The modern era of bridge technology in this country was ushered in about 1800 when the truss was applied to longer-span bridges. Until that time, bridge technology was limited to stone arches or timber beam structures. The truss is a triangular structure where all members take either tension or compression and loads generally come through the vertical members and are transmitted by the diagonal members into the horizontal members and back to the bearings. While the truss was known since at least the third century B.C., what was innovative at the beginning of the 19th century was that the basic truss pattern was multiplied many times over to span much greater distances than those possible with timber beam or king or queen-post truss bridges of the 18th century.

Truss types and designs vary according to the configuration of the members. There are three truss types. In the thru truss bridge the road passes between the truss lines and is carried on the deck and floor system connected to the bottom chords at the panel points. There is lateral bracing connecting the top chords of the trusses. This type is generally used for spans more than 100’ long. A pony truss bridge is the same as a thru truss, but it does not have lateral bracing between the top chords. This type is generally used for shorter spans 45’ to 100’ long. In a deck truss bridge the road is above the trusses, and the deck system is on the top chords. There are a variety of truss designs, and all have different ways of accommodating the tensile and compressive forces. They are frequently named for the engineer that patented the design such as the Pratt truss patented by Thomas C. Pratt.

Metal truss bridges began appearing on Delaware highways in numbers after 1875, and reached their peak between 1890 and 1910.
in 1844 or the Warren truss patented by James Warren in 1848.

Wood Truss Bridges

During the late-18th century the need for bridges of sufficient length for long waterway crossings stimulated the burgeoning of bridge engineering. By 1800 master carpenters/architects were applying truss and arch principles to span greater lengths, and many of the early, impressive wood truss bridges were built nearby over the Schuylkill and Delaware rivers in Pennsylvania and New Jersey. Nationally important bridges included Timothy Palmer's 1806 arch-truss bridge over the Schuylkill River at Philadelphia and Theodore Burr's 1804-05 arch-truss over the Delaware River at Trenton. The first documented covered arch-truss bridge in Delaware was the Market Street bridge over the Brandywine Creek at Wilmington, built in 1822.
A significant innovation in the application of truss technology to bridge design was American architect Ithiel Town’s lattice truss design. Patented in 1820, the truss was constructed of a closely spaced array of intersecting diagonal members forming a web between the parallel chords. It was easy to fabricate and erect, and the simple design could be repeated for any desired length. The Town lattice truss was immensely popular and was used for highway as well as railroad bridges. Delaware’s two surviving historic wood truss bridges at Ashland (State Bridge NC-118) and Wooddale (State Bridge NC-137) are Town lattice trusses. Both were built during the mid-19th century, and both were rebuilt in the late-20th century.

In Delaware, the wood truss bridge was most popular in New Castle County where at least 125 wood truss bridges are known to have existed during the 19th century. Only 67

Vanished wood truss bridges. The Yorklyn bridge over Red Clay Creek (above), a Town lattice truss covered bridge built in 1863 and removed ca. 1929, and an uncovered lattice wood thru truss bridge near Wooddale over Red Clay Creek, (left) built ca. 1860, are examples of the dozens of wood truss bridges known to have existed in Delaware. They were most numerous in northern New Castle County.
35 wood truss bridges remained in the county by 1900, and only two remained by 1965. As significant as were their contributions to the history of bridge technology in Delaware, wood truss bridges were not without inherent weaknesses that eventually made them defunct as bridge builders developed stronger metal bridge types. They were also susceptible to fire, from both locomotives and carelessness, insect damage, and moisture-related deterioration.

Metal Truss Bridges

The most influential factor in the disappearance of wood truss bridges was the development and acceptance of metal truss bridges. Wood works well in compression, but it cannot accommodate tensile forces efficiently, especially at the connections. This limitation was resolved by William Howe (1803-1852) who, in 1840, patented a truss bridge design that used wrought iron rods for the tension members (verticals) and wood for the bulkier compression members and chords. His design with iron tension rods heralded the beginning of the switch from wood to metal truss bridge technology.

