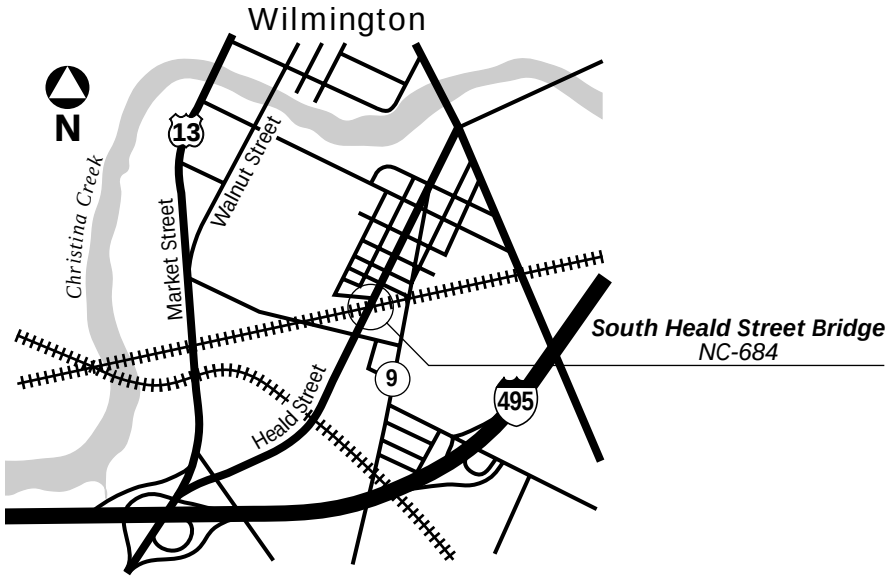
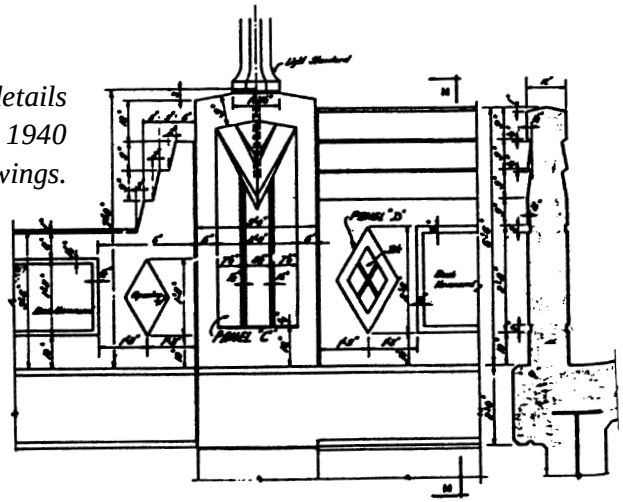
State Bridge NC-684 (South Heald Street) over Conrail before rehabilitation in 1994. The main span over the tracks was a steel multi beam span, shown here, replaced by a prestressed concrete box beam span. The historically noteworthy, flanking reinforced concrete slab spans on mushroom columns were not replaced.



Mushroom columns support the continuous, reinforced concrete slab approach spans of the South Heald Street bridge (1941-42). The mushroom column design was developed in 1908 by engineer Claude A. P. Turner.

The contractor, J. A. Bader & Company of Wilmington, started work in October 1941, but construction was delayed from the outset by difficulties obtaining critical materials due to the war. The Bureau of Public Roads took two months before obtaining a preference rating of A-7 from the Office of Production Management for concrete and reinforcing bars. The bureau acknowledged the effect of this lag and recommended the contractor not be held liable for damages, despite completing the structure far behind schedule and opening it to traffic in July, 1942.



Parapet details from original 1940 drawings.

Original parapets were removed from State Bridge NC-684 in 1994, but the replacement parapets of a lightweight concrete replicated the original architectural features to maintain the bridge's historic character.

