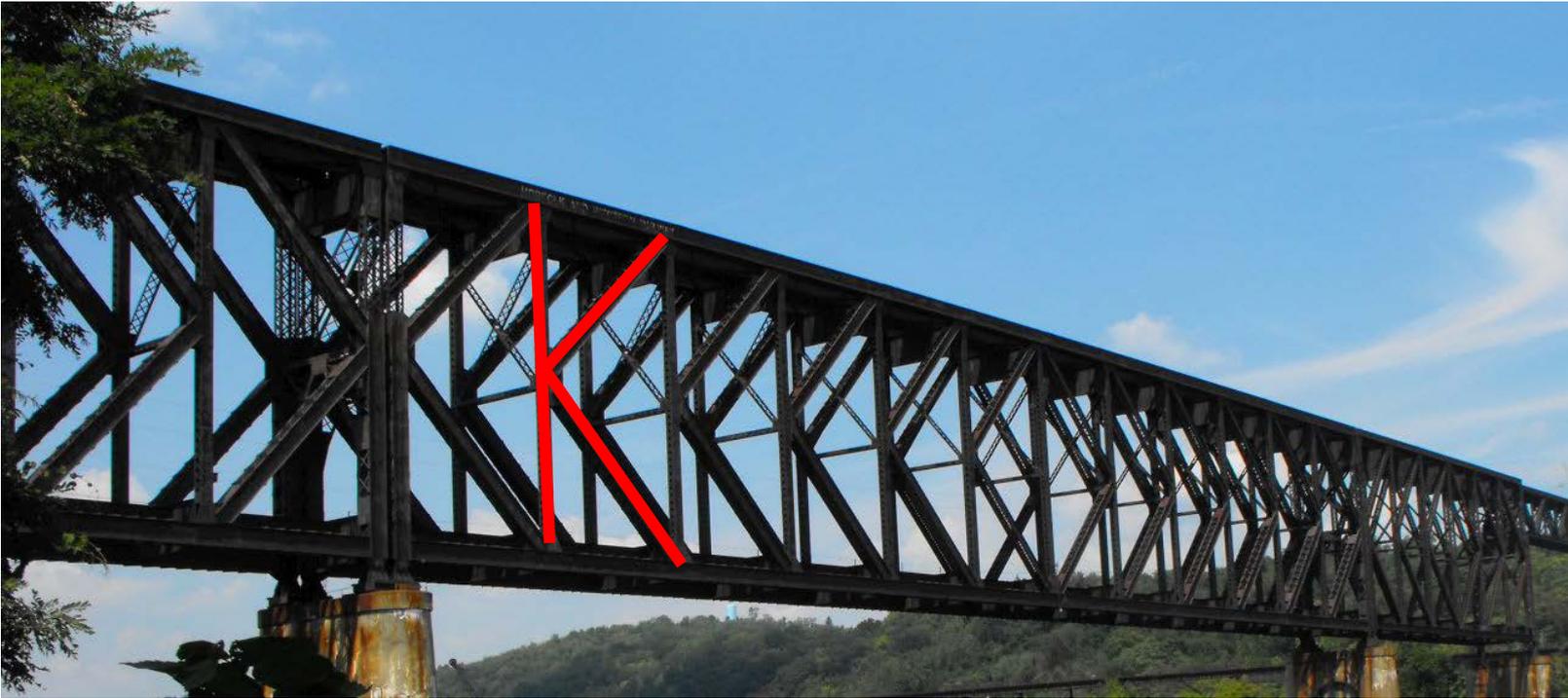
Polygonal Warren



Overview: For greater efficiency, strength, and length, engineers changed the top chord of the bridge to run at different angles across the bridge forming an arch shape, much like a Parker.

Appearance: Features an arch-like (polygonal) shape accompanied by diagonals assuming a Warren configuration. Normally has riveted connections and dates to the 20th Century.

K-Truss



Overview: An uncommon configuration that stands on its own and is difficult to compare to other configurations. Invented c. 1910 by Phelps Johnson for the design of the Quebec Bridge.

Appearance: Features a repeating “K” pattern of verticals and diagonals mirrored around the center of the truss span.

Kingpost



Overview: An extremely rare truss configuration, this was an early truss design used for short crossings.

Appearance: Features exactly one vertical member and two inclined end posts.

Queenpost



Overview: An extremely rare truss configuration, this was an early truss design used for short crossings.

Appearance: Exactly two vertical members, inclined end posts, and an “X” pattern of diagonal members in the center panel.

Bollman

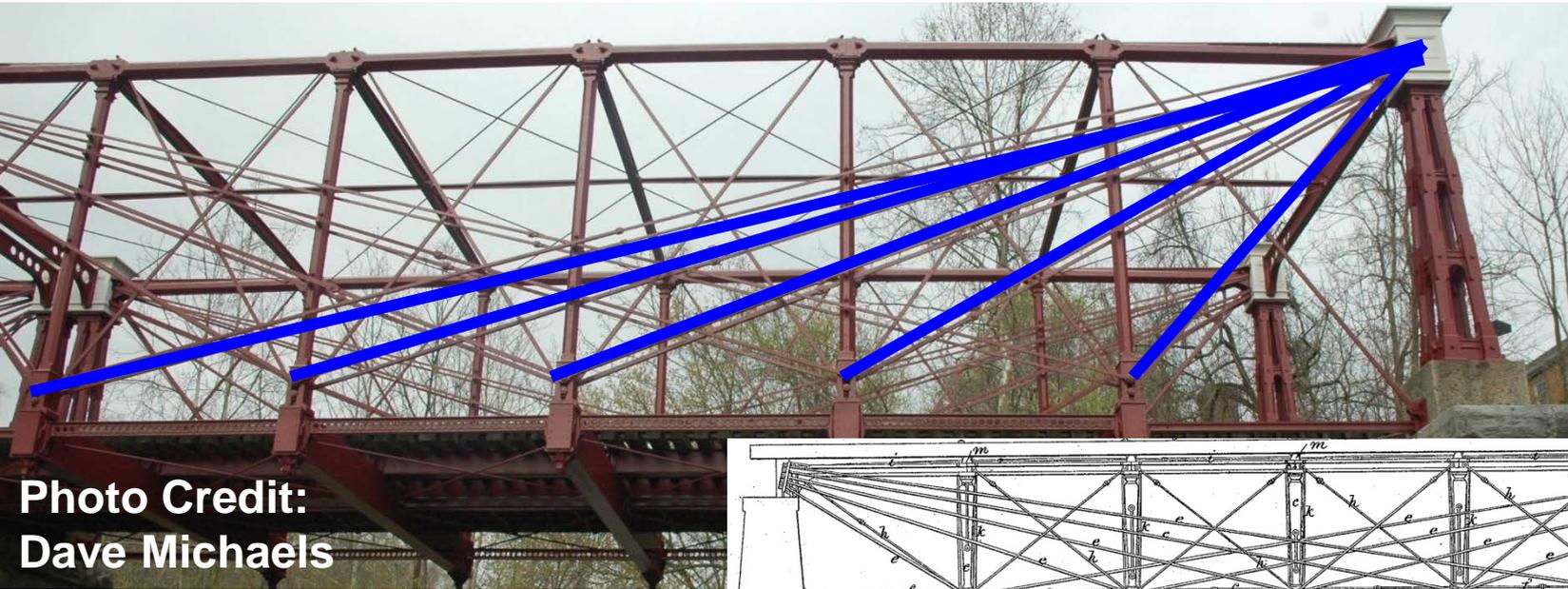


Photo Credit:
Dave Michaels

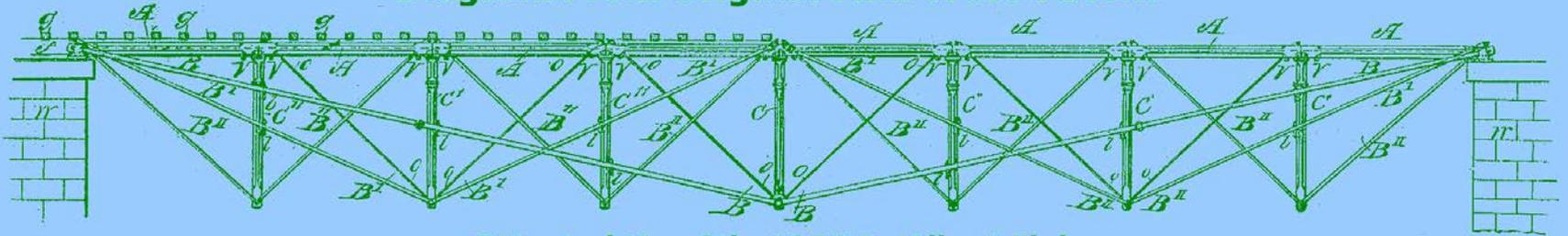
Overview: Wendell Bollman's patented design was used on the earliest generation of metal railroad truss bridges, only one example remains in Savage, Maryland.

Appearance: Diagonal members radiate out from the top of the end post to the bottom chord connections out to the center of the span.

Fink



Diagram From Original Fink Truss Patent



Patented May 9th, 1854 By Albert Fink

Overview: Albert Fink's patented design was used mostly used on the earliest generation of metal railroad truss bridges; only a few examples remain nationwide.

Appearance: Overlapping kingpost trusses of varying sizes contained within the endposts of the span.

Howe



Overview: Howe trusses are common for wooden trusses and uncommon for metal trusses because of the way stresses work. It is the opposite of a Pratt.