Cast iron, due to its brittleness, was used only for compression members. Wrought iron possesses good tensile qualities, and William Howe, Thomas Pratt, Squire Whipple, and others patented historically and technologically important truss designs utilizing these qualities. Their truss designs

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TOWN LATTICE TRUSS.

Ithiel Town of New Haven, Connecticut, submitted this drawing with his patent application for a lattice truss bridge in 1820.
ushered in an era of unprecedented advancement in metal bridge technology that was both a product of and a response to industrial advancement in this country.

It was the railroads and their need for long spans capable of carrying ever-increasing live loads that stimulated the great era of metal truss bridges after the Civil War. The era also swept in new scientific methods for analyzing and predicting the structural action of bridges. After the war, advances in engineering education accompanied new standards and understanding of materials, workmanship, and construction. A generation of college-educated civil engineers applied scientific theory and experimentation to bridge construction and energetically sought out the cooperation of manufacturers and builders. They established the modern approach to bridge building that includes stress analysis, plans, specifications, testing, and inspection.

Nationally and in Delaware, the application of metal truss bridges to highway use was generally not as early, quick, or crucial as with the railroads. Metal truss bridges began appearing on Delaware highways in numbers after 1875, and reached their peak between 1890 and 1910. Photo archives at the Delaware Department of Transportation document at least ninety metal truss highway bridges in New Castle County prior to 1930. Similar archival photos have not survived for Kent and Sussex counties. It is known that the lower counties had metal truss bridges but in far fewer numbers than New Castle County because of their less developed, rural character.

Over 500 bridge fabricating companies...
Construction Company of Wilmington, and the Edge Moor Bridge Company, located north of Wilmington, are the only two known Delaware-based metal truss bridge companies active in the late-19th century. Operated in the United States from 1840 to 1900. They varied from large fabrication and erection companies, often owned by large iron and steel manufacturers, marketing their bridges all across the country, to small independent contractors operating within a limited geographic region. The Delaware Construction Company of Wilmington, and the Edge Moor Bridge Company, located north of Wilmington, are the only two known Delaware-based metal truss bridge companies active in the late-19th century. The Edge Moor Bridge Company is the fabricator of Delaware's oldest surviving truss bridge.
highway bridges, three nearly identical Warren pony truss bridges dating from the mid 1880s to 1890s (State Bridges NC-66, NC-179A, and NC-424).

The two most common truss designs built in Delaware, and all across the country, were the Pratt and the Warren. Both designs offered simplicity of design and fabrication, made economical by the use of standard rolled angle and channel sections, plates, bars, rods, and I beams. Standardization of truss design was driven by economy and the trend of engineering science toward greater uniformity and better metallurgy. A significant factor in standardization was the availability of economical steel from about 1890 onward. Steel performs well in both tension and compression, but it generally has a higher tensile strength than wrought iron and was thus a superior material for metal bridges.

The Pratt truss design was patented in 1844 by Thomas and Caleb Pratt. The original design was for a composite timber and iron truss, with the wrought-iron diagonals...
Located on the banks of the Delaware River north of Wilmington, the Edge Moor Iron Company was incorporated in 1869 as an iron works and rolling mill for the manufacture of iron rails, rods and bar stock, rolled sections and I beams. Under the direction of President William Sellers, the company evolved into a major manufacturer of iron and steel for bridges, viaducts and roofs. Sellers, the son of an Upper Darby, Pennsylvania, flour miller, was a significant figure in American industrial history. In 1853, he and his brother John organized the Sellers Machine Company of Philadelphia, one of the first factories in the United States to manufacture lathes, planers, and machine tools of many kinds, in large numbers, for other machine shops. Sellers was granted over 90 patents for various inventions related to the manufacture of machinery for industrial uses. He was also a president of the Franklin Institute.

In 1873, Sellers incorporated the Edge Moor Bridge Company as an offshoot of the Edge Moor Iron Company. The company built several large river crossing bridges for major railroads and also supplied most of the structural iron for the Brooklyn Bridge. From 1873 to 1900, the Edge Moor Bridge Company was considered one of the most complete and up-to-date shops in the nation, equipped with Sellers Machine Company rolling mills and machine tools. By 1900,
the company employed approximately 550 workers, most of whom lived in the company town of Edgemoor.