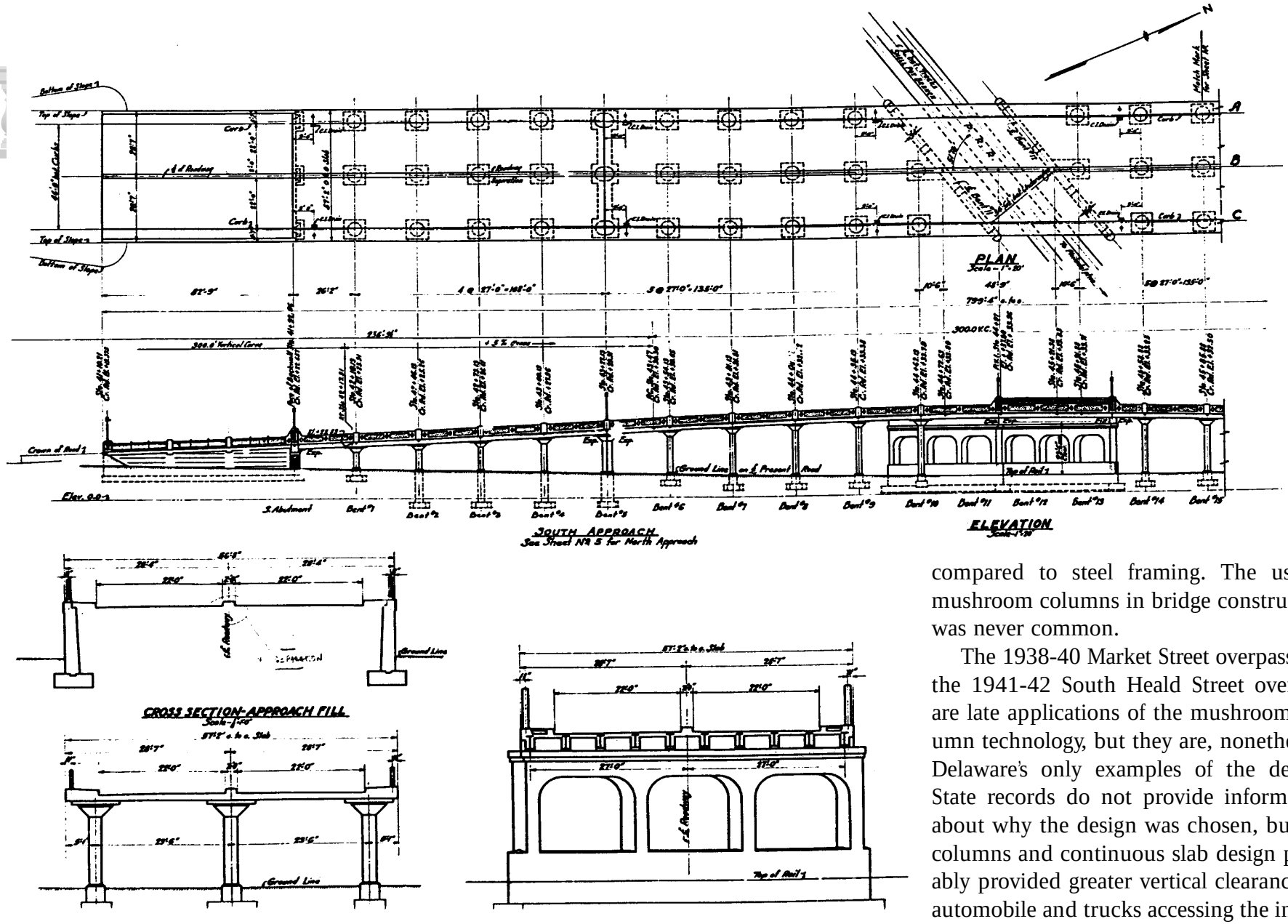
South Heald Street *(Road 28)* over Conrail and State Route 9 Ramp

State Bridge NC-684
South Wilmington, New Castle County
Designer/Builder: Delaware State Highway Department/J. A. Bader & Company

1941-42

The 23-span, 608'-long South Heald Street bridge consists of 22, reinforced concrete slab approach spans supported on mushroom columns and a skewed, 34'-long steel multi girder main span over a single railroad track. The line is the former Shellpot Branch freight secondary of the Pennsylvania Railroad. The multi girder main span replaced the original encased steel multi girder span of the same over all dimensions in 1994. The original Moderne-style parapets were removed at the same time and replaced with new parapets of a lightweight concrete. The replacement parapets were finished with architectural details similar to the original, including diamond-shape tile mosaics. The alterations were done in a sensitive manner to maintain the bridge's historic character. The technologically significant mushroom column-supported slab approach spans retain integrity of original design.