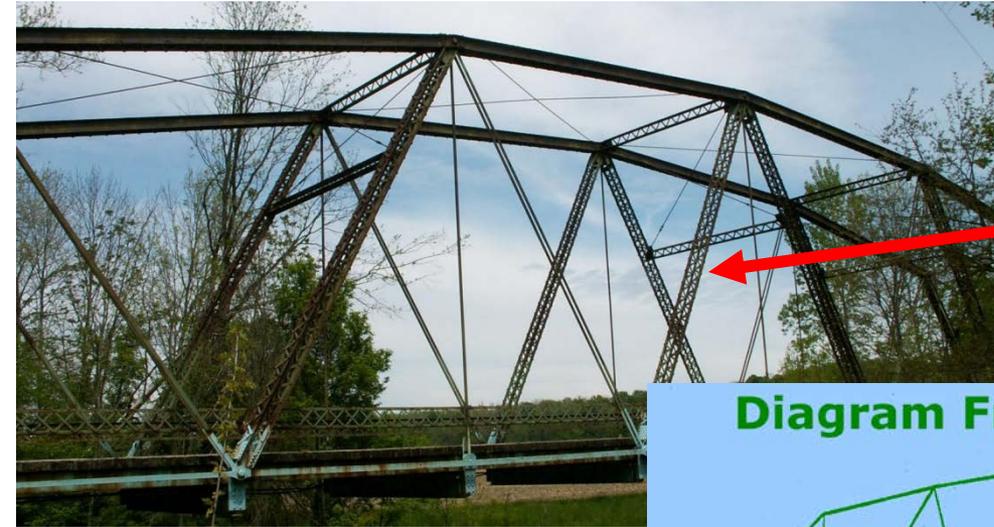
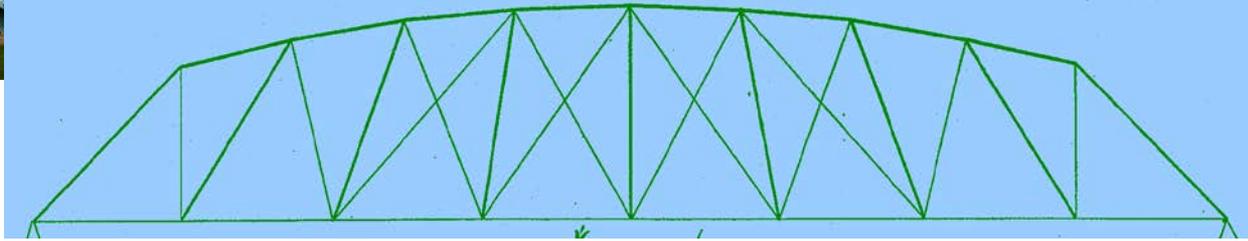
Appearance: Diagonals point towards the center and top of bridge. A Howe often has counters at all panels which is uncommon in a Pratt. Might be confused with a Double-Warren as a result, but a Howe has vertical members.

Truss Configurations

Pegram

Indiana Bridge Company "High Triangular" truss.

Diagram From Original Pegram Truss Patent



Overview: Extremely rare design patented by George Pegram. True examples are products associated directly with the patent, but Indiana Bridge Company's similar "high triangular" truss, not associated with Pegram, are usually classified as Pegram trusses as well.

Appearance: Similar, yet different, from a polygonal Warren in terms of member angle, as shown above.

Post



Overview: Simeon S. Post's patented design, one of the rarest truss configurations in the country, with only three known surviving examples remaining.

Appearance: Difficult to identify without knowledge of stress in members. Diagonals in compression incline toward the center of the bridge, and diagonals in tension incline toward the ends of the bridge.

Truss Configurations

Thatcher



Overview: One of the rarest truss configurations in the country, with only a few surviving examples remaining. The above bridge is no longer extant.

Appearance: Diagonal configuration features an unusual “W” shape that runs the entire span. The central diagonal members are in compression, while the outermost diagonals are in tension.

Lenticular



Overview: One of the rarest and most unusual truss bridge designs in the country.

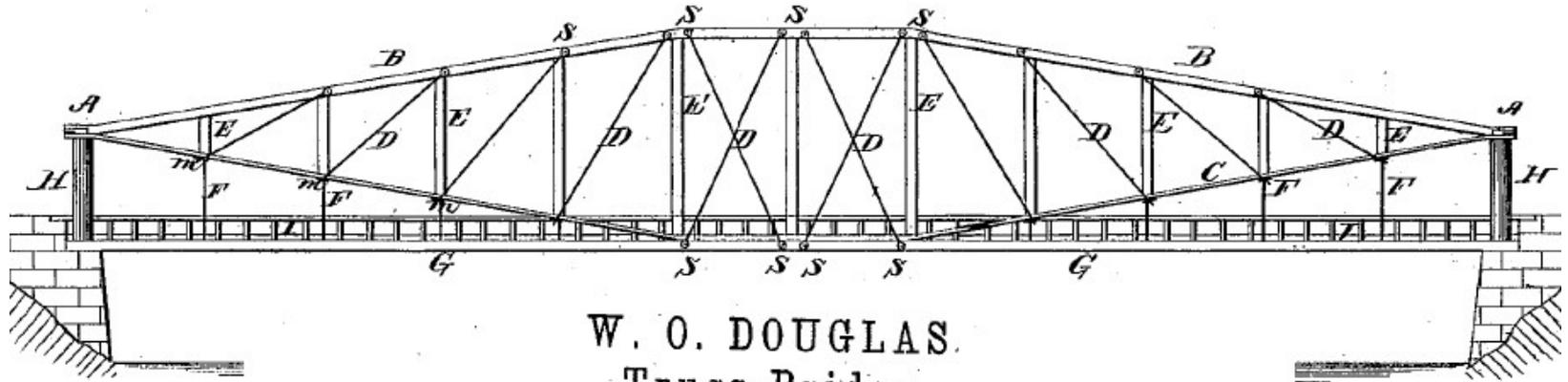
Appearance: Both the top chord and bottom chord have an arched appearance, forming a distinctive oval or eye-like shape.

Lenticular: Additional Notes



Lenticular truss bridges originated in Europe, and famous engineer Gustav Lindenthal built America's largest span in Pittsburgh at Smithfield Street in 1883.

Lenticular: Additional Notes



W. O. DOUGLAS.
 Truss-Bridge.

No. 202,526.

Patented April 16, 1878.

Aside from Smithfield Street Bridge, all other lenticular truss bridges in the United States were built by the Corrugated Metal Company, which later became the Berlin Iron Bridge Company. This East Berlin, CT company held a patent for their variety of lenticular truss. Sometimes, the East Berlin lenticular trusses are described as “Jarvis-Douglas Parabolic Trusses” after the names of the involved East Berlin engineers/inventors.

Bailey

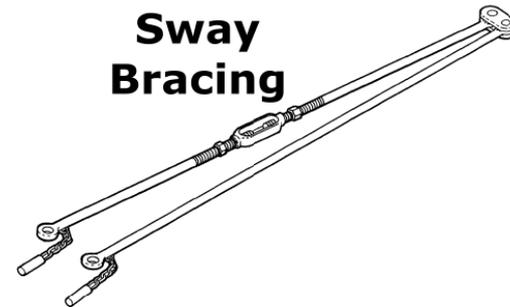
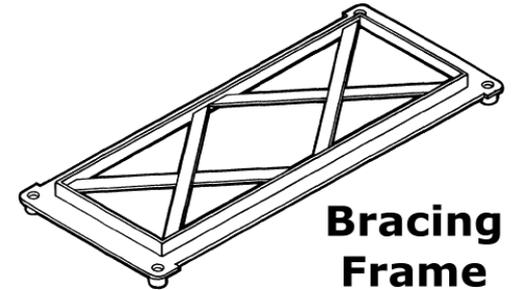
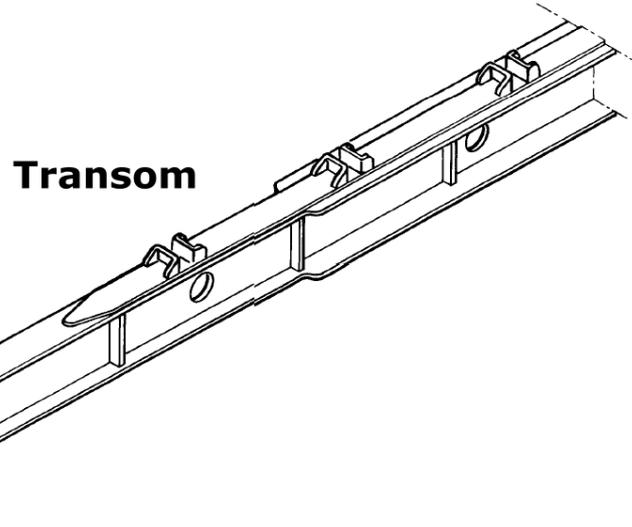
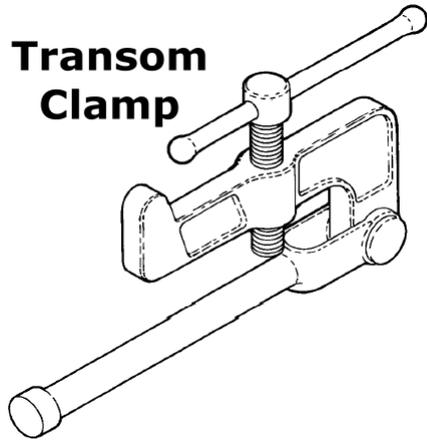


Overview: Developed during World War II as a bridge type that was portable, quick to erect, and easy to adjust for different loads and spans. A late truss design, and still built today. Only the older and World War II surplus examples should be considered historic.

Appearance: A unique design of pony truss composed of modular X-shaped panels. Height and width varies.

Truss Configurations

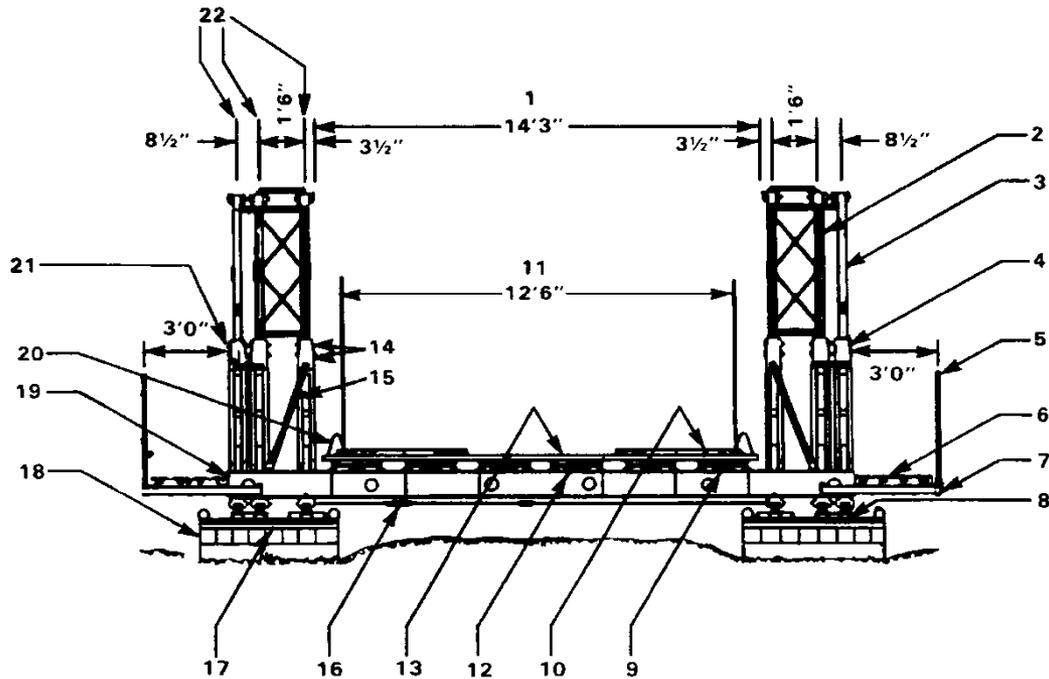
Bailey Details



The parts of Bailey trusses were given specific names by their designers and used by the U.S. Army. Some of these terms differ or conflict with traditional truss terminology. For example, floor beams are called “transoms” on Bailey trusses. Trusses can be doubled or tripled up on each side, or stacked (each level is a “story”), leading to additional classifications. See Army Field Manual FM 5-277 for details.