In 1900, the Edge Moor Bridge Company was acquired by the American Bridge Company, a monopoly formed by J. P. Morgan & Company. Edge Moor was one of 24 bridge companies folded into the new corporation, which was intended to dominate the metal bridge fabrication industry. William H. Conuel, who succeeded Sellers as president of Edge Moor, was the first treasurer of the American Bridge Company. In 1901, American Bridge was itself acquired by U.S. Steel Corporation. American Bridge continued to operate the Edge Moor works until 1921, when the plant was closed. Its operations were consolidated at more up-to-date facilities at Trenton, New Jersey, and Ambridge, Pennsylvania. The Edge Moor Iron Company continued as a separate organization concentrating on the production of steam boilers until its liquidation in 1933. The last of its bridge and iron works structures and buildings were demolished in the 1970s.

Most metal truss bridges built before 1895, from light Pratt pony trusses to heavier thru truss railroad spans, were assembled in the field (at the site) with pinned connections. Better knowledge of the strength of materials and metallurgy in the 1880s combined with the improvement of field pneumatic riveting equipment by 1899 leading to the transition from pinned to riveted connections. This resulted in a rapid shift from the Pratt to increased use of the Warren truss design by 1905. Patented in 1848 by British engineers James Warren and Willoughby Monzani, the straightforward truss is particularly well suited for rigid connections. It is distinguished by its simplicity of design, ease of construction with equal-sized members, and ability of some of the diagonals to act in both tension and compression. Capacity could be increased by adding a second set of diagonals (double intersection Warren), and it could be stiffened by the addition of verticals.

Despite the large number of metal truss bridges that once existed in Delaware, today only six remain in service on public
The Locations of Delaware's Historic Truss Bridges

1. Brackenville Road over Red Clay Creek
   State Bridge NC-118
   Ashland, New Castle County

2. Wooddale Drive over Red Clay Creek
   State Bridge NC-137
   Mt. Cuba, New Castle County

3. Wiggins Mill Road over Wiggins Mill Pond*
   State Bridge NC-424
   Townsend, New Castle County

4. Breck Lane over Pancake Run
   State Bridge NC-66
   Wilmington, New Castle County

5. Rising Sun Lane over Brandywine Creek
   State Bridge NC-1 A&B
   Wilmington, New Castle County

6. Evanson Road over Mill Creek
   State Bridge NC-179A
   Hockessin, New Castle County

7. Chambers Rock Rd. over White Clay Creek
   State Bridge NC-216
   Thompson, New Castle County

8. Yorklyn Road over Red Clay Creek
   State Bridge NC-112
   Yorklyn, New Castle County

roads. Five are riveted Warren pony trusses dated from 1884 to 1929, and the sixth is a riveted Pratt thru truss from 1928. Several additional metal truss bridges survive, including two pin-connected Pratt trusses, but they are located on private properties.

The metal truss bridge type’s decline, like its own rise in prominence, was based on technological advances of other bridge types, particularly steel multi girder and reinforced concrete spans. Those technologies, introduced in numbers during the first decades of the 20th century, proved to be more economical and required less maintenance than metal truss bridges, and both technologies were favored by the new Delaware State Highway Department as it began developing the state highway system starting in 1916. Additionally, metal truss bridges were the subject of a concentrated bridge replacement program from the 1930s through the 1960s. As a result, most metal truss bridges were removed and replaced by wider spans.

Brackenville Road over Red Clay Creek

State Bridge NC-118
Ashland Covered Bridge
Ashland, New Castle County
Designer/Builder: Unknown
ca. 1850

The Ashland Covered Bridge is a Town lattice truss, composed of oak planks connected together in a lattice pattern with tapered wood dowels known as trunnels. The bridge measures 52’ long, 14’-6” wide, and carries a single lane of traffic. The truss bridge has plank siding, painted red, and is covered by a timber frame roof with cedar-shake shingles. The portals are accented by pilasters with flared capitals. The truss bridge is supported on rubble stone abut-
ments. The flared stone wingwalls have stone parapets with concrete coping.