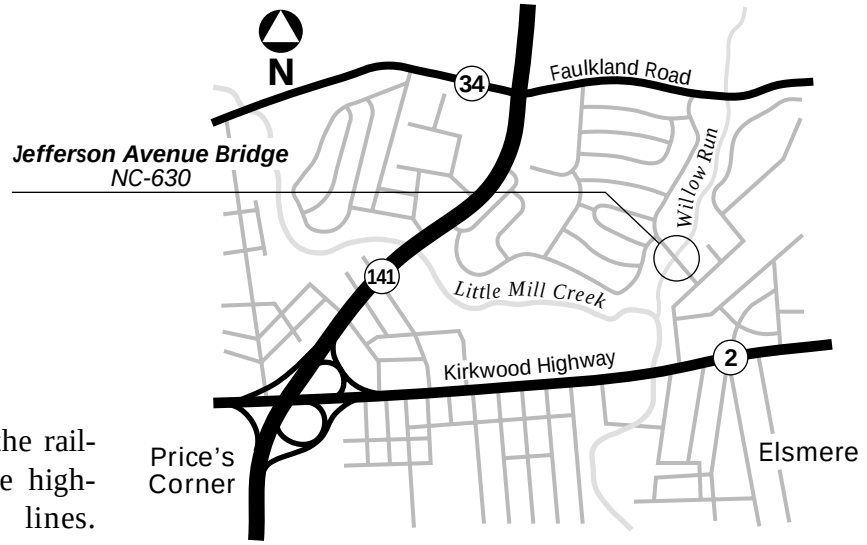
The South Heald Street overpass is most noteworthy as one of two bridges in the state that have continuous slab spans supported by mushroom columns. The other is the nearby 1938-40 Market Street overpass (State Bridge NC-686). The mushroom column design was developed by engineer Claude A. P. Turner, who received a patent for its use in 1908. The economies of the mushroom-column slab construction were most obvious in the case of warehouses and factories where the design could be used to increase overhead space and reduce the number of interior columns and beams as



Plan, elevation and section from the original 1940 drawings for State Bridge NC-684.

compared to steel framing. The use of mushroom columns in bridge construction was never common.

The 1938-40 Market Street overpass and the 1941-42 South Heald Street overpass are late applications of the mushroom column technology, but they are, nonetheless, Delaware's only examples of the design. State records do not provide information about why the design was chosen, but the columns and continuous slab design probably provided greater vertical clearance for automobile and trucks accessing the industrial areas along the railroad tracks. Both bridges were built with financial assistance from a federal-aid grade crossing elimination program initiated nationwide in the



mid-1930s. The cost of construction was born by the federal government with the state and railroad companies sharing responsibility for right-of-way acquisition. The general contractor for the South Heald Street overpass was J. A. Bader & Company of Wilmington.

Grade-crossing eliminations were an area of concern for both railroads and highway departments throughout the first half of the 20th century. In Delaware, the Pennsylvania Railroad raised its main line tracks through downtown Wilmington in 1901-07, thus lifting its own traffic out of the dangers and delays caused by autos, wagons, and pedestrians. Eliminating grade hazardous crossings was always a goal of the state highway department from its inception in 1917. State officials sought out the cooperation of the railroads wherever state highways crossed rail lines. Usually, adequate warning signs or realignment of the road was a preferred solution to building bridges, which were more costly, but as automobile traffic grew expanding the chances for railroad-automobile collisions, the state highway department with federal and state aid began more systematic construction of overhead bridges in the late 1920s. The grade-crossing elimination effort continued through the 1950s. The South Heald Street bridge is representative of these efforts.

The South Heald Street bridge is dedicated to former Delaware State Legislator, Paul F. Livingston (1895-1963), who served in the statehouse from 1953 to 1963.

Jefferson Avenue over Chestnut Run

State Bridge NC-630
Willow Run, New Castle County
Designer/Builder: Delaware State Highway Department

1953

The Jefferson Avenue bridge is a one-span, 18'-long, reinforced concrete slab bridge finished with vertically scored concrete parapets. The 47'-wide bridge is supported on concrete abutments with U-shaped wingwalls. It is historically signifi-

State Bridge NC-630 (1953) was a reinforced concrete slab bridge built to provide access to a new residential subdivision. It represents a standard design that was used by the state highway department from the 1930s through the mid 1950s.

The Willow Run Section 2 subdivision was built from 1949 to 1953. It is an excellent example of post-World War II architectural trends in suburban housing. The subdivision consists of nearly identical one-story, two-bedroom stuccoed houses with broad gable roofs, casement windows, and brick quoins. The houses were marketed under the name "The Westerner."

cant as a contributing resource to a potential Willow Run Section 2 historic district northwest of Elsmere. The bridge was designed by the Delaware State Highway Department's Bridge Department and built in 1953 as an extension of Jefferson Avenue to connect Elsmere with the subdivision. The bridge is an example of the department's standard-design reinforced concrete slab bridge that was used from the 1930s through the mid 1950s.