Bailey Details

Many Bailey trusses seen today lack details found in the original Bailey truss designs. These changes may help determine whether a Bailey truss is old or not. Original details shown here.



- | | |
|-----------------------------|-------------------------|
| 1 CLEARANCE BETWEEN TRUSSES | 12 PLAIN STRINGER |
| 2 BRACING FRAMES | 13 CHESS |
| 3 PANEL | 14 PANEL PINS |
| 4 END POST | 15 RAKER |
| 5 FOOTWALK POST | 16 SWAY BRACE |
| 6 FOOTWALK | 17 BASE PLATE |
| 7 FOOTWALK BEARER | 18 GRILLAGE |
| 8 BEARING | 19 TRANSOM |
| 9 BUTTON STRINGER | 20 STEEL RIBBAND |
| 10 WEAR TREAD | 21 SHORT PANEL PINS |
| 11 ROADWAY | 22 CENTERLINE OF PANELS |

Bailey Classifications

- 1 SINGLE-TRUSS SINGLE-STORY (SS)
- 2 DOUBLE-TRUSS SINGLE-STORY (DS)
- 3 TRIPLE-TRUSS SINGLE-STORY (TS)
- 4 DOUBLE-TRUSS DOUBLE-STORY (DD)
- 5 TRIPLE-TRUSS DOUBLE-STORY (TD)
- 6 DOUBLE-TRUSS TRIPLE-STORY (DT)
- 7 TRIPLE-TRUSS TRIPLE-STORY (TT)

Table 1-1 Abbreviations for single-lane panel bridges, Bailey type M2

TYPE		USUAL	ABBREVIATION
TRUSS	STORY	NOMENCLATURE	
Single	Single	Single-single	SS
Double	Single	Double-single	DS
Triple	Single	Triple-single	TS
Double	Double	Double-double	DD
Triple	Double	Triple-double	TD
Double	Triple	Double-triple	DT
Triple	Triple	Triple-triple	TT

The adaptive nature of the Bailey truss means that optionally, each truss line can consist of two panels side-by-side (called a double truss) and additionally, an additional row of panels can be placed on top of the first row adding a “story” to the truss. Bailey trusses are described by observing these configurations. Typical combinations described in the Army manual are shown here.

Other Truss Types

There are some non-standard configurations that do not appear to have an official name.



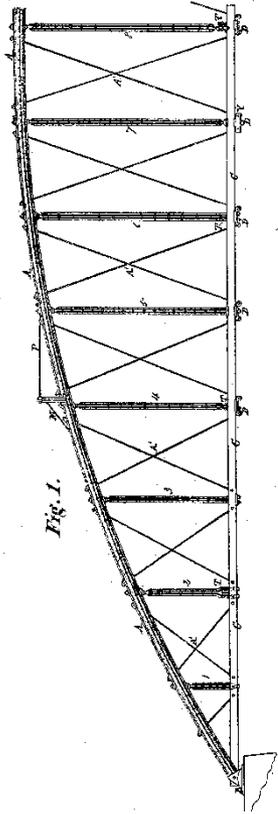
For example, this Warren truss has been subdivided like a Baltimore truss. It could be called a **subdivided Warren truss**, although “Baltimore Warren” or even a “Modified Warren” truss would be descriptive.

Bowstring Truss Bridges

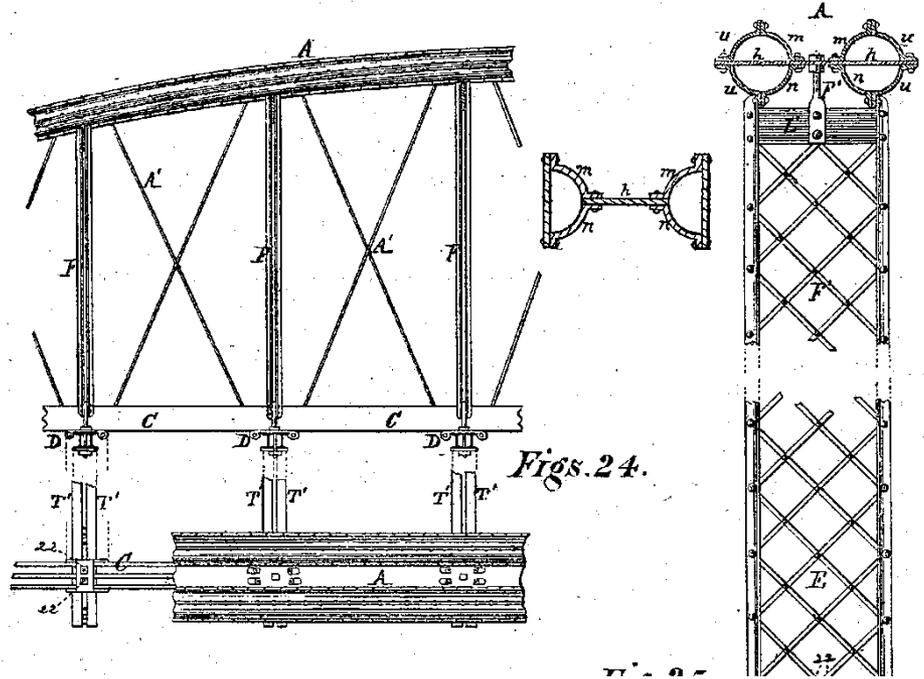


A special variation of the truss bridge is the bowstring truss bridge. It is one of the rarest and oldest metal bridge types around. They have a true curve to their arched top chord. They generally date to the 1870s, but the design began to be used in the 1850s. They also share some engineering and design thinking with that of a tied arch.

Bowstring Truss Bridges



6 Sheets--Sheet 6.
 D. HAMMOND, M. ADLER & J. ABBOTT.
 Iron-Bridges.
 No. 135,802. Patented Feb. 11, 1873.



Bridge companies at the time designed the bridges using their own ideas and patents. Thus, bowstring bridges have their own distinctive appearance based on what company built them.

Bowstring Truss Bridges



Squire Whipple, who also invented the Whipple truss, is credited with developing and popularizing the bowstring truss. His special design, often called Whipple Arch bridges, also have a distinctive cast iron top chord and can date back to the 1850s.

Bowstring Truss Bridges



The Wrought Iron Bridge Company of Canton Ohio built bowstrings that often used Keystone-style column top chords, and also used a lot of lattice on built-up members for larger bridges.

Bowstring Truss Bridges



The King Bridge Company of Cleveland, Ohio used i-beams or a box-shaped beam for the top chord. Their bridges tend to have a fairly utilitarian appearance.

Bowstring Truss Bridges



The Massillon Bridge Company of Massillon, Ohio used a very unique and impressive top chord. It was a patented design they used that was composed of poles mounted between bars to form the top chord.

An Introduction To Historic Bridges

Part 5: Cantilever and Continuous Truss Bridges

Cantilever Truss Bridges



Hinge Points

Anchor Arm Cantilever Arm Suspended Span Cantilever Arm Anchor Arm

Cantilever truss bridges are a complex, hinged structure type that feature cantilevered arms that extend from a pier to normally hold a structurally independent suspended span at one end, and balance the weight out at the other end extending from the pier.

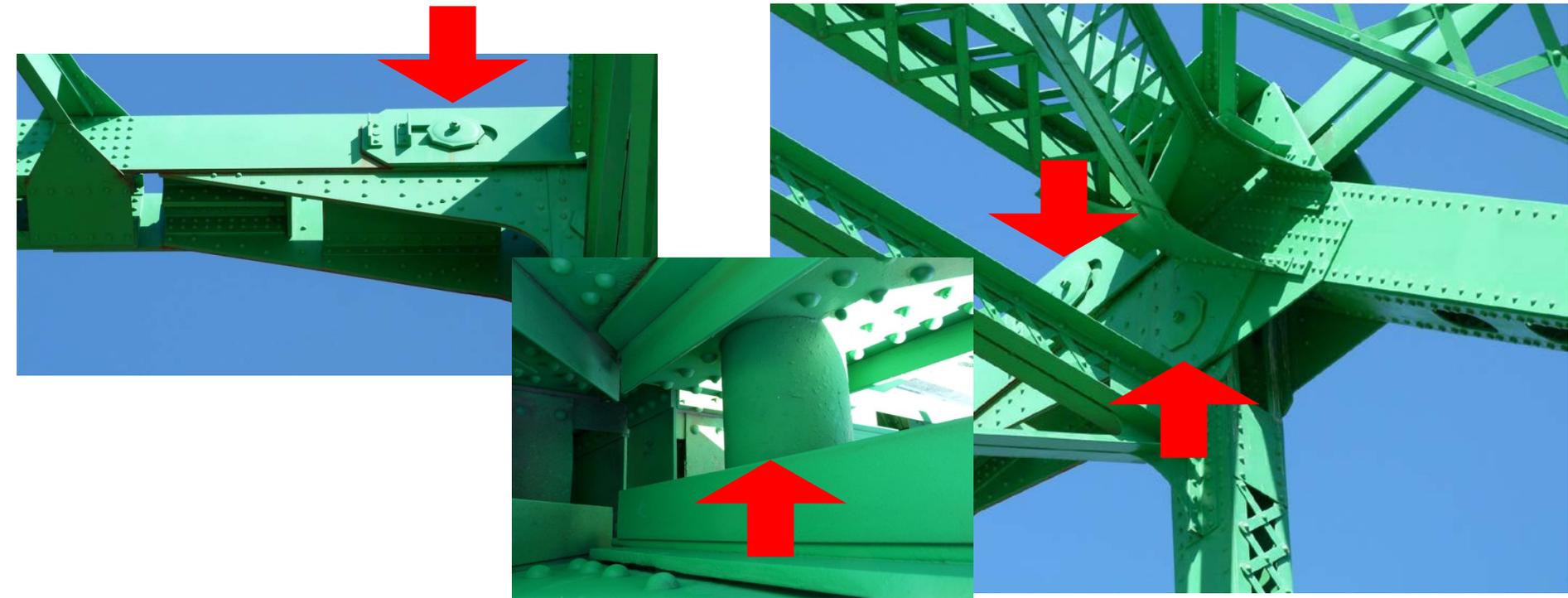
Cantilever Truss Bridges



Suspended spans may not always be readily apparent. Look for pin connections or look for a change in truss member size and configuration.

Visually, cantilever truss bridges often (but not always) have “towers” at the piers.

Cantilever Truss Bridges



The above photos show the types of details and pins (found at top and bottom chord connections) that indicate hinge points, which on this example bridge, marked the transition to the suspended span. Arrows note the tell-tale pins.

