



Historic Bridge Bulletin

From the Director's Desk

Dear Bridge Enthusiasts,

Our newsletter editor, Nathan Holth, recently had the opportunity to do a bridge tour in England, Wales, and Scotland. This issue of the *Historic Bridge Bulletin* highlights five bridges he visited and provides an opportunity to learn about how the history, design, and maintenance of British bridges differs in comparison to historic bridges in the United States.

Please visit page 11 of the newsletter and learn about Historic Bridge Finder, our historic bridge app. Although the app is a work in progress, there are over 5,000 bridges included with many entries for bridges in Michigan, Pennsylvania, Indiana, Ohio, and the Bay Area of California as well as several major cities including Chicago, Kansas City, and Minneapolis/St. Paul. The Canadian province of Ontario including the city of Toronto is also covered. We appreciate comments and suggestions as we continue to develop a great tool for bridge hunters throughout North America.

Kitty Henderson
Executive Director

In This Issue:

From the Director's Desk

**Royal Albert Bridge: Achieving a 100
Year Service Life**

**Connel Bridge: Scotland's Less
Famous Cantilever Bridge**

**In The Shadow of Castle Conwy:
Three Bridges**

**Introducing the Historic Bridge
Foundation's Bridge App: Historic
Bridge Finder**



The Gauxholme Viaduct in England is an unusual cast iron arch bridge that was completed in 1840. It features a skewed span of 102 feet and had load-bearing girders added in 1906. *Photo by Nathan Holth.*

Royal Albert Bridge

Achieving a 160 Year Service Life

A quick search on Google for “100 Year Bridge Life” returns a number of results from researchers, departments of transportation and other sources as engineers try to find ways to make bridges built today last longer. Yet 159 years ago, famous engineer Isambard Kingdom Brunel designed the Royal Albert Bridge to stand the test of time. His crowning achievement, the bridge is still open to rail traffic today—thanks not only to his design, but also to diligent efforts to maintain the bridge throughout its service life.

The Royal Albert Bridge was surveyed in 1848, with construction started in 1854 and completed in 1859. The bridge has been a Grade 1 listed structure since 1952 and is located in England, crossing the River Tamar between Portsmouth and Saltash. The bridge was constructed using 2,650 tons of wrought iron, 1,200 tons of cast iron, and 459,000 cubic feet of masonry at a cost of £225,000. The bridge consists of a curved series of plate girder approach spans, which lead to two large 455-foot lenticular through truss spans over the River Tamar. The lenticular truss is noteworthy for its top chord, which is a large riveted tube. The lenticular truss spans sit 100 feet above the river. The total length of the bridge is 2,187.5 feet.

The construction of the bridge included the assembly of each 455-foot truss span along the shore



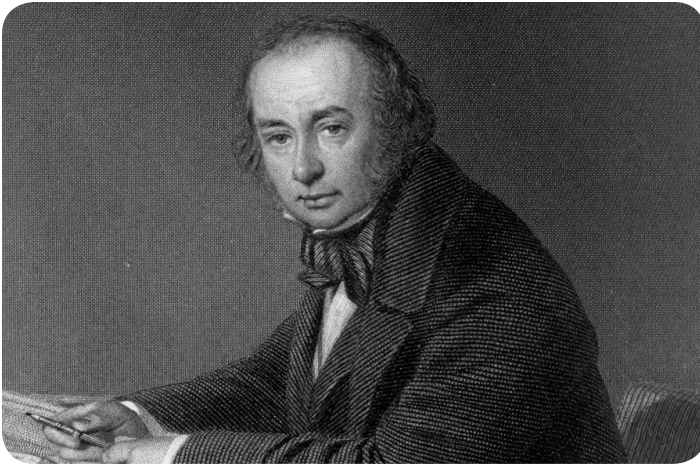
This photo was taken during the construction of the bridge and shows one of the spans floated into position where it was slowly jacked up to the proper height as the piers were completed.

of the river. Once assembled, the truss span was floated into position on the river and jacked up the 100 feet in 3 foot increments as the piers were built up underneath. Note that since each span was jacked up independently of the other, the center pier was erected in two sections, with one half for each span. This off-site assembly and jacking procedure would have been quite an achievement in 1859, especially considering that similar projects today in the 21st century still manage to grab the attention of the news media.

