METAL GIRDER

BRIDGES

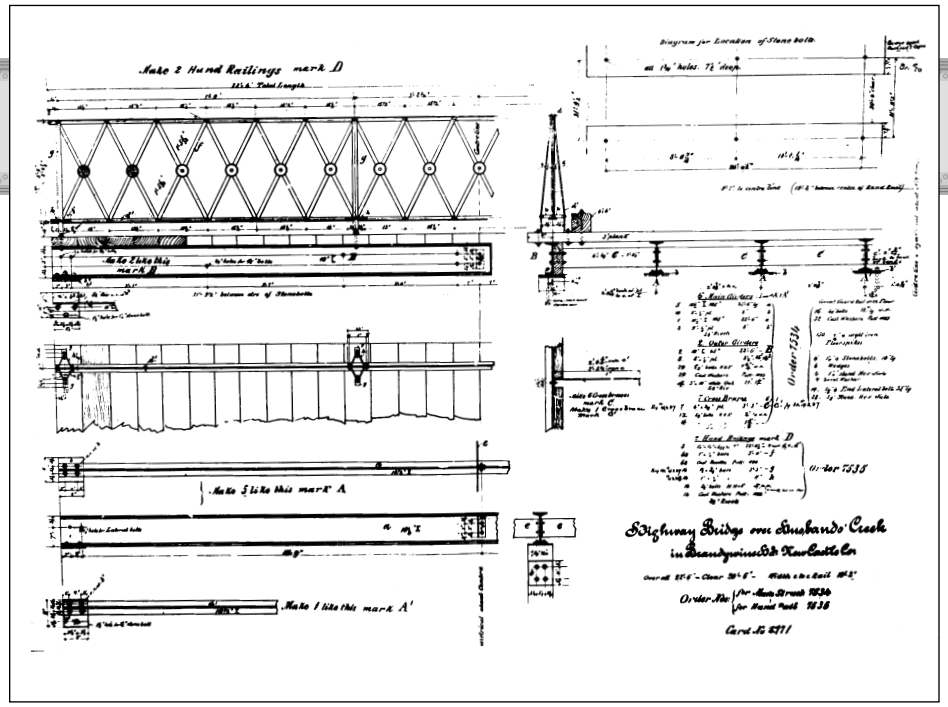
In Delaware, as in most other states, steel girder bridges were the most frequently built types of highway bridges from the late 1910s through at least the mid 1950s.

A steel multi girder bridge (non-extant) with lattice railings and stone abutments and wingwalls on Duncan Road, New Castle County, ca. 1920.

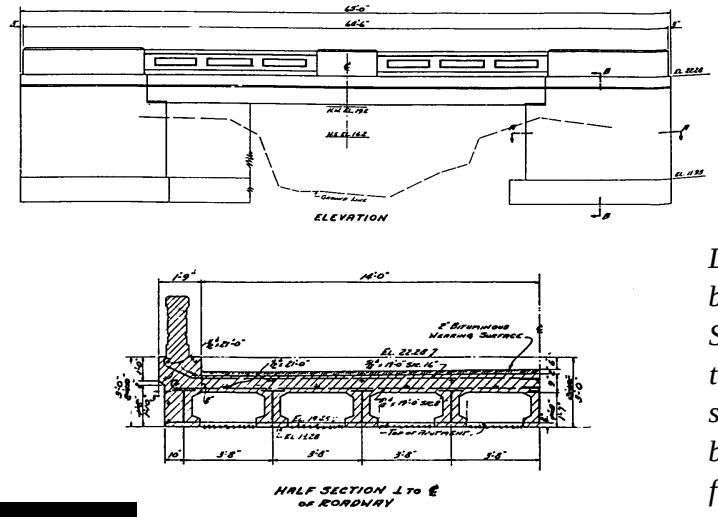
This chapter includes multi girder bridges that are longitudinal beams with no transverse floorbeams, and girder and floorbeam bridges (i.e. deck girder and thru girder, see page 118). The engineering principle underlying all types of girder bridges is the same; the bending strength of the material resists the load. Most often, the multi girder bridges are composed of rolled wide flange beams. The built-up girder and floorbeam bridges are generally used for the longer spans.