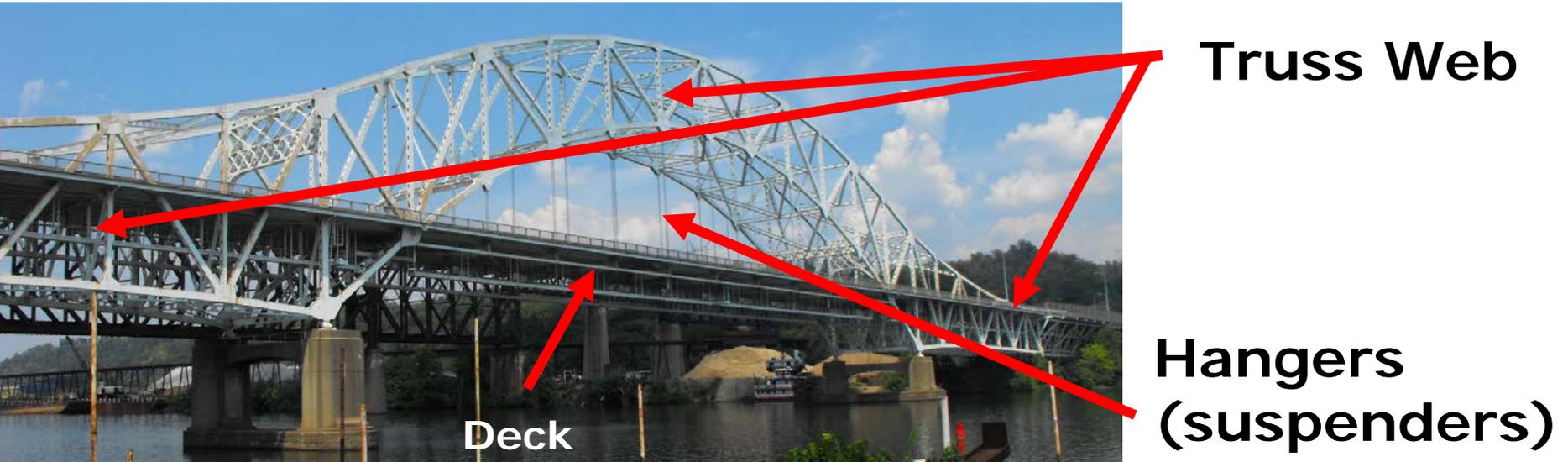
Continuous Truss Bridges



Some bridges that look like cantilever trusses, and even were constructed in a manner similar to a cantilever truss, lack hinges and function as a continuous truss bridge. Its easy to be fooled if you don't look closely.

Cantilever/Continuous Truss

Arched Truss (And Suspended Deck)



This bridge may look like an arch bridge (discussed later) but it is in fact a truss whose entire truss web arches far above the deck at the center span, and has suspenders (hangers) that connect the deck to the truss above. Note how the truss extends beyond the piers in a continuous fashion. Bridges of this form are generally continuous truss bridges, but hinged function as a cantilever truss is also possible.

Arched Truss (No Suspended Deck)



The design above, often called an “arched truss,” is essentially the same concept as the suspended deck arched truss, except that the truss does not completely rise above the deck, thereby eliminating the need for a suspender/hanger system. Bridges of this form come in both continuous and cantilever configurations.

An Introduction To Historic Bridges

Part 6: Concrete Slab Bridges

Concrete Slab Bridges



Concrete slab bridges are literally a solid slab that normally contains reinforcing rods (rebar) within to provide strength and support. Sometimes the slab may have a slight arched design.

An Introduction To Historic Bridges

Part 7: Concrete Rigid-Frame Bridges

Concrete Rigid-Frame Bridges



Rigid-frame bridges are concrete bridges where the superstructure and the substructure are cast as one single unit. As such, there are no bearings on rigid-frame bridges.

Concrete Rigid-Frame Bridges



Rigid-frame bridges dating to historic periods tend to be small to medium span concrete slab-like bridges with an arch shaped to them.

An Introduction To Historic Bridges

Part 8: Girder Bridges

Metal Girder Bridges



Metal girder bridges are often called **plate girder** bridges. They were common on railroads and some states built them on highways frequently as well. They generally date from 1900 on.

Rare Variation: Lattice Girders



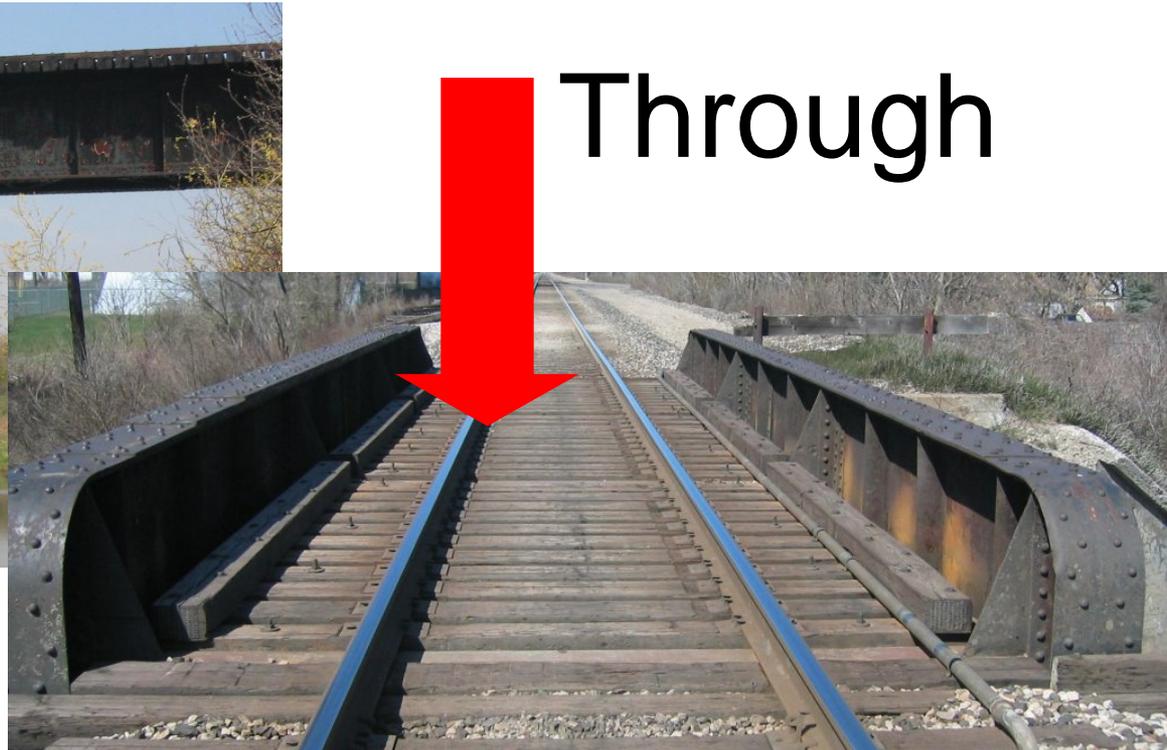
Overview: Far more common and larger examples are found in Europe. Most North American examples are diminutive spans that could be mistaken for stringer/beam bridges with lattice guardrails, except for careful observation that reveals the railings also function structurally by being attached to transverse floor beams.

Appearance: Might be confused with a “lattice truss” but the lattice is much more dense relative to the entire structure size, and is normally composed of simple bars or angles.

Girder Types



Deck



Through



Similar to truss bridges, the girders can be beside the road or below. Typically metal girders do not have overhead bracing, and those with girders beside the roadway are usually considered through girders.

Parts: Stiffener Plates



Stiffener
Plates

Metal girders often have rib-like plates on their beams. These help keep the girder from bending or twisting and are called stiffener plates.

Materials: Concrete



Concrete girder bridges were also built. They generally date from 1910 through 1935.

Materials: Concrete: Floor Beams



Visible
Floor
Beams



Floor
Beams
Integral



Concrete girder bridges may not have visible floor beams if they are integral with the concrete deck. Hidden reinforcing rods provide the strength.

Michigan's Unique Concrete Camelback Bridges



Michigan designed and built a unique bridge concrete girder design called the curved chord through girder, often called simply the concrete camelback. These were built in the 1920s.

Concrete Camelback Bridges



These bridges vary in size and design, and each remaining example is rare and significant, especially on a national scale.

Concrete Camelback Bridges



Some other states and provinces had similar designs of this type, but they were never built frequently and few examples remain. Surviving examples should be considered noteworthy.

Concrete Camelback Bridges

HistoricBridges.org has a special webpage dedicated to discussing the history, design, and significance of Michigan's Concrete Camelback Bridges.



historicbridges.org/info/curved/

An Introduction To Historic Bridges

Part 9: Concrete Arch Bridges

Concrete Arch Bridges



Concrete arch bridges were built generally after 1900 and usually are reinforced, with reinforcing rods (rebar) inside to help hold them together.