The Royal Albert Bridge is one of the most significant heritage bridges of the 19th century in the UK, due to its use of cast and wrought iron, its span lengths, and its construction methods. It is also



The Royal Albert Bridge as viewed from the Plymouth side of the river. Behind the bridge is the Tamar Bridge, built in 1961 to carry motor vehicles over the river. Photo by Nathan Holth.



Isambard Kingdom Brunel.

considered a crowning achievement of engineer Isambard Kingdom Brunel who died very soon after the bridge was completed. Large letters reading “I.K. BRUNEL ENGINEER 1859” were then added to the bridge in honor of Brunel. Each letter is a little over 3 feet tall. The bridge was originally built with a broad gauge track (about 7 feet), which was converted into a standard gauge (4.8 feet) in 1919. In 1921, a set of stairs and walkways were added to the portals of the bridge for inspection and maintenance purposes, although these walkways covered up the text recognizing Brunel as engineer of the bridge. The walkways were briefly removed in 1959 in celebration of the bridge’s 100th anniversary, but were reinstalled afterwards. In 2006, a project to relocate the stairs and walkways to the interior face of the tube supports was completed, enabling the commemorative sign to be visible permanently.



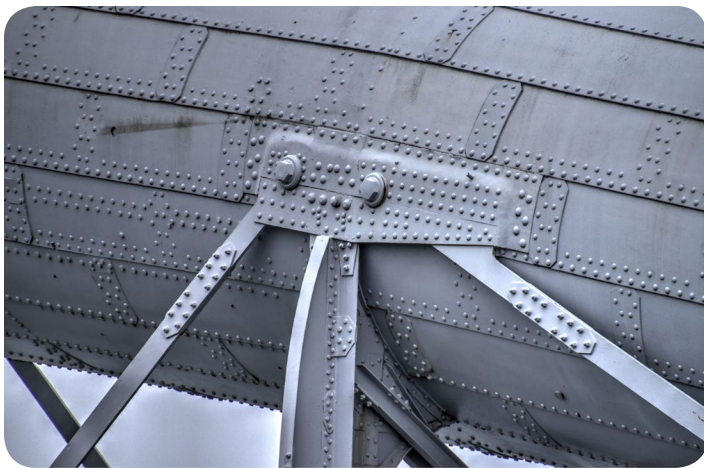
A view of the bridge from the Tamar Bridge walkway. Visible on the portal is the name of the engineer and the year the bridge was built. Photo by Nathan Holth.



This photo shows the floorbeams of the main spans of the bridge. Visible are the original diagonal floorbeams as well as the perpendicular floorbeams added at a later date. Photo by Nathan Holth.

In May 2011, Network Rail, the owner of the bridge, began a major rehabilitation project involving the two main lenticular truss spans. The project was described as the largest project in the bridge’s history and cost £15,000,000. Structural repairs included the use of 112 tons of steel and 50,000 new bolts. While the new bolts undoubtedly replaced many original rivets, this quantity is a minority of the bridge’s total use of rivets so the overall bridge retains its riveted appearance and construction. This project also included full blasting to bare metal and repainting of the bridge. In some areas, a total of 46 layers of paint were blasted off. There were 9,510 gallons of paint used on the bridge. One interesting aspect of the project was the containment required to perform the blasting and painting. For a bridge this large, in a location that can see heavy winds, the effect of the wind pressure against the containment was a concern because high wind events could turn the containment into sails and add significant pressure to the actual bridge. As such, the containment was designed to be retracted in high wind events. Additionally, only one fifth of each span was encapsulated at any one time. The paint color chosen was “goose grey.” The bridge was originally off-white, and was also various shades of brown, white, and red before being painted grey in 1911.

The vertical hangers for the deck required repairs. The original hangers were repaired and retained, but were also made redundant by the addition of a supplemental hanger system.



Detail of the upper chord and its connection to diagonal and vertical members. *Photo by Nathan Holth.*

One unusual feature of the Royal Albert Bridge is the floorbeam system for the bridge. Brunel's original design used diagonal floorbeams so that at any one time a train's wheels would always be bearing on more than one floorbeam at a time. In the early 1900s, additional floorbeams of traditional design that are perpendicular to the trusses were installed. The added perpendicular floorbeams were repaired during the 2011 project and they are strong enough to render the original diagonal floorbeams, which were not removed, redundant.