The date of construction and builder of the Ashland Covered Bridge are undocumented in state and county records. Most likely, the bridge dates to about 1850, but could have been built as early as 1840, or as late as 1880. Ithiel Town of New Haven, Connecticut, patented the lattice truss design in 1820, but it was not until about 1840 that the truss design gained popularity as a common type of highway and railroad bridge, built from New England to Virginia, and as far west as Ohio. The Town

Built in the mid-19th century, the Ashland Covered Bridge (above) is one of only two covered bridges surviving in Delaware.

LEFT: Interior view.
lattice truss, easily erected by local craftsmen, remained popular in some rural localities until the 1880s, and only fell from popularity after the widespread introduction of prefabricated metal truss bridges.

The Ashland Covered Bridge was listed in the National Register of Historic Places in 1973 as one of only two remaining wood truss covered bridges in Delaware. DelDOT strengthened the structure in 1982. During rehabilitation, the truss bridge was lifted from place, while a new steel multi girder system was installed on the stone abutments. When the wood truss bridge was set back in place, its timber floorbeams were removed, and the truss lines, which had become racked, were realigned with the lower chords bolted to the fascia of the steel beams. The steel multi girder system supports the deck relieving the trusses of live loads.

**Wooddale Drive (Road 263A) over Red Clay Creek**

State Bridge NC-137  
Wooddale Covered Bridge  
Mt. Cuba, New Castle County  
Designer/Builder: Unknown  
ca. 1850

The Wooddale Covered Bridge is a Town lattice truss bridge measuring approximately 53’ long, 16’-wide, and carrying a single lane of traffic. The bridge is one of only two covered bridges surviving in Delaware, and is nearly identical to the Ashland Covered Bridge (State Bridge NC-112). The Wooddale Covered Bridge is composed of oak planks forming a lattice pattern joined by wood dowels called trunnels. The truss bridge has wood plank siding, painted red, and a cedar shake shingle covered roof. The covering protects the truss from the weather. The portals are accented by pilasters with flared capitals. The bridge is supported on stone abutments. Wingwalls have stone parapets with granite capstones.

The builder and date of construction of the Wooddale Covered Bridge are undocumented. The bridge dates in style to ca. 1850, and may have been built to provide improved access to the Delaware Iron Works, a slitting and rolling mill that occupied the
adjacent property on the northwest bank of Red Clay Creek from about 1814 to 1891. The earliest documentation for the bridge in State Highway Department records is a drawing dated 1939, apparently made to record the bridge shortly after the July 1938 flood had washed out another Town lattice truss, which carried Road 261 over Red Clay Creek upstream of the Wooddale Covered Bridge.

In 1969, the bridge was strengthened by the addition of two steel beam girders used to support the wood floorbeams and partially relieve the truss of live loads. Extensions were made to the stone abutments to provide a bearing for the girders. Further strengthening was required in 1981 when DelDOT replaced the deck and doubled-up the floorbeams, bolting new timbers to the older timbers. The portal and upper lateral bracing were raised to increase vertical clearance.

The Wooddale Covered Bridge was listed in the National Register of Historic Places in 1973.

These plans, prepared in 1939 by the Delaware State Highway Department, are the earliest known drawing of the Wooddale Covered Bridge.
The Wiggins Mill Road bridge is historically significant as Delaware's oldest documented metal truss highway bridge. It is the work of the state's most prominent late-19th-century metal truss bridge fabricator, the Edge Moor Bridge Works of Wilmington. The 34'-long, three-panel, riveted, Warren pony truss bridge has chords, diagonals, and verticals all composed of wrought iron angles. The bridge is supported on stone abutments and wingwalls topped by stone parapets. It carries one lane of traffic on a 14'-8" wide deck. In 1998, DelDOT was preparing plans to relocate this bridge to a park in Middletown.

The bridge was built in 1884, replacing a bridge of unknown type. The southwest wingwall has a capstone that bears the inscription, “Rebuilt 1884, J. T. Taylor, L(ower). C(ounty). Com(missioner).”