Concrete Arch Spandrels

Open
Spandrel



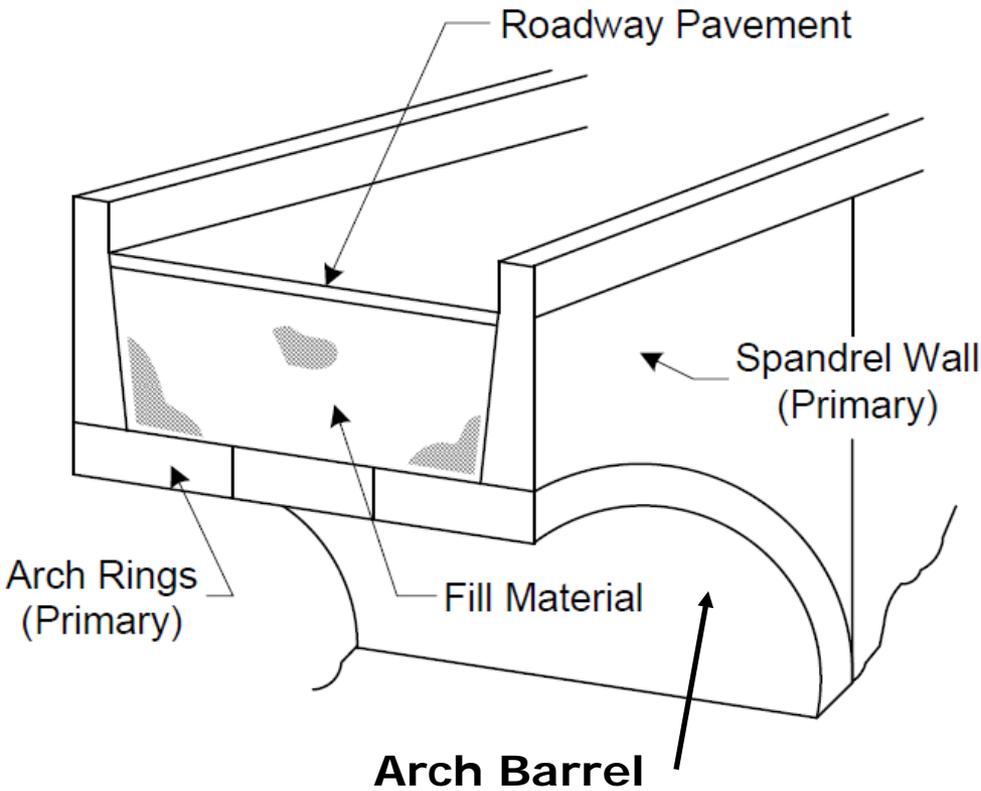
Closed
Spandrel



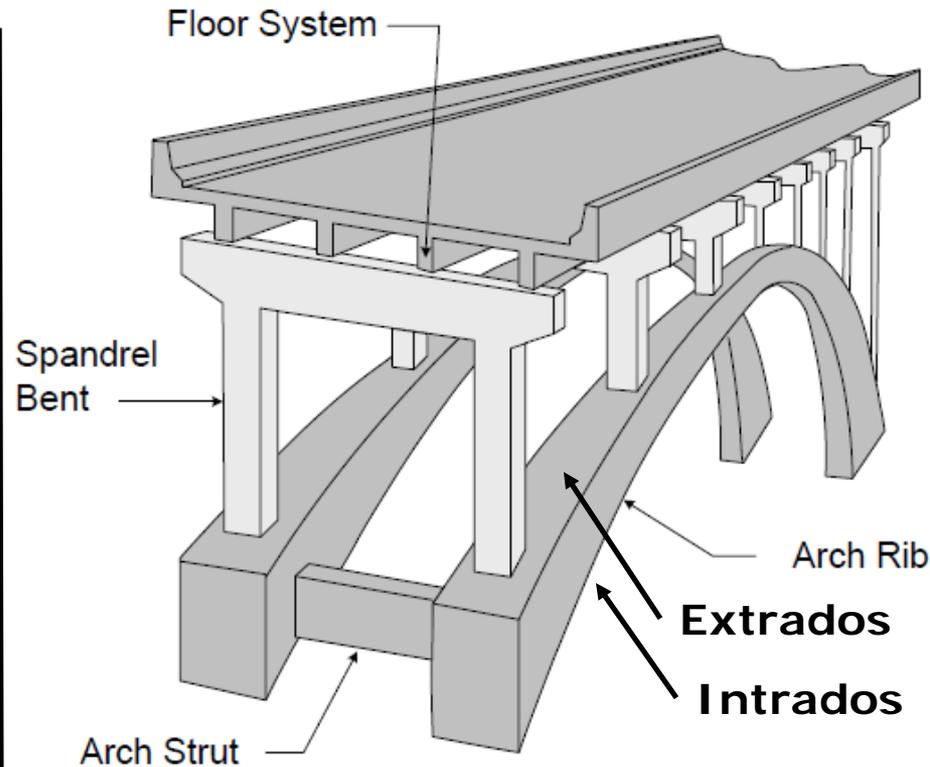
Bridges with visible vertical members,

are **open spandrel** bridges. Those without visible vertical members are **closed spandrel** bridges.

Concrete Arch Spandrels



Closed Spandrel

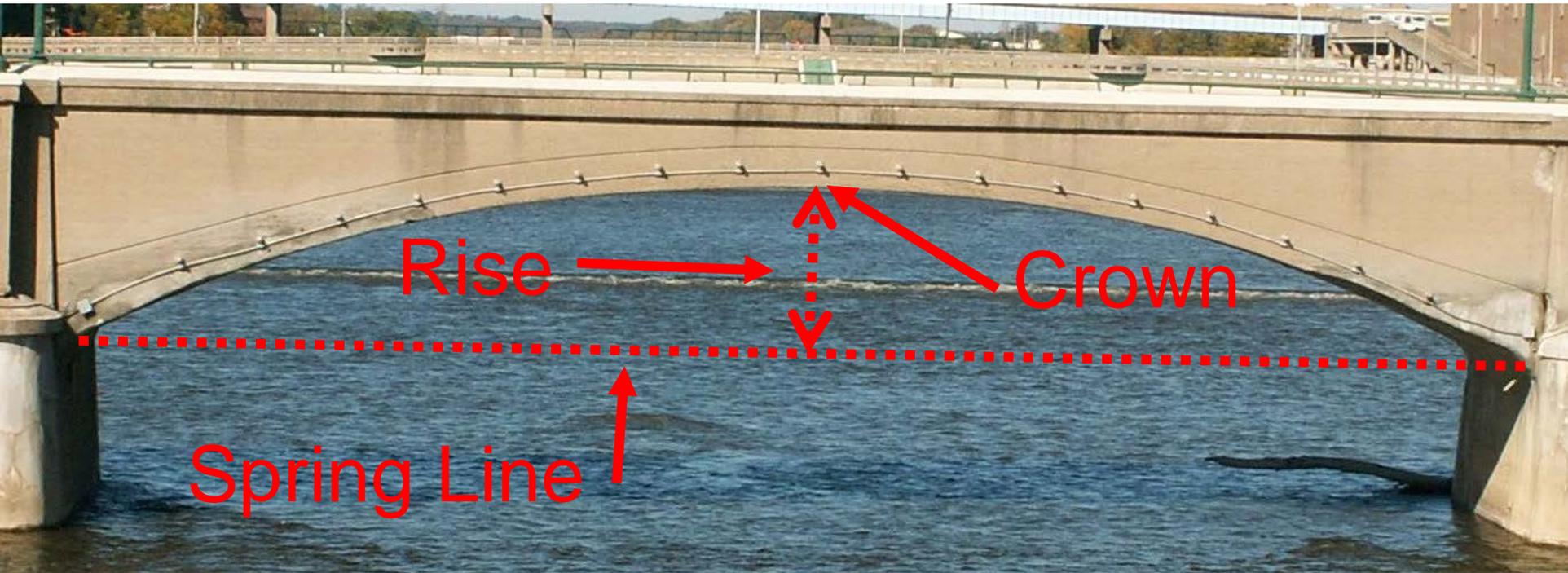


Open Spandrel

Concrete Arch Bridge Parts.

Source: Pennsylvania Department of Transportation

Concrete Arch Spandrels



More Concrete Arch Bridge Terms.

Closed Spandrel Arches



**Earthen Fill
Visible With
Removed
Deck**



Closed spandrel arches may have an earthen fill inside.

Rainbow Arch Bridges



Through concrete arch bridges are often called “Rainbow Arch” bridges, and may also be described as concrete “bowstring arch” bridges. All forms are quite rare.

Rainbow Arches – Marsh



**Exposed
Reinforcing**

Josef Melan was another engineer who developed a solid steel reinforcing for use in concrete arch bridges. In contrast to Marsh arches, Melan arches are generally deck arch bridges and are also rare. A deteriorated example above reveals the steel arch reinforcing within.

Concrete Arch: Stone Facing



Some concrete arch bridges may have a stone facing that was added to them to make them look like stone arch bridges. Popular in parks and other developments completed with Federal relief programs during the Great Depression.

An Introduction To Historic Bridges

Part 10: Stone Arch Bridges

Stone Arch Bridges



Stone arch bridges were generally built in the United States from the 1600s through the 1910s.

Stone Arch Bridges

Segmental



Semicircular



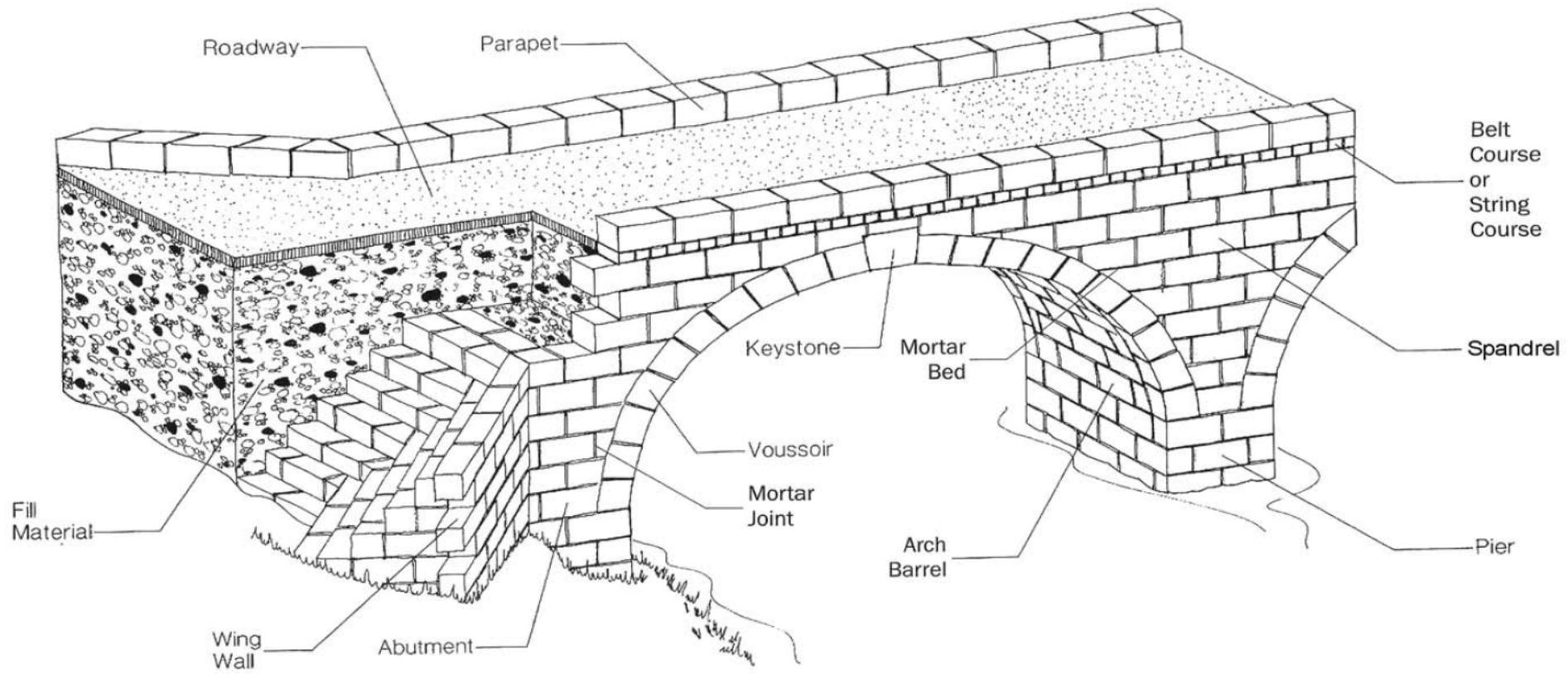
Stone arches usually assume one of two shapes, segmental and semicircular.