The intent of this project was to maintain the historically significant design of the bridge, while also strengthening the bridge and adding redundancy to some areas of the bridge. The Royal Albert Bridge continues to play a vital role in railway transportation, with 21,000 trains crossing the bridge in 2006.

AECOM was the consulting engineer for the project and Taziker Industrial Ltd was the prime contractor.



A passenger train crosses the bridge. *Photo by Nathan Holth.*

Connel Bridge

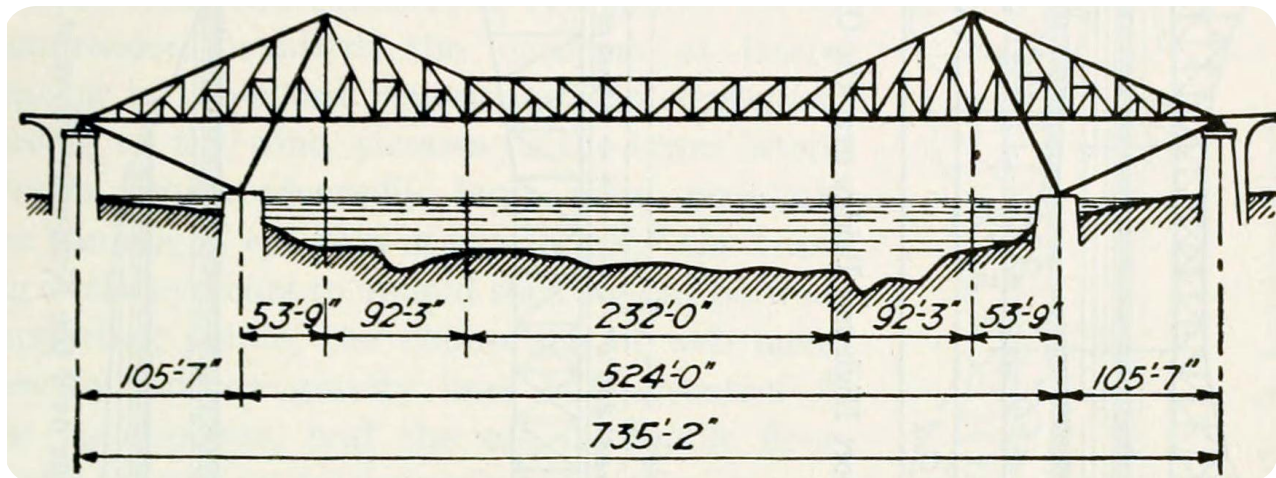
Scotland's Less Famous Cantilever Bridge

Scotland is famous for its Forth Rail Bridge, the record-breaking cantilever truss bridge near Edinburgh completed in 1889. Less famous is a smaller steel cantilever truss bridge located in Connel on the west side of the country. Built in 1903, and with a main span of 524 feet (500 foot clear span) over Loch Etive, the Connel Bridge is both younger and smaller than the Forth Rail Bridge. However, it was the largest cantilever span in Great Britain aside from the Forth Bridge when completed. It is also noteworthy for its unusual design which includes several members positioned in unusual angles and inclines, resulting in a striking appearance that looks ahead of its time and may even call to mind images of modern cable-stayed and steel rigid-frame bridges.

The Connel Bridge has an unusual history of usage. The bridge was originally built as a single-track railway bridge to carry the Callander and Oban Railway. In 1909, a special railway service was added that carried motor vehicles across the bridge, albeit only one car at a time. This unusual arrangement did not last long, however. By 1914, the bridge was reconfigured with a roadway along the western side of the deck and the railway on the east side of the deck. Despite this arrangement, the relatively narrow width of the bridge prevented cars and trains from crossing the bridge at the same time. When a train needed