A bridge of this size could have been fabricated at Edge Moor's shops and shipped to the bridge site with a minimal amount of on-site assembly. It demonstrates the economy of design that contributed to the dominance of prefabricated metal truss bridges.
Truss Bridges

over earlier traditional bridge types such as stone arches and timber trusses.

Brecks Lane (Road 260) over Pancake Run

State Bridge NC-66
Wilmington, New Castle County
Designer/Builder: Edge Moor Bridge Works
ca. 1890

The Brecks Lane bridge is a rare surviving example of a late-19th-century metal truss bridge fabricated by Wilmington's Edge Moor Bridge Works. The 21'-long, two-panel, riveted, Warren pony truss bridge is composed of wrought iron angles for the chords, diagonals and verticals. It carries two lanes of traffic, and measures 20'-8" wide. Early 20th century alterations to the bridge included replacement of the timber deck with a concrete slab, encasing the floor-beams and stringers. The slab relieves the truss bridge of live loads.

DelDOT records do not document the bridge's date of construction, but based on style and comparison to other documented examples, it dates to ca. 1890. Two other nearly identical Warren pony truss bridges in New Castle County are the Wiggins Mill Road bridge (State Bridge NC-424) and the Evanson Road bridge (State Bridge NC-179A). The Brecks Lane bridge is located in the Henry Clay Village Historic District, adjacent to Breck's Mill that dates to 1814. The bridge is a contributing resource to the National Register-listed district.
Rising Sun Lane (Road 279) over Brandywine Creek

State Bridge NC-1A&B
Wilmington, New Castle County

1928

The Rising Sun Lane bridge consists of a 127'-long, riveted, steel Pratt thru truss span and a 25'-long, stone arch approach span for an overall length of 193' including roadway and fill. The massive ashlar abutments and stone arch over a former mill race were built in 1833 when a Burr arch-truss covered bridge was erected. In 1928, the covered bridge was replaced by the present metal truss bridge. The abutments, which were in sound condition, were reused.

The 1928 Pratt thru truss bridge incorporates truss details that were standard after 1900. The truss members are all built-up of standard steel sections such as angles, channels, and plates. The bridge is rivet connected with gusset plates at each panel point. A sidewalk with a lattice metal railing is cantilevered from the south side of the bridge. In 1979, the original steel...
stringers and concrete deck were removed and replaced with deeper stringers and a composite concrete slab deck. Rivets have been selectively replaced by high-strength bolts, but otherwise the bridge is unaltered.

A representative example of a standard early 20th century Pratt truss bridge, the Rising Sun Lane bridge is historically noteworthy in the statewide context as one of only two surviving pre-1956 thru truss highway bridges. It is the only thru truss bridge on a public road; the other carries a private road over Brandywine Creek north of the Hagley Museum. A historically significant feature of the Rising Sun Lane bridge is also its 25'-long stone arch, built in 1833, and one of the oldest and longest stone arch highway spans in Delaware.

Harrington, Howard & Ash, consulting engineers and designers of the truss bridge, were among the most prolific American bridge engineering firms of the 20th century. Founded in 1914 by John L. Harrington, Ernest E. Howard, and Louis R. Ash, the firm was known prior to 1940 primarily for its work with movable bridges. In Delaware, Harrington, Howard & Ash designed Wilmington’s 1927 South Market Street bascule bridge (State Bridge NC-688) and 1932 North Church Street bascule bridge (State Bridge NC-577). The Rising Sun Lane Bridge was not among the firm’s most noteworthy projects, however, it does document a growing presence for the firm in Delaware during the late 1920s. After World War II, the firm under its new name,

Details from the 1927 drawings for the Rising Sun Lane bridge show the decorative lattice railings with scroll work.
The 20'-long, two-panel, riveted, Warren pony truss bridge is composed of wrought-iron angles for the chords, diagonals, and verticals. DelDOT records do not document its date of construction or builder, but based on the style of construction and similarity to two other extant bridges in New Castle County, the bridge dates to ca. 1890 and is likely the work of the Edge Moor Bridge Works.