An important advance in girder technology occurred with the transition from wood to metal girders in the mid-19th century. America's antebellum bridge engineers understood the superior bending strength of metal but the initial development of the technology, and its widespread application, relied upon later improvements in the manufacture of rolled-iron structural shapes, such

Conrail Bridge Number 44.75, built in 1903, carries the Delaware Railroad over St. Jacobs Creek near Dover. The metal girder bridge technology was fully developed by America's railroads by the last quarter of the 19th century. The girder bridges were built prolifically across the United States throughout the first half of the 20th century.



ABOVE: Plans for a simple steel multi girder bridge composed of rolled I-beams supporting a wood plank deck enclosed by lattice railings. Rockland Road over Husbands Run, near Rockland, New Castle County, ca. 1900, replaced in 1932 by State Bridge NC-20.



LEFT: Plans for the Road 46 over Deep Creek bridge (State Bridge S-239) at Old Furnace, Sussex County. The 1932 drawings illustrate the state highway department bridge division's standard design for encased steel multi girder bridges. Similar bridges were built in numbers from the 1920s to the 1950s.

as angles, channels, plates, and I-beams.

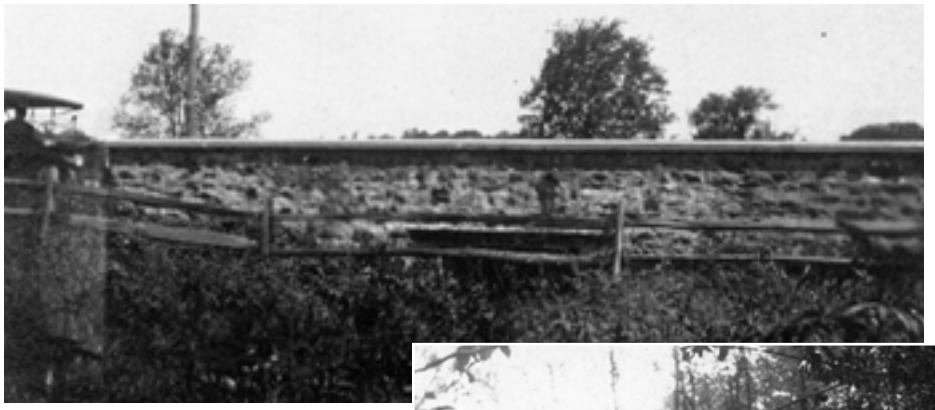
Wrought-iron girder bridges were introduced by the railroads as early as 1847. In most instances, the railroads used built-up beams, composed of rivet-connected plates for the web and angles for the flanges, to make a beam of sufficient depth to span greater distances than possible with then available rolled beams. (Depth of a beam is related to span length, with the greater the desired length, the greater the depth.) Built-up girder with transverse floorbeams bridges proved to be efficient and economical for railroad-carrying spans, and they were the only serious competitors to metal trusses for railroad use in the late-19th century. Bridge engineers especially appreciated the ease of installation. Since the built-up girders were almost completely assembled in fabricating shops, conveniently located on rail lines, they could be loaded easily onto flatbed cars. Once at the site, cranes quickly hoisted them into position with minimum traffic interruption. The ability to transport the girders was often a factor limiting their length, and in general, built-up girder highway bridges were not built in great numbers prior to 1900 because of the difficulty of transporting the beams overland by wagons or sleds. Most extant 19th century girder bridges and many 20th century ones are associated with railroads.

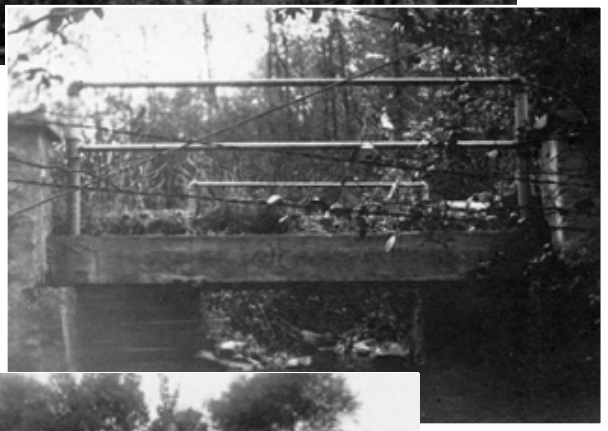
By the 1890s, improvements in the open-hearth steel making process resulted in larger quantities of structural steel at lower prices. A major technological breakthrough occurred in 1908 when the Bethlehem Steel Company began producing wide-flange rolled steel beams on the Grey Mill, named