Elevation view of the Connel Bridge. *Photo by Nathan Holth.*



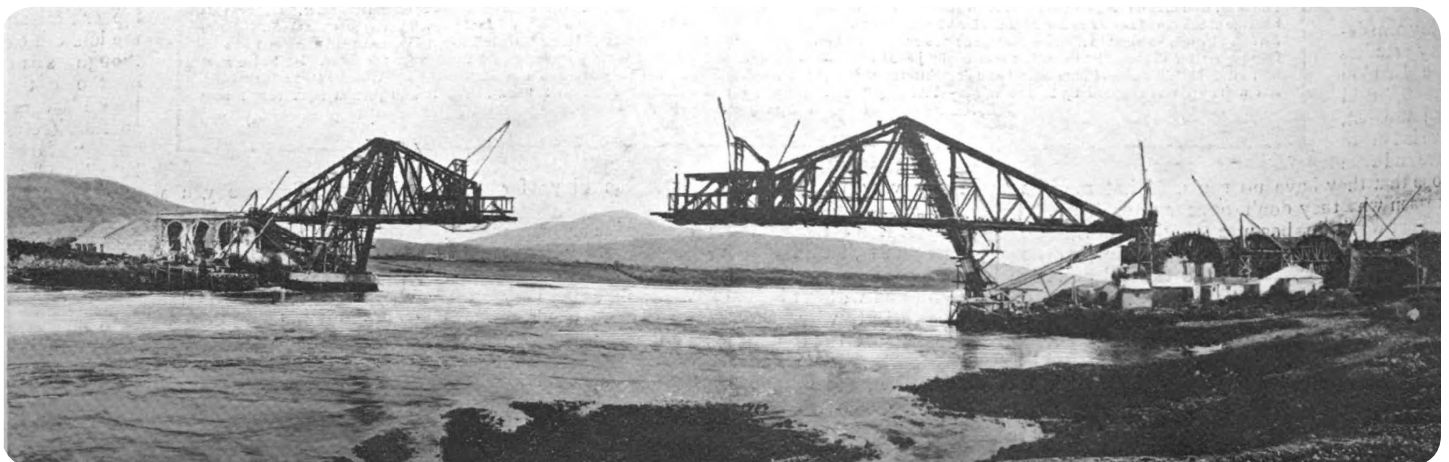
J.A.L. Waddell's famous 1916 book *Bridge Engineering* provided this drawing of the Connel Bridge with principal dimensions of the cantilever truss.

to cross the bridge, the crossing was treated like a grade crossing, with gates to keep cars off the bridge. In 1966, the railway line was closed and bridge was reconfigured as a highway-only bridge, with the rails being removed. Despite the reconfiguration, the bridge was still not wide enough for two-way highway traffic. As such, the bridge operates to this day as a one-lane bridge, with traffic signals controlling the flow of traffic over the bridge.

The Connel Bridge was designed John Wolfe Barry and built by Arrol's Bridge and Roof Company of Glasgow. A number of steel companies supplied the steel on the Connel Bridge as evidenced by the names found on the steel of the bridge. These include David Colville and Sons (Dalzell Steel and Iron Works), Glengarnock Iron and Steel Company, Glasgow Iron and Steel Company, Joseph Cliff and Sons (Frodingham Iron and Steel Company), and Steel Company of Scotland (Hallside Works).

The bridge consists of a three span cantilever truss, including a 232 foot suspended span section within the main 524-foot span. The suspended span is a subdivided Pratt (Baltimore) truss with vertical end posts. The unique cantilever truss is contrasted by three stone arch approach spans of traditional design and appearance at each end of the bridge. The bridge crosses the Falls of Lora, turbulent rapids that are strongly affected by tidal flows. This is one of the reasons a cantilever truss bridge was constructed at this location— it could be erected over the waterway without the use of falsework in the fast-flowing rapids. The entire center span of the truss (cantilever arms and suspended span) was erected using the cantilever method: building out into the waterway from the piers.

The distinctive design of the cantilever truss is due to the configuration of the trusses over the piers. Typically, cantilever trusses have a vertical post,



This historical photo shows the construction of the Connel Bridge. Note how the cantilever bridge design allowed for construction over the waterway without the use of temporary falsework in the waterway.