Elliptical



A third design, elliptical, is extremely rare to find. It features an oblong shape, like a slightly squashed semicircular arch.

Stone Arch Bridges



Stone Arch Bridge Parts.

Source: Pennsylvania Department of Transportation

Stone Arch Bridges

Spandrel Wall

Parapet (Railing)

Keystone

Voussoir

Barrel



Some parts of a stone arch bridge.

An Introduction To Historic Bridges

Part 11: Metal Arch Bridges

Metal Arch Bridges



Through Arch With Braced Rib

Deck Arch With Solid Rib



Metal arch bridges are generally an uncommon structure type. The main structural element, the arch “rib” may be braced with a truss-like design.

Metal Arch Bridges

Spandrel
 Brace

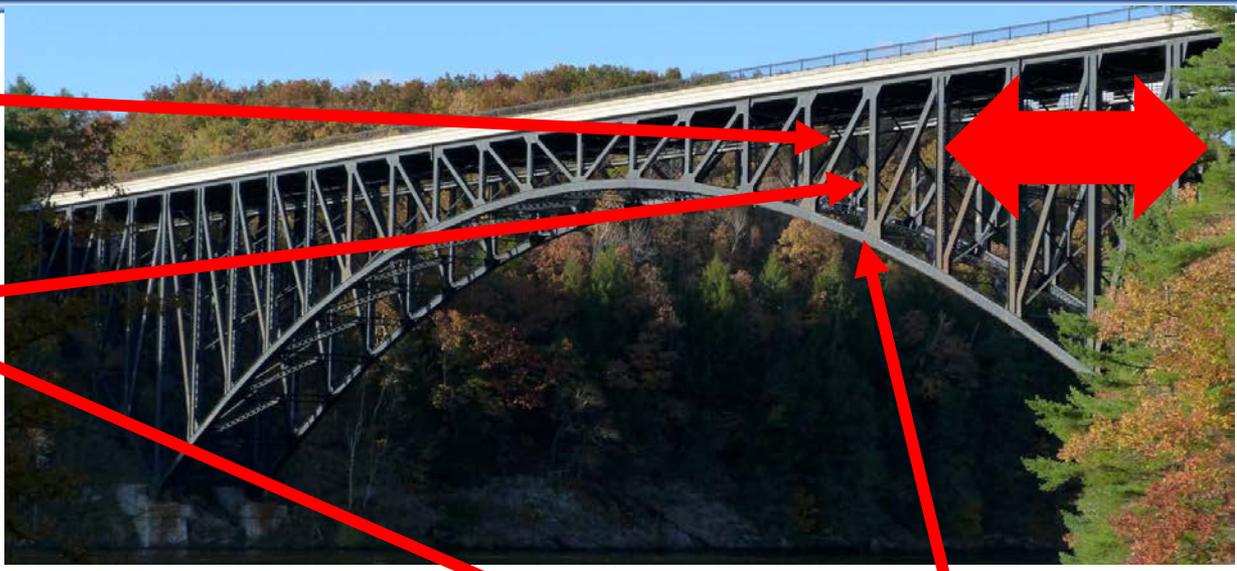
Spandrel
 Column

Spandrel

Skewback

Crown Hinge

Arch Rib (Solid) Hinge



Metal deck arch bridge diagram. Arches may have diagonal “spandrel bracing.”

Metal Arch Bridges



In traditional metal arch bridges, the ends of the bridge will thrust their forces into the piers/abutments at an angle. This angled bearing point at the ends of such arches are called **“skewbacks.”**

Metal Arch Bridges



Metal arch bridges may have any number of hinges, from zero to three. Hinges, identified by the presence of a pin can be found at the crown (center of arch) and/or at the skewbacks.

Example hinges shown above.

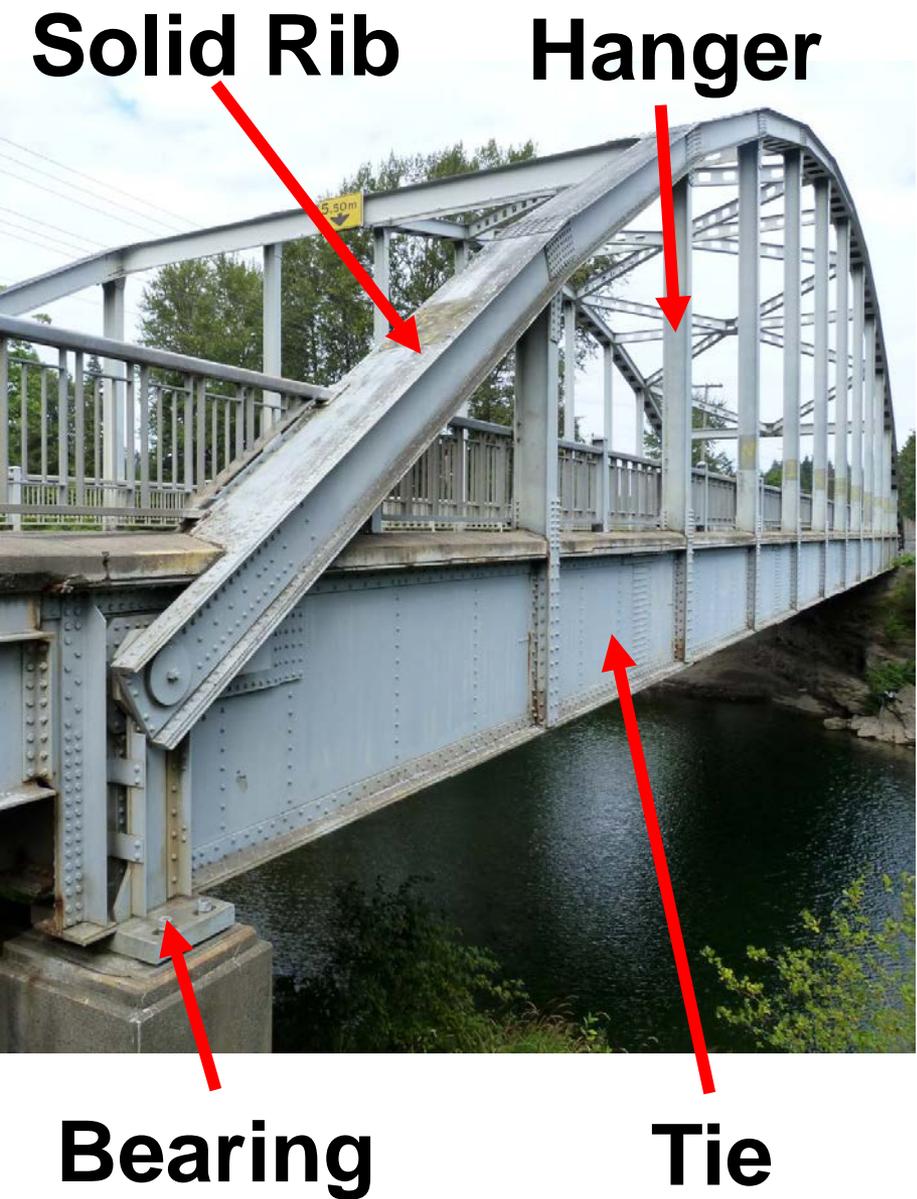
Metal Arch Bridges



In some cases, hinges on arch bridges were only functional during construction and were made rigid after the bridge was completed.

Example hinges shown above.

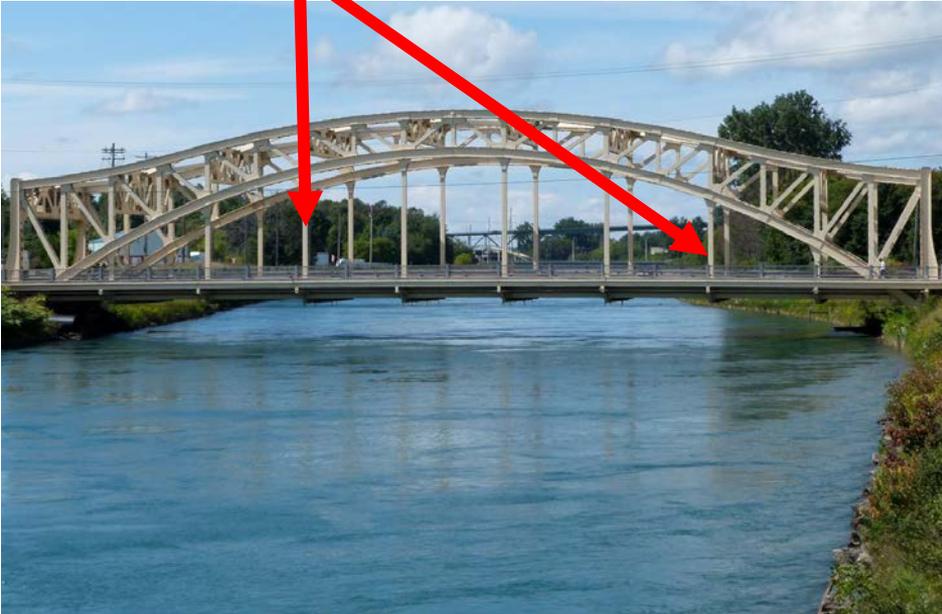
Metal Arch Bridges



Some metal through arch bridges will have a special steel element called a “tie” that is in tension as it connects the ends of the arch and enables an arch bridge to rest directly on top of a pier or abutment, like a truss bridge. Such arch bridges are called “tied arch bridges.”

Metal Arch Bridges

Through Arch Hangers



Deck Arch Columns



In through arch bridges, the deck is suspended from vertical “hangers” which are in tension. In deck arch bridges, the deck rests upon vertical columns, which are in compression.

Metal Arch Bridges



Some steel through arch bridges use cables instead of rigid elements like i-beams for their hangers (suspenders). The West End Bridge in Pittsburgh, PA is a good, and large, example.