Willow Run Section 2, constructed from 1949 to 1953, is a post-World War II subdivision of approximately 200 nearly identical one-story, two-bedroom, stuccoed houses with broad gable roofs, casement windows, and brick quoins. The houses are an excellent example of post-World War II architectural trend in suburban housing with a simplified form and lack of traditional detailing. Large concentrations of nearly identical and relatively modest postwar vernacular houses are rare in suburban northern Delaware where custom designs and Colonial Revival and larger ranch-style residences dominated. Original house plans and maps on file at the New Castle County Department of Land Use provide documentation to confirm that Willow Run Section 2 has integrity of original design.

Willow Run Section 2 is located south of SR 34 (Faulkland Road) northwest of Elsmere. According to

Baist's Atlas of New Castle County (1893), the tract of land was part of a farm belonging to the Hollingworth family. The farm was purchased in 1946 by Gilpin, Vantrump, and Montgomery, developers who applied for and received permits to construct the Willow Run Section 1 subdivision from the county planning commission. Between 1946 and 1949, Gilpin, Vantrump, and Montgomery developed Willow Run Section 1 on the north side of the farm between Willow Run creek on the east and SR 141 (Center Road) on the west. In 1949, Gilpin, Vantrump, and Montgomery transferred the southern section of the property between Willow Run and Elsmere to the Collins Reality Company owned by F. A. Collins. Collins constructed Willow Run Section 2 from 1949 to 1953.

The Collins house plan was marketed under the name "The Westerner." The first floor plan of all houses included two bedrooms, a living room, a kitchen, and a bath. Some houses had a shed roof dormer providing space for an upstairs bedroom. County planning office records include original house plans signed by Frank Parker, Jr., presumably the architect. The plans included interior views of the kitchen and living room complete with built-in cabinetry.

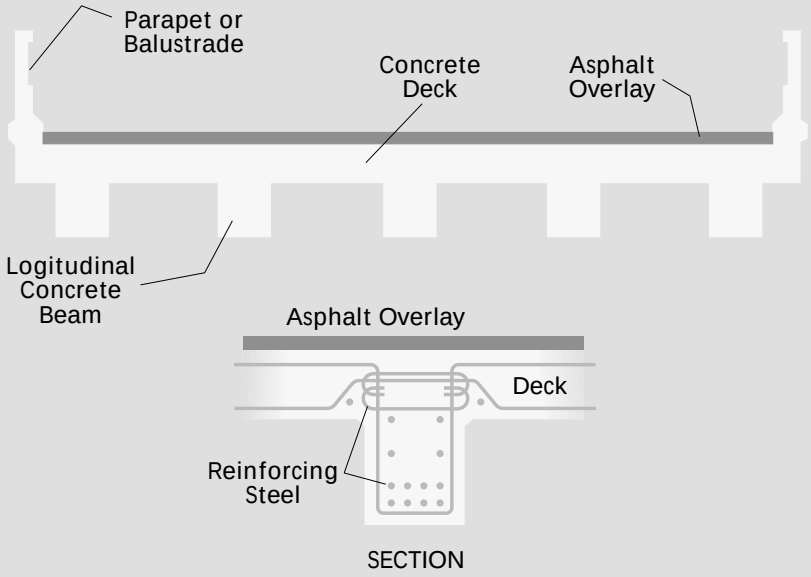
The curvilinear street plan for Willow Run Section 2 included an extension connecting across Chestnut Run to Jefferson Avenue in Elsmere. According to state records, the Delaware State Highway Department constructed the reinforced concrete slab bridge and widened and paved Jefferson Avenue in 1953, replacing a dirt lane and wood bridges, presumably placed by the developer.

T Beam Bridges

T beam bridges are composed of cast-in-place reinforced concrete beams with flanking integral monolithic deck sections. The primary reinforcing steel is placed longitudinally at the bottom of the beam stem, and the deck or flange reinforcing is placed perpendicular (transversely) to the stem. The T beam bridge type appeared nationally around 1905 as a more efficient use of material than the slab design for spans over about 25'. The T beam design proportions the deck thickness and longitudinal beam size and spacing to achieve a lighter, stronger, more economical section. By the mid 1910s, the T beam bridge technology was well established and understood by engineers.