Metal Girder Bridges

after its inventor Henry Grey. The mill rolled beams at greater speeds and depths and at an approximately 10 percent savings in material with no reduction in strength. Although the company first met difficulties marketing the new 26", 28", and 30" deep beams, Bethlehem had overcome the problems by the early 1910s. In his 1916 edition of *Bridge Engineering*, J. A. L. Waddell touted the superiority of the improved steel I-beams, calling them "a great boon to bridge designers and builders" because of their simplicity, compactness and lower price.

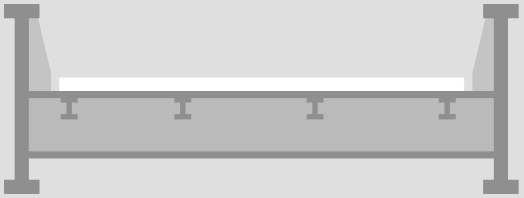
As a class, rolled steel multi girder bridges proved ideally suited for the highway building campaigns of the 20th century. They came to the fore before World War I, and by the mid 1920s, rolled section multi girder bridges were ubiquitous. The advantages of the technology were particularly attractive to state and county bridge engineers for spans up to 60' in length. They could be easily erected with readily available beam sections and were cheaper than pony truss bridges. Rubber-tired trucks and



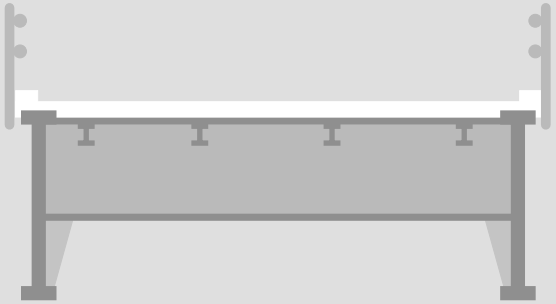


Steel multi girder bridges were a simple, low-price solution for the bridge building needs of Delaware's county governments during the early 20th century. New Castle County bridge photos of the 1920s and 1930s illustrate at least 40 such bridges. No such archives exist for the lower counties, but written records indicate that Kent and Sussex county governments had adopted the bridge type by the end of the first decade of the 20th century. Typical non-extant examples from the New Castle County bridge photo archives include a concrete-encased steel multi girder bridge with stone parapets on the Lancaster Pike (Above), a concrete encased steel multi girder span with metal pipe railings on Silverside Road (Center) and a concrete-encased steel multi girder bridge with concrete parapets near the Maryland line (Below).

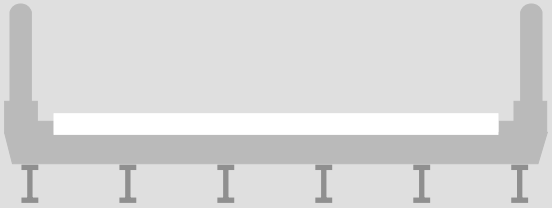
Metal Girder Bridges



Thru Girder Cross Section



Deck Girder Cross Section



Multi Girder Cross Section

improved heavy construction equipment eased the problems of transporting girders and on-site erection. With primarily accessible flat surfaces, girder bridges were easier to clean and paint than trusses, and a concrete deck over the beams added protection from exposure.