Howard Needles Tammen & Bergendorff, had a significant influence on Delaware's transportation history designing the Delaware Memorial Bridge (1951, 1968) and the Delaware Turnpike (1961-1964).

Evanson Road (Road 285) over Mill Creek

State Bridge NC-179A
Hockessin, New Castle County
Designer/Builder: Edge Moor Bridge Works
ca. 1890

The Evanson Road bridge is one of three nearly identical Warren pony truss bridges surviving in New Castle County.
Works of Wilmington, the fabricator of the other two bridges (State Bridge NC-66 and NC-424).

The bridge underwent emergency repairs in 1995. The truss lines were cleaned and repainted, and a laminated timber slab deck was constructed that bears on the stone abutments. The trusses now serve as railings. Although the bridge has been altered, the truss lines are considered significant due to their rarity and age.

Warren pony truss bridges, such as the Thompson’s Station Bridge erected in 1928, were a common highway bridge type from the first three decades of the 20th century.

Chambers Rock Road (Road 329) over White Clay Creek

State Bridge NC-216
Thompson’s Station Bridge
Newark, New Castle County
Designer/Builder: New Castle County Engineer’s Office/Belmont Ironworks
1928

The Thompson’s Station Bridge is a 66’-long, Warren with verticals pony truss bridge that was fabricated in 1928. It has standard built-up members composed of angles, channels and plates. In 1995, DeDOT rehabilitated the structure. The truss lines were disassembled, and severely rusted members, including all of the lower chords, were replaced in-kind. Rivets at the panel points were replaced by high-strength bolts. A new laminated timber deck replaced the older steel grate deck.

New concrete abutments and wingwalls were built and then faced with stone.
In 1990, DelDOT rehabilitated the bridge. The truss was widened from 20'-wide to 30'-wide, and the original floorbeams, stringers, and wood deck were replaced by new floorbeams supporting a laminated timber slab deck. During construction, the trusses were removed, cleaned and painted, and then replaced. Rivets at the lower panel points were replaced by high-strength bolts. New concrete abutments and wingwalls were constructed.

Although the bridge has been altered, the truss lines are considered historically significant because they document a once common but now rare bridge type in the state.

Thompson's Station Bridge was built in 1928 by the authority of the Levy Court of New Castle County. Plans were prepared by the County Engineer's office using a set of standard specifications for Warren pony truss bridges prepared by the county engineer. The bridge contractor is undocumented, but the structural steel was fabricated by the Belmont Ironworks of Philadelphia. The bridge is one of only two surviving 20th-century examples of the once ubiquitous Warren metal truss bridge type and design in Delaware. The other is the 1929 Yorklyn Road Bridge (State Bridge NC-112). In 1990, DelDOT rehabilitated the bridge. The truss was widened from 20'-wide to 30'-wide, and the original floorbeams, stringers, and wood deck were replaced by new floorbeams supporting a laminated timber slab deck. During construction, the trusses were removed, cleaned and painted, and then replaced. Rivets at the lower panel points were replaced by high-strength bolts. New concrete abutments and wingwalls were constructed.

Although the bridge is altered, it documents a popular early 20th century design. In the 1920s, Warren pony truss bridges were the most common type of metal truss bridges on county roads in New Castle County. The Yorklyn Road bridge is a 75'-long, riveted, Warren with verticals pony truss, fabricated in 1929. The bridge is composed of built-up members of standard steel sections including angles, channels, and plates. A sidewalk with wood deck is cantilevered from the east side with an ornamental steel railing. The bridge is historically significant as a rare surviving example of this once common bridge type in the state.
County Levy Court. It was designed by the County Engineer’s office, and original plans are on file at DelDOT. The structural steel was fabricated by the Belmont Ironworks of Philadelphia. The contractor who erected the bridge is not recorded.

ABOVE: The 1929 Yorklyn Road bridge is one of only six truss highway bridges remaining in public service in Delaware. Although once common in the state, the truss bridge type rapidly vanished from state roads in the mid-20th century, in part because truss bridge roadway widths were often too narrow to be safe for larger and faster trucks and cars.

LEFT: This plaque detail is from the original 1929 drawings for the Yorklyn Road bridge.