A builder plaque and numerous mill marks on the steel of the bridge indicate that Arrol's Bridge & Roof Company used steel from a variety of companies on the Connel Bridge. Photos by Nathan Holth.

sometimes called the “main post,” located directly over the pier that is also at the deepest section of the truss web. For the Connel Bridge, these posts are instead inclined, not only inward toward the center of the span, but also inward toward the center of the roadway. As such, the inclined main posts extend out beyond the truss lines to the pier below, giving the



A view of the Connel Bridge from the approaching roadway. Photo by Nathan Holth.

bridge a bowed out appearance when viewed from certain angles. The inclined posts also mean that the deepest “tower” section of the truss is located not over the pier, but partway into the central span of the truss. The inclined main post is countered by what engineering periodicals described as a “back strut” extending from the bearing on the piers back to the abutment at the roadway level. The back struts angle out to meet the main post locations outside of the truss lines, adding to the bowed out appearance of the bridge. The end post of the truss, also inclined, extends all the way to the main post of the truss, meaning there is no upper chord for this entire length, an unusual design that gives the bridge a striking appearance when approached on the road. If the end post, the main post, and the back strut at each end of the bridge are looked at as a single shape, the bridge has the appearance of two giant triangles resting on their apex at the piers. Another unusual detail of the truss is found at the deck level, where a beam that may look like a lower chord of the truss to casual viewers also angles out to meet the inclined main post at the roadway level, and was described as an “outer boom” in engineering periodicals.

The Connel Bridge remains today a functional and important crossing as few bridges cross Loch Etive and River Erive. The traffic signals that control traffic ensure the one-lane bridge can be crossed safely. The bridge is a popular local destination for tourists because not only is the bridge itself an attraction, it provides a viewing point for the Falls of Lora. Unlike the more famous Forth Rail Bridge, the Connel Bridge has a sidewalk and is open to pedestrians. Despite

the long history of the Connel Bridge, the historical and structural integrity has been maintained, and there are very few if any alterations to the original truss materials and design. The reconfiguration of the roadway is the only notable change over the service life of the bridge. As such, this bridge remains an outstanding and important part of Scottish transportation heritage.



This view taken from a lookout on the Connel Bridge shows how several of the bridge members angle out to accomodate a bearing point that is outside of the truss lines. *Photo by Nathan Holth.*

In the Shadow of Castle Conwy: Three Bridges

The town of Conwy, Wales, is a historic walled city that includes a famous castle completed in 1287. And Castle Conwy, a UNESCO World Heritage Site, sits next to three impressive bridges. Although each bridge crosses the River Conwy at the same general location, and all are parallel to each other, the design of each bridge is quite different. As such, this is a unique location to experience historic bridges, with the beautiful castle adding to the ambience of the location, as well as providing unique viewing angles of the bridges. These three bridges are the Conwy Railway Bridge, the Conwy Suspension Bridge, and the Conwy Road Bridge.

The Conwy Suspension Bridge was completed between 1822 and 1826 and was designed by famous engineer Thomas Telford. As old as this bridge is, the castle it leads to is even older, with the castle already a historic landmark at the time of the bridge's construction. Telford designed the suspension bridge to harmonize with the castle, and the bridge's towers and bridge keeper's lodge have architecture matching that of the castle. The bridge spans 326 feet and is an eyebar chain suspension bridge. The Conwy Suspension Bridge originally had a wooden deck that was replaced with an iron deck in 1896. This bridge is noteworthy for its surviving original eyebar chains,



Eyebar chains now pass through Castle Conwy as the suspension bridge anchorages were constructed within the castle walls. *Photo by Nathan Holth.*



Top: From left to right, the road bridge, the suspension bridge, and the railway bridge as viewed from the castle. Center: Elevation of the railway bridge showing the piers that were added to the bridge. Bottom: A view on the suspension bridge facing Castle Conwy. *Photos by Nathan Holth.*



The toll-keeper's house of the Conwy Suspension Bridge.

Photo by Nathan Holth.