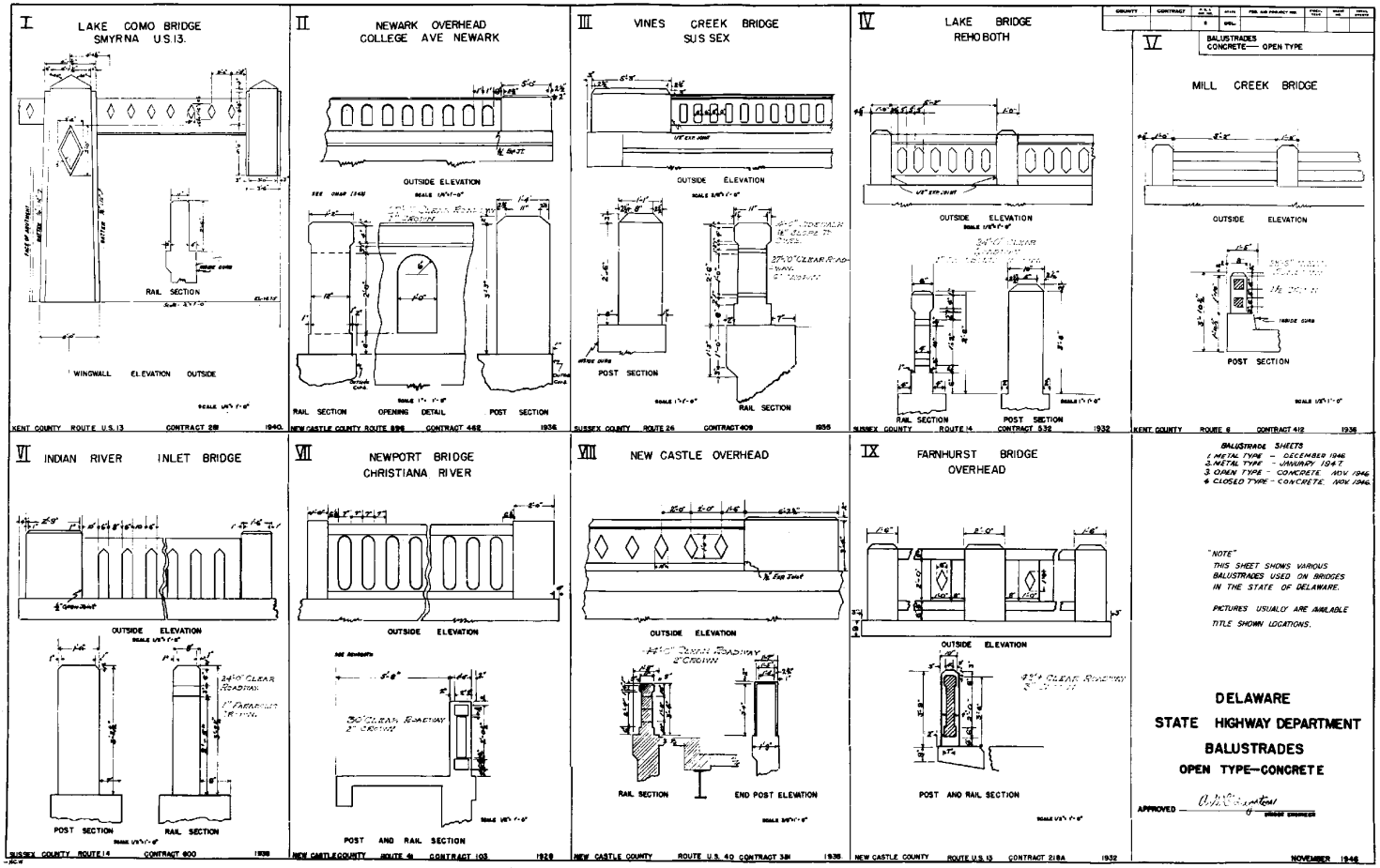
The multi girder, thru girder, and deck girder are the three most common girder bridge types. The *multi girder* type consists of a series of parallel, longitudinal steel beams supporting a deck. Concrete or steel diaphragms are often used between the beams to stiffen multi girder bridges. The deck and thru girder bridge types are distinguished from the multi girder by transverse floorbeams between the longitudinal girders, which are usually built up rather than rolled. The *thru girder* is where the floorbeams are placed in line with the bottom flanges of the girders with the roadway passing between the paired girders. The *deck girder* is where the floorbeams are placed near the top flanges of the girders and the roadway located at the top of the girders. Deck girders are often associated with locations where vertical clearances are not critical.