The T beam bridge type was not widely used by either Delaware's county engineers or state highway department, and thus never achieved the same degree of frequency as

Reinforced Concrete T Beam Bridge



in neighboring states such as New Jersey and Pennsylvania, where the standardized T beam bridge type is ubiquitous, especially for use on state highways. A factor limiting the use of T beam bridges was its comparison in economy and price with a number of other bridge types, most notably steel multi girder bridges. The Delaware State Highway Department, early in its history, showed a preference for steel multi girder bridges for span lengths common to T beam bridges. No extant pre-1930 T beam bridges were identified by the survey, and, on the whole, the bridge type never has been of historic importance to the overall development of Delaware's roads and bridges.

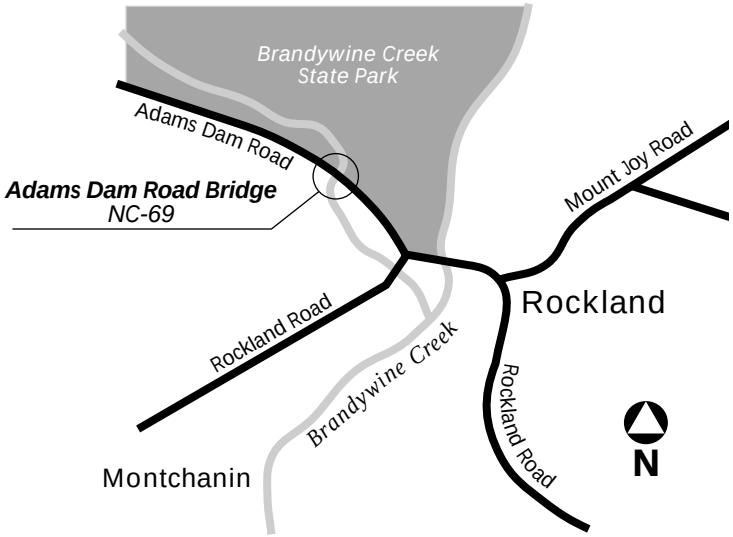
Two of the handful of surviving pre-1957 Delaware T beam bridges are noteworthy. The 1934 Adams Dam Road over Wilson Run bridge (State Bridge NC-69) is the earliest identified extant use of the T beam technology in Delaware. Another, the three-span, 200'-long, continuous, T beam bridge carrying US Route 13 over the St. Jones River (State Bridge K-24A) in Dover is by far the most visually impressive and technologically significant of all of Delaware's T beam bridges. The 1951 bridge reflects post-1940 advances in the application of the T beam bridge technology to longer span continuous structures. Like other previously mentioned continuous designs, it has haunched beams achieving the characteristic greatest depth at the piers. The Delaware State Highway Department Bridge Division designed the bridge as part of the Dover bypass project

Adams Dam Road *(Road 232)* over Wilson Run

State Bridge NC-69
Rockland, New Castle County
Designer/Builder: New Castle County Engineer

1934

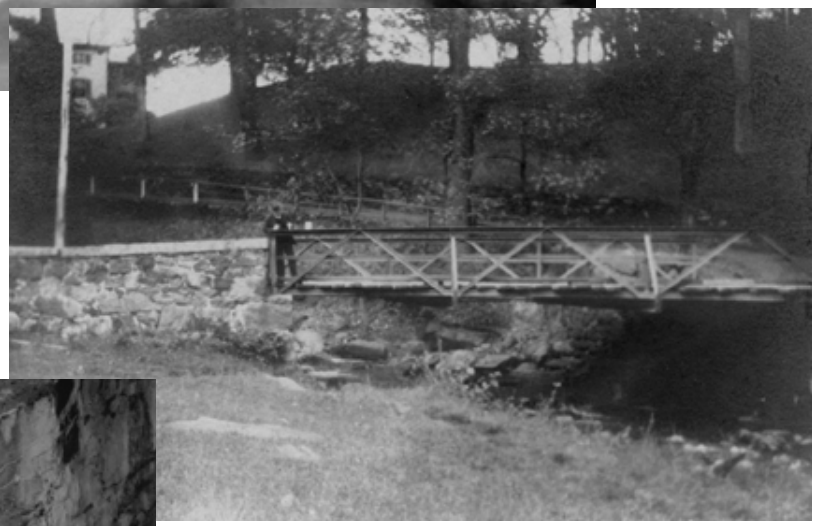
The 1934 Adams Dam Road bridge is a hybrid reinforced concrete T beam and reinforced concrete deck girder bridge. The center section of the one-span, 40'-long bridge is a deck girder with floorbeams. It is flanked to both sides by integral T beam sections. The hybrid design appears to have been an economical means of handling the skew of the bridge while limiting the amount of substructure work needed to reuse and extend the older abutments and wingwalls of a previous pony



truss bridge. The fasciae T beams have a stone veneer presenting the appearance of an arch bridge. The bridge is finished with stone balustrades. The bridge is the oldest identified uses of the T beam technology in Delaware, but is a very late use in the national and regional contexts.