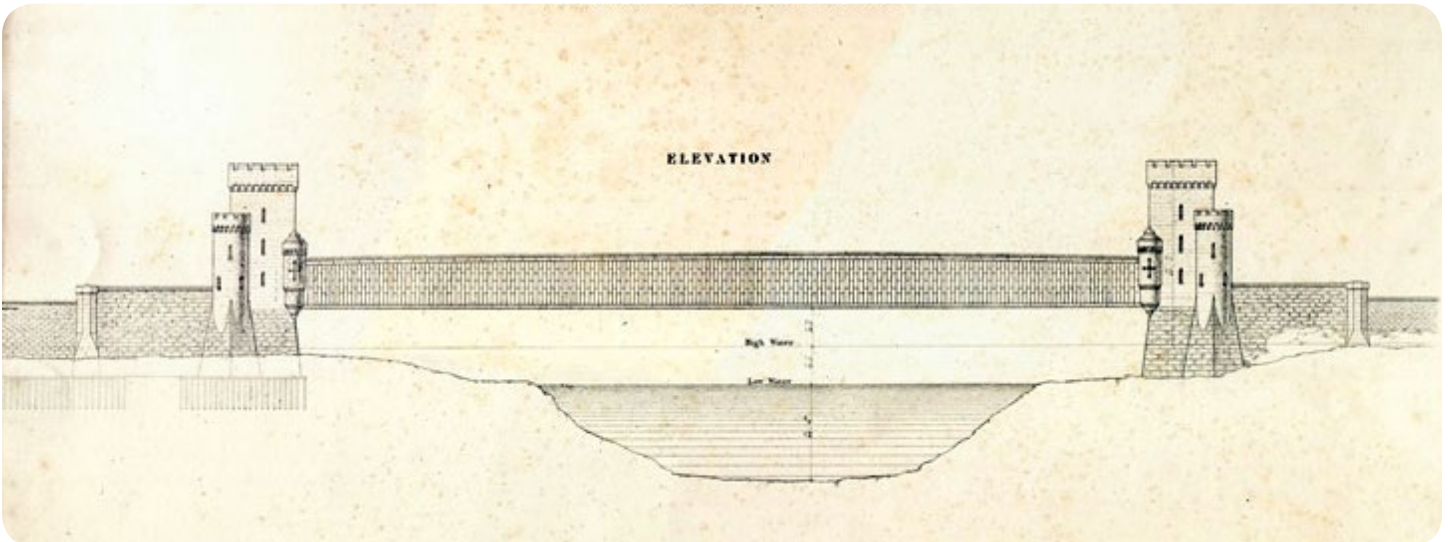
composed of four bundles of chains on each side of the bridge. Each bundle contains five eyebars. In 1903, wire cables were added above the original eyobar chains to strengthen the bridge. The design of the bridge is noted for its western anchorage, with the eyebars passing right through the walls of the castle where they are anchored inside. When the Conwy Road Bridge was completed, vehicular traffic began using that bridge, leaving the suspension bridge as a pedestrian-only crossing. The National Trust today operates it as a tourist attraction. The bridge is one of the oldest bridges of its kind surviving today, and unlike Telford's larger Menai Straits Bridge, the Conwy Suspension Bridge retains its original eyobar chains.

South of the suspension bridge is the Conwy Railway Bridge, a riveted tubular girder bridge, whose



A view beside the Conwy Railway Bridge. Note the additional vertical stiffeners added to the girder when the piers were added. *Photo by Nathan Holth.*

design is essentially a riveted metal box that spans the waterway. Traffic crosses by traveling inside the box. Robert Stephenson was the engineer for this bridge, although he worked with another engineer, William Fairbairn, who developed the idea for a riveted tube girder. The bridge was completed in 1850. In 1899, the main span was decreased by 90 feet by adding two piers. Additional ribs were riveted to the girders in the areas of the piers as well using steel supplied by the Stockton Malleable Iron Company. The purpose of this alteration was to strengthen the bridge. The tubular girder design was later used in the Britannia Bridge over the Menai Strait, as well as the very long Victoria Bridge in Montreal, Canada. The Conwy Bridge, the first of its kind, is now the only surviving example of the tubular girder design as the other two



This historical engineering drawing shows the Conwy Railway Bridge as originally designed and constructed, as a single-span bridge with no piers.



Detail of the added stiffeners on the Conwy Railway Bridge where the newer 1899 steel displays “STOCKTON MIC” referring to Stockton Malleable Iron Company .
Photo by Nathan Holth.

bridges have been replaced. When it was built, the Conwy Railway Bridge received attention from the engineering community since it was an early bridge constructed from wrought iron, sometimes called more generally “malleable iron” in period texts.

Like the suspension bridge, the Conwy Railway Bridge features abutments and towers to match the architecture of the castle. The bridge continues to carry trains over the River Conwy, a testament to the quality of the construction and its careful maintenance over the years.