In Delaware, as in most other states, steel multi girder bridges were the most frequently built type of highway bridges with span lengths of over 20' from the late 1910s through at least the mid 1950s. They continue to be built today. Delaware's state highway department and county engineers prepared standard specifications for multi girder bridges, facilitating quick and economical design and construction. The Kent County engineer, for instance, issued "General Specifications for Highway Bridges" (ca. 1910) to provide written directions to contractors for simple multi girder bridges on rubble masonry abutments. Such standard specifications, often taken from correspondence-school textbooks or technical pamphlets prepared by the federal government or professional engineering societies, were not a milestone in the development of bridge technology, but rather an economical and expedient engineering solution that found broad application across the nation in the early 20th century. Another advantage of multi girder bridges that was particularly important in the era of rapidly in-

creasing traffic volume and weight demands was the ability readily to widen the bridge or salvage the beams for reuse at another location.

A common detail of steel multi girder bridges is the concrete encasement of the beams. The technique was introduced in the 1890s to protect beams from corrosion and eliminate the need for periodic painting. Although it added dead load to the bridge, encasement had long-term maintenance cost benefits and was used frequently as a technique by highway departments and railroad companies through the mid-20th century.

Economy of design and ease of construction were the most significant factors in the bridge type's widespread and long-lived use. Historically, multi girder bridges frequently were finished with paneled concrete parapets, concrete balustrades, or decorative metal railings designed to be both safe and attractive. In general, architectural treatments, when applied, reflected period tastes and styles. After 1945, bridge builders increasingly turned to stock railings, such as W-beam and wire-rope guide railings.



A 1946 plan sheet illustrates nine variations of concrete balustrades used by the Delaware State Highway Department during the 1930s and 1940s.

Under the tenure of State Bridge Engineer Arthur G. Livingston (1918-1948), multi girder bridges on Delaware state highways re-

The Locations of Delaware's Historic Metal Girder Bridges

1. Still Road over Choptank River
State Bridge K-211A
South of Marydel, Kent County

2. Frederica Road over Murderkill River
State Bridge K-8F
Frederica, Kent County

3. Faulkland Road over Hyde Run
State Bridge NC-182
Northwest of Prices Corner, New Castle County

4. North Market Street over Brandywine Creek
State Bridge NC-575
Wilmington, New Castle County

5. Old Capital Trail over Red Clay Creek
State Bridge NC-155
Marshallton, New Castle County

6. Road 46 over Deep Creek
State Bridge S-239
Old Furnace, Sussex County

7. Rockland Road over Wilson Run
State Bridge NC-68
Rockland, New Castle County

8. Rockland Road over Brandywine Creek
State Bridge NC-2
Rockland, New Castle County

9. Washington Street over Mispillion River
State Bridge K-501
Milford, Kent County

10. Silver Lake Road over Silver Lake Spillway
State Bridge NC-407
Southeast of Middletown, New Castle County

11. Carr Road over Shellpot Creek
State Bridge NC-543
Bellevue State Park, New Castle County

12. State Route 7 over Christina River
State Bridge NC-257
Christiana, New Castle County

13. Snuff Mill Road over Red Clay Creek Tributary
State Bridge NC-88
West of Centreville, New Castle County

14. State Route 82 over Red Clay Creek
State Bridge NC-119
Ashland, New Castle County

15. State Route 20 Eastbound over Conrail and Cedar Street
State Bridge S-257E
Seaford, Sussex County

16. State Route 141 over Brandywine Creek and Road 260
State Bridge NC-587
East of Greenville, New Castle County

ceived a variety of individualistic aesthetic railings, in both metal and concrete, some with diamond-shape cutouts or panels (for the Diamond State) or Art Moderne-style architectural detailing. In northern New Castle County, Livingston faced steel girder bridges as well as reinforced concrete bridges with native stone in a desire to blend the bridges with the natural landscape. The practice of stone facing, begun by Livingston in the 1930s, continues today.