An Introduction To Historic Bridges

Part 12: Stringer Bridges

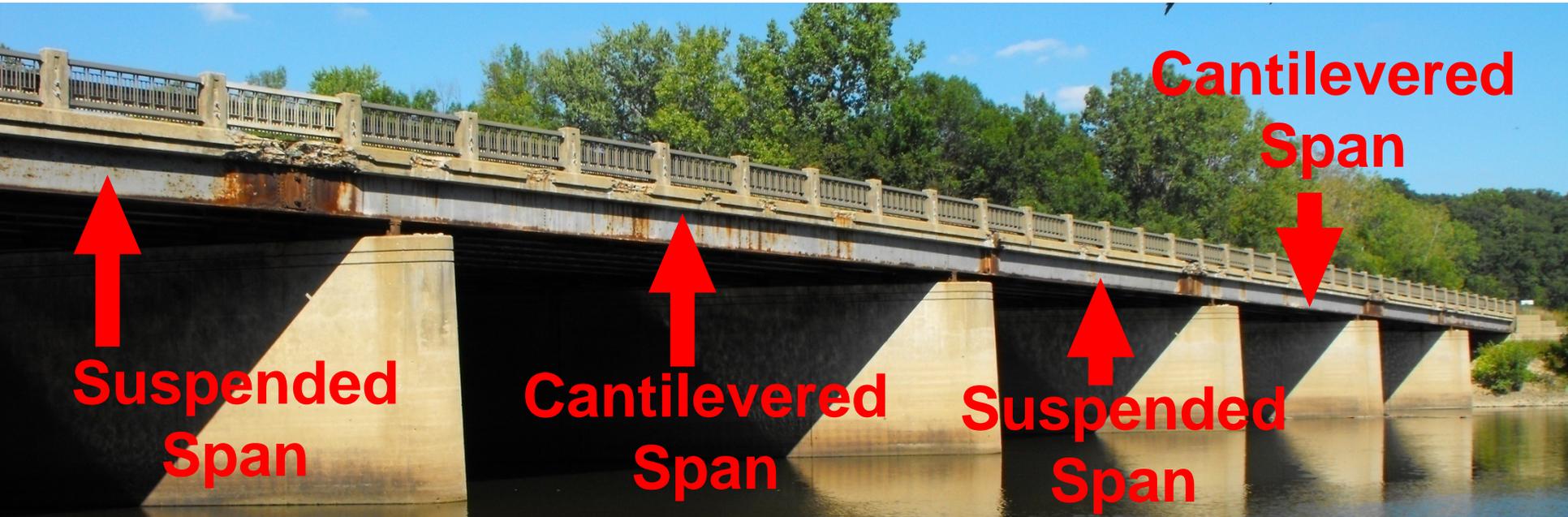
Stringer Bridges: The Basics



Stringer bridges, also called multi-beam bridges, work by using a series of parallel beams to support the deck and load. Diaphragms may be placed between beams to stabilize the beams. They vary widely in size and number of spans, and usually date from 1900 on.

Stringers: Pin And Hanger

Stringer Bridges: Pin And Hanger



In a pin-and-hanger stringer bridge, longer stringers extend beyond the piers slightly to act as cantilevers for a shorter suspended stringer span, which is hung from bars connected to the cantilever spans on either side.
Note: plate girders can also have pin and hangers.

Stringers: Pin And Hanger

Stringer Bridges: Pin And Hanger

The pin-and hanger joints allow the bridge to expand and rotate, and also place the expansion joints away from the piers, reducing moisture and salt deterioration of the pier from expansion joint leakage.



**Deterioration
From Joint
Leakage**

**No Deterioration
Over Or On Pier**

Stringer (Beam) Bridges



Stringer bridges can take on a variety of appearances.

Stringer (Beam) Bridges



Concrete may be used to hide the steel beams, for aesthetic purposes or to protect the beams. Michigan, in particular had a design in late 1920s into the 1930s that covered the outermost beams with concrete.

Stringer (Beam) Bridges

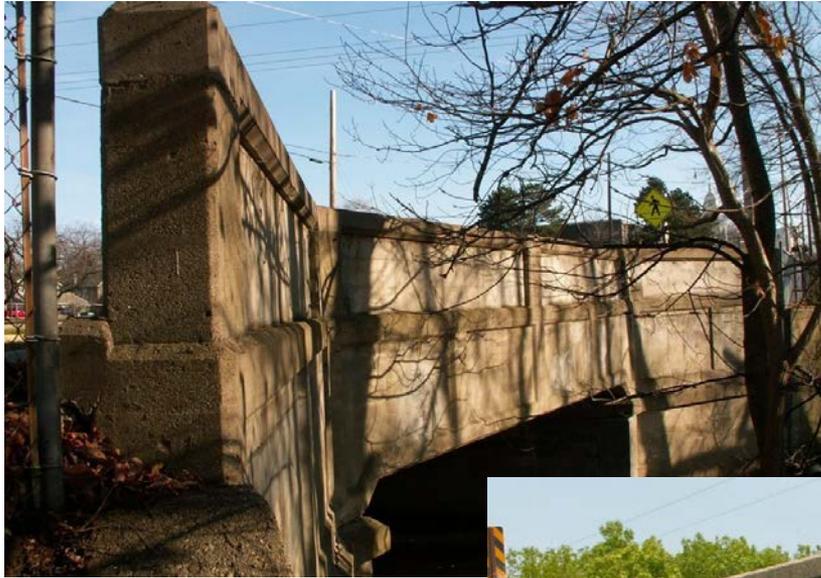


On old bridges, guardrails were more than just functional, they were decorative. They play a major role in making old bridges beautiful, especially on simple bridge types like the stringer.

An Introduction To Historic Bridges

Part 13: T-Beam Bridges

T-Beam Bridges



T-Beam bridges consist of bridges that use concrete beams that are cast uniformly with the deck. They function similarly to stringer bridges.

Sizes



T-Beam bridges tend to be used on small spans, but in some cases can come in large sizes.

Curved T-Beam Overpasses



Michigan built a number of t-beam bridges in the 1950s and early 1960s on its expressways that were noted for their curved beams.

Curved T-Beam Overpasses



Those that retain their original railings remain a rare example of an expressway bridge that has a high degree of beauty. The arches were also designed for the increase in vertical clearance.

Curved T-Beam Overpasses



This is a heavily skewed example. Note the longer spans and thicker beams.

An Introduction To Historic Bridges

Part 14: Suspension Bridges

Suspension Bridges



Suspension bridges are usually very large landmark bridges. John Roebling made major developments in the design of these bridges in the 1800s, and this bridge type was further perfected during the 20th Century.

Suspension Bridges



Tower

Stiffening Truss

Anchorage



Main Cable

Suspender Cables

Suspension bridges feature a main cable that has suspender cables that hold the deck up. The main cable is tied into an anchorage. Stiffening helps to keep the bridge from oscillating (moving) from wind & loads.

Suspension Bridges



A few suspension bridges, such as the Mackinac Bridge, also features a metal deck grating in the center lanes which allows wind to pass through. This was done to further decrease the effects of wind on the structure.

Stiffening Types



Through Plate Girder



Stiffening can vary in terms of structure type. For instance, it might be a through or deck plate girder or a deck, pony or through truss (metal or timber).

Suspension Bridges



A few suspension bridges, such as the “Three Sisters” bridges in Pittsburgh, use eye bars instead of the more common metal wire cables.

An Introduction To Historic Bridges

Part 15: Pre-Stressed Concrete Bridges

Pre-Stressed Concrete Bridges



Pre-stressed concrete is a type of reinforced concrete that can be used to make concrete slab or concrete multi-beam/stringer bridges. Instead of traditional reinforcing rods, wires are placed in the concrete and “tensioned” or tightened to hold the concrete together.

Pre-Stressed Concrete Bridges



A modern material, gaining popularity since the 1950s, only a small number of the oldest pre-stressed concrete bridges are considered to have value as historic bridges.

An Introduction To Historic Bridges

Part 16: Movable Bridge Types

Movable Bridges

Metal Truss



Metal Girder



Bridges may be movable, which means they are designed to open to make way for boats. Movable bridges are defined by the way they move. The actual structure type may vary, including metal truss, girder, and stringer.

Movable Bridges: Swing

Closed



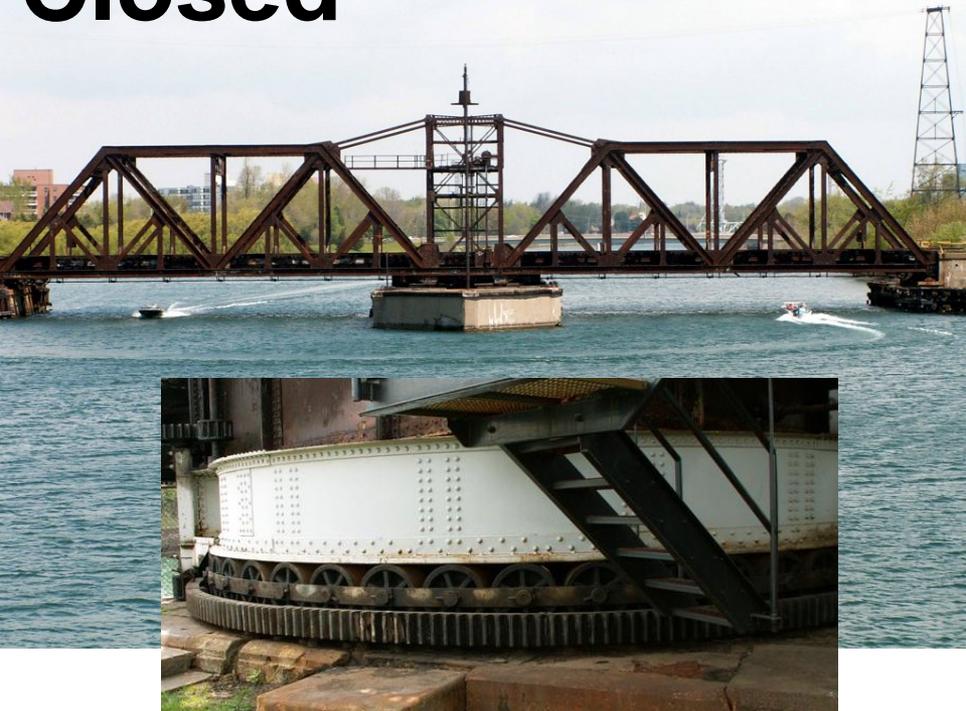
Open



Overview: The swing bridge is the oldest of the common movable bridge designs. In these, the movable span turns on a pier 90 degrees to open a channel for the boats. They fell from favor because their central pier limited the width of the channel.

Movable Bridges: Swing

Closed



Open



Appearance: Look for the central pier. The superstructure appears as two spans, in a continuous format, although with some bridges, they may look more like simple spans in design.

Movable Bridges: Swing

Offshore Pier



Bobtail



Appearance: Some rare bridges may have the center pier of the bridge offshore, which increased channel width. Other rare examples may be shorter at one end which will also have a counterweight, and are known as bobtail swing bridges.

Movable Bridges: Bascule



Overview: Bascule literally means “seesaw.” A bascule bridge operates by rotating up to open the channel. Counterweights provide the balance to make this motion possible. Offering good channel clearance, they are a popular type of movable bridge, and are still built today.

Movable Bridges: Bascule

Single Leaf



Double Leaf



Appearance: Bascule bridges may have one moving section, called a single-leaf bascule bridge, or have two sections, called a double-leaf bascule bridge. With double-leaf bascules, when closed, the bridge generally operates as a continuous structure.