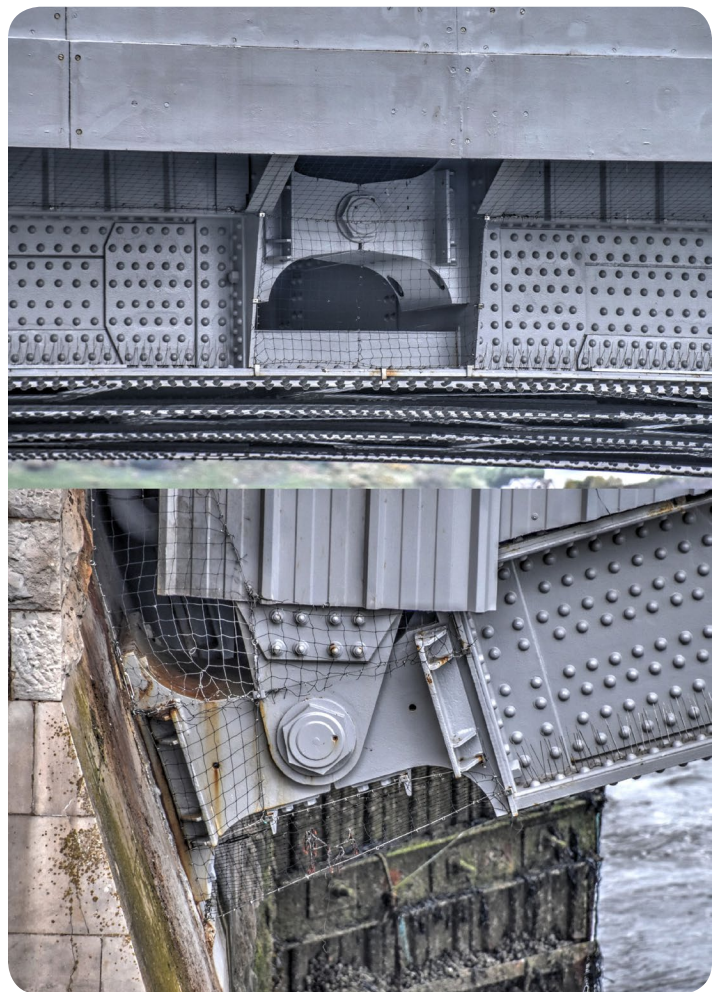
North of the suspension bridge, the Conwy Road Bridge was built in 1958 as a replacement for the suspension bridge. The engineer for this bridge was Herbert Walter Fitzsimons. The contractor for the bridge was Sir William Arrol and Company, which was the builder of the famous Forth Railway Bridge and



A view beside the Conwy Road Bridge. *Photo by Nathan Holth.*

many other famous bridges in the UK. The bridge is a three hinged steel deck arch bridge. The spandrel wall is covered with a decorative facing that matches the visual style of the Conwy Railway Bridge. The actual arch structure is of riveted construction. As with the other two bridges, the abutments and approaches are of stone design to better harmonize with the castle. The Conwy Road Bridge has since been supplemented by a tunnel under the river that was completed in 1991 and carries the A55 around Conwy.

These three bridges at Conwy represent a unique trio of bridges, and are an integral part of the experience of touring Castle Conwy, since many lookouts in the castle offer spectacular views of these bridges. Two of the bridges, the Conwy Railway Bridge and the Conwy Suspension Bridge, are Grade 1 listed structures, an indication that they are among the most significant of the United Kingdom’s historic bridges.



The crown hinge and one of the skewback (abutment) hinges of the Conwy Road Bridge. *Photos by Nathan Holth.*

Introducing the Historic Bridge Foundation's Bridge App: Historic Bridge Finder

The Historic Bridge Foundation is proud to present our Historic Bridge Finder app, which allows you to locate, learn about, and visit historic bridges near your location. With this app it is easy to discover bridges near where you live or when you travel.

The app allows you to find bridges several ways. You can quickly display a map of all bridges near your current location using your phone's location services. Additionally, you can browse the map on your own to locate bridges, or search for bridges in a location you choose. Lastly, a search tool to filter results on the map is also available. Mark your favorite bridges and the app will keep a list of them for you.

This app is powered by a database that is a work in progress, so if you do not see any bridges for your location, please check back in the future. The app's database is being expanded as time and funding allows. Your donations to the Historic Bridge Foundation can assist in the further expansion of this database.

The smartphone app is available for both Android and iOS (iPhone) devices. You may find it in the app stores by searching for Historic Bridge Finder, or use the buttons below. If you have trouble installing or using the app, please ensure that your phone is fully updated to the latest operating system and software.