Over 120 steel girder bridges from 1901 to 1956 have been identified by the Delaware historic bridge inventory. Pre-World War I bridges are with few exceptions standard thru girder bridges, many built as part of grade-crossing elimination programs by the Pennsylvania and B&O railroads in Wilmington. The railroad-built girder bridges represent the continuance of the built-up girder technology that was well established during the second half of the 19th century.

The majority of surviving girder highway bridges date from after World War I and were built by the state, counties, or municipalities as part of ongoing road improvement campaigns. In general, highway bridge engineers handled girder bridge design in a formulaic manner and very few examples are noteworthy for innovative features. Early standard examples and those that first incorporated later refinements of design, such as achieving economy of material by making the beams continuous over the piers, and aesthetic treatments, such as

stone facing or Art Moderne-style architectural detailing, best represent the significance of the bridge type in the Delaware context. The Delaware historic bridge inventory has identified 16 girder bridges, dated from ca. 1909 to 1952, that stand out in the larger population based on their age, technological details, aesthetic treatments, or geographic distribution.

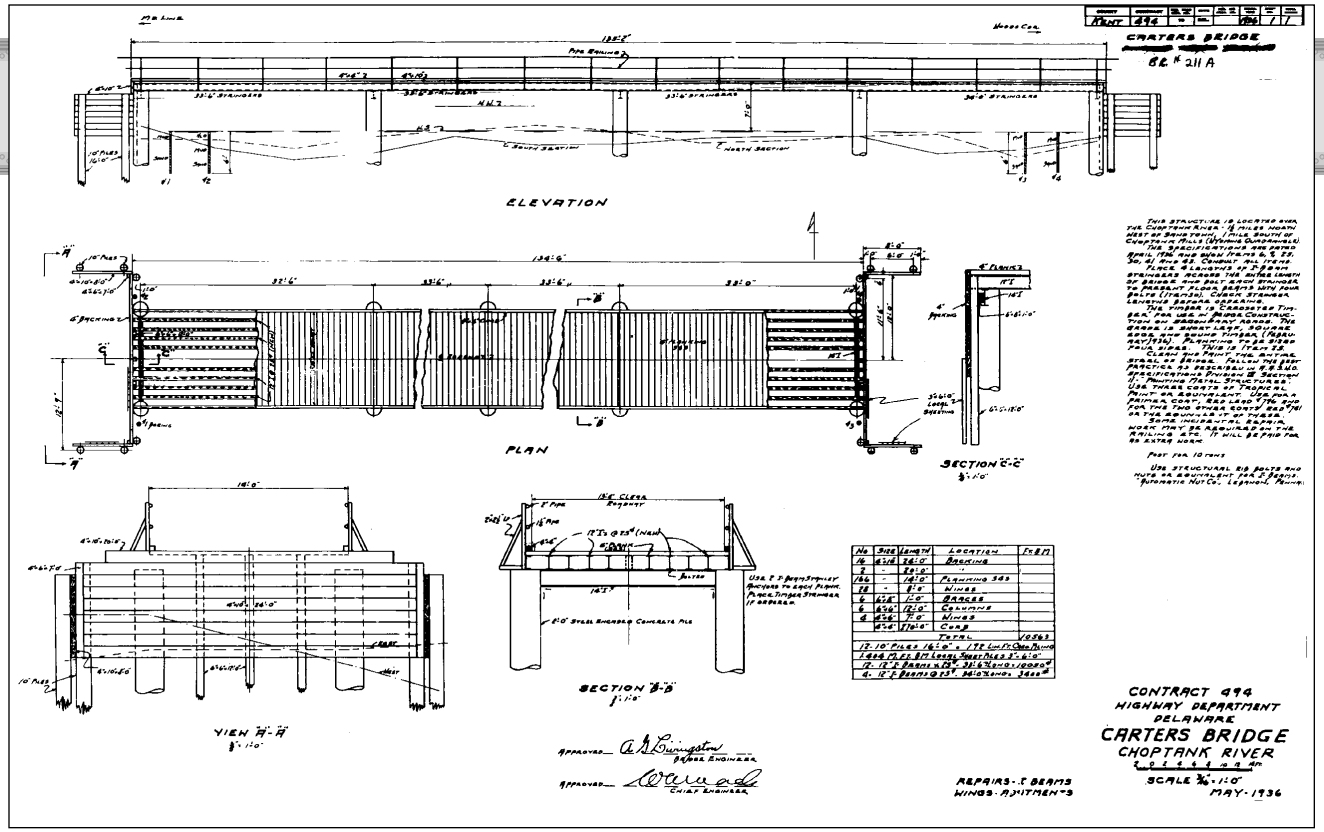
Still Road *(Road 211)* over Choptank River *(Carters Bridge)*