Movable Bridges: Bascule

Trunnion



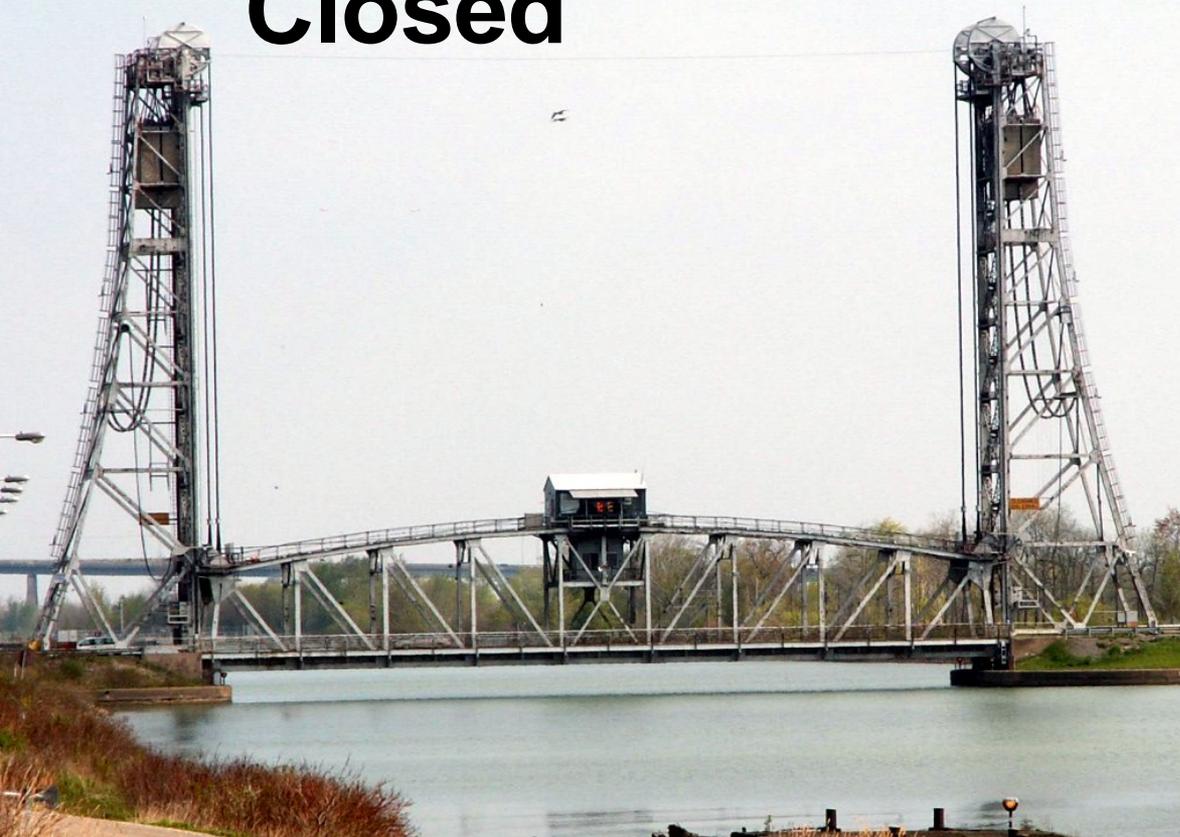
Rolling Lift



Appearance: Bascule bridges operate in different ways. There are two common methods of operation. One is to rotate around a trunnion, or large axel, to raise, called a trunnion bascule bridge. Others roll back on a track, and are called rolling lift bascule bridges.

Movable Bridges: Vertical Lift

Closed



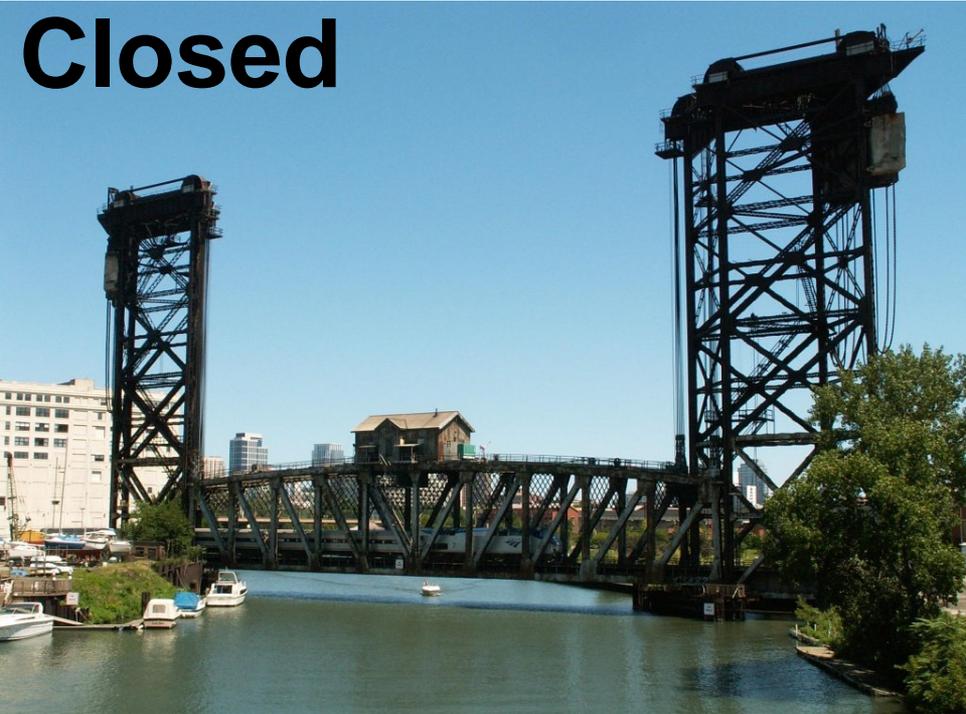
Open



Overview: Vertical lift bridges raise the bridge superstructure directly up, to provide the clearance for boats to pass. They can span the entire channel, but are limited in terms of how tall a boat they can service.

Movable Bridges: Vertical Lift

Closed



Open



Appearance: Vertical lift bridges feature a single span. Usually, towers will be present at each end. The towers will have counterweights and cables in them to raise the span up.

Movable Bridges: Vertical Lift



Appearance: Some rare vertical lift bridges, such as those on the Erie Canal, have no towers and raise on supports that rise out of the ground to provide a limited increase in vertical clearance for boat traffic.

Movable Bridges: Retractable



An extremely rare type of movable bridge, the retractable bridge rolls back away from the navigation channel on rollers.

An Introduction To Historic Bridges

Part 17: Historic Bridges: A Threatened Resource

A Threatened Resource

Historic Bridges At Risk



Historic bridges are a threatened resource. With the exception of wooden covered bridges, only limited protections and funding exists to preserve them.

Historic Bridges At Risk



As historic bridges age, government agencies seek to replace these bridges with mundane modern structures.

Even if more expensive, it is generally easier for agencies to secure funding for replacement rather than rehabilitation.

A Threatened Resource

Historic Bridges At Risk



Historic bridges are currently being demolished at an alarming rate. If legislators are not convinced to expand protection and funding for historic bridges, it may soon be too late to save the best bridges.

A Threatened Resource

Historic Bridges At Risk



Successful preservation projects often depend on heavy local community interest. This is a serious problem since often the oldest and best historic bridges are in rural locations

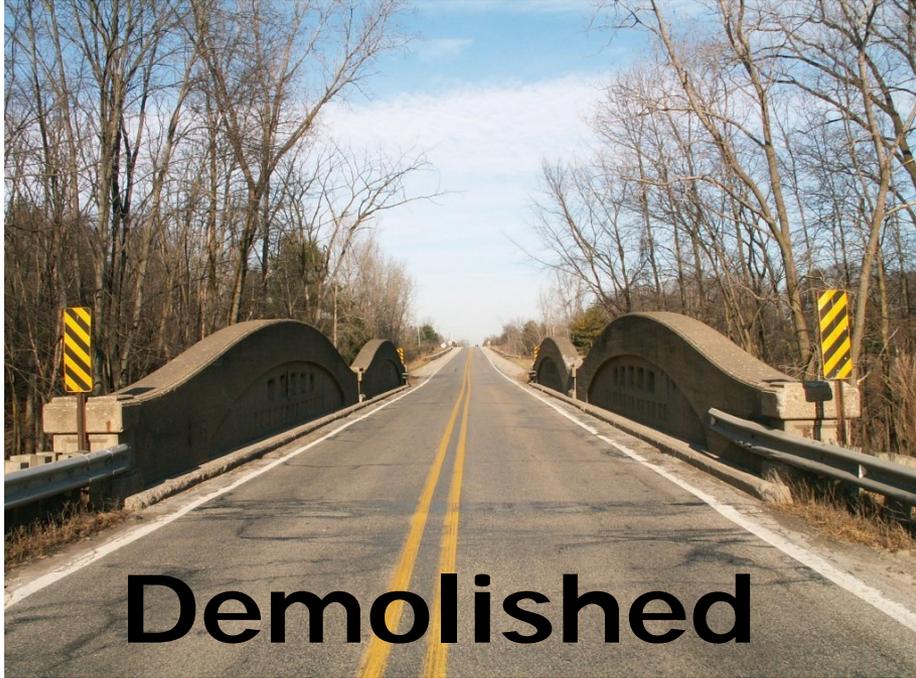
A Threatened Resource

Historic Bridges At Risk



Contacting federal, state, and local legislators and getting others to do the same is a key step than anyone can take to help raise awareness for historic bridges. Historic Bridges of Michigan and Elsewhere's Turning the Tide page can help.

Historic Bridges At Risk



Demolished



Preserved

Local engineers may tell you preserving a bridge is not feasible or possible due to some sort of restrictions. However, successful preservation projects elsewhere often suggest that this is not really the case.

An Introduction To Historic Bridges

Part 18: Conclusions

Wooden Covered Bridges

But What About Wooden Covered Bridges?!



Covered bridges have been sensationalized by the media and by tourism organizations, even if they are not original or historic. Government programs fund covered bridges, while demolishing other types.

HistoricBridges.org seeks to raise awareness of the rest of the fascinating historic bridge world, which has been being demolished for far too long.

Wooden Covered Bridges

Travel agents, published books, government and personal websites, and even organized covered bridge groups all can help you plan a covered bridge tour should you wish to take one.



Currently however, only historic bridge websites like HistoricBridges.org, and similar websites on the Internet offer you the vast, rich world beyond covered bridges.



Visit The Website



HistoricBridges.org is a key to the world of historic bridges. Informative narratives provide you with history, news, and technical facts for each bridge. Maps allow you to plan a historic bridge trip. Thousands of photos are offered, including large-size photos for printing or use as computer wallpaper.

Visit The Website

Enjoy the world of historic bridges. Take a trip, either far away or in your own county and see what it offers!

Be sure to let your lawmakers and government officials know that historic bridge preservation is important to you.



The Historic Bridge World



This presentation has been a sampling of the world of historic bridges. It is a seemingly endless world of variety and exploration, yet at the same time it is a limited world, endangered by the continuing demolition of countless historic bridges.