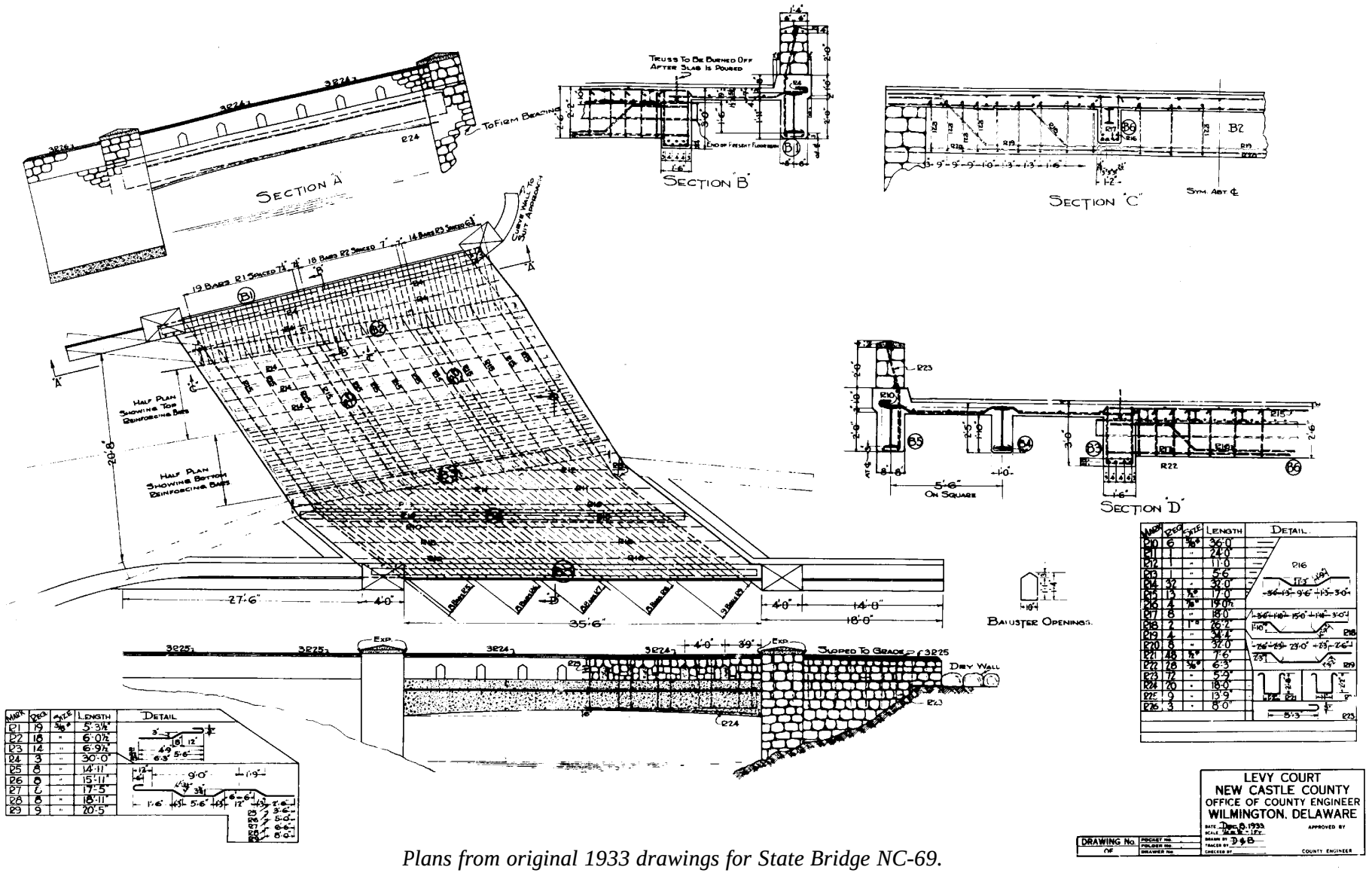
The Adams Dam Road bridge was part of the program of bridge replacements undertaken throughout New Castle County in