State Bridge K-211A
South of Marydel, Kent County
Designer/Builder: Canton Bridge Company

ca. 1909

The Still Road bridge is a four-span, 135'-long, 14'-wide, steel multi girder bridge supported on concrete-filled riveted steel caisson with I-beam cap bents. The bridge dates to ca. 1909 and was built by the Canton Bridge Company for the Kent County government as a replacement for an earlier timber bridge. The oldest surviving plans are from 1936, after the state highway department had taken over the bridge from Kent

The ca. 1909 Still Road bridge (State Bridge K-211A) was built by the Canton Bridge Company of Canton, Ohio. The bridge is among the state's oldest extant multiple-span steel multi girder highway bridges.



In 1936 the Delaware State Highway Department prepared plans to strengthen the Still Road bridge by adding four longitudinal steel I-beams to each span. Repairs also included replacing the timber deck and timber pile and sheeting abutment backwalls and wingwalls. These repair plans are the earliest known surviving plans for the ca. 1909 bridge.

County. In 1936, the department strengthened the bridge by adding four longitudinal steel I-beams to each span, changing it from the original six to ten lines of beams.

The bridge is among the state's oldest multiple-span multi girder highway bridges. It reflects the early 20th century application of the technology in a rural setting. Although the concrete-filled, riveted steel caisson bents were once very common, these are the only extant examples identified in Delaware. The timber deck, and timber pile and sheeting abutment backwalls and wingwalls were rebuilt in 1936, and, according to state records, again ca. 1970. The railings were altered in the early 1990s by removal of the bottom pipe rails and attachment of W-beam guide railings in their place.

Kent County carried out an extensive program of bridge construction during the years 1909-1914, building or rebuilding at least thirty-one bridges. The present Carters Bridge is the third span built to carry Still Road across the Choptank River. The two earlier bridges, one presumably constructed in 1867 and the other some time between 1867 and 1909, had both been timber structures. The Levy Court made a call for proposals for the construction of the third bridge around the early autumn of 1909. The county's specifications directed the removal of the present wooden bridge, and the construction of a replacement wooden structure with its floor one foot higher than that of its predecessor.

In its final form, the 1909 Carters Bridge diverged considerably from the county's initial intentions, being a steel multi girder structure supported by bents with caissons. The firm that constructed the new bridge, the Canton Bridge Company of Canton, Ohio, had been contracted by Kent County the preceding

The 1920 Frederica Road bridge (State Bridge K-8F) is an example of the state highway department's standard encased steel multi girder bridge design.

April to erect a relatively long bridge across the inland margin of the tidal estuary of the Leipsic River at the village of Leipsic. The Levy Court awarded the contract for Carters Bridge to the company on November 9, 1909, for $2,418, a sum well above the competing wooden-bridge bids of local contractors. Perhaps Kent County officials had been persuaded by arguments made by the Canton Bridge Company's engineer for the Leipsic bridge regarding the superiority of steel multi girder construction. The following year, 1910, the Kent County Engineer issued standard specifications for steel multi girder bridges.

The Canton Bridge Company, established in 1876, had its offices and shops in Canton, Ohio, a small city that had emerged around 1875 as a secondary center for the steel industry. The company was a relatively minor bridge building concern, generating 5,000 long tons of production in 1903, tying for eighth place among fourteen Ohio bridge companies for that year.

Frederica Road *(Road 10)* over Murderkill River

State Bridge K-8F
Frederica, Kent County
Designer/Builder: State Highway Department/S. S. Jones Contracting Corp.
1920

The Frederica Road bridge is a four-span, 116'-long, 35'-wide, encased steel multi girder bridge finished with incised paneled concrete parapets and supported on concrete abutments and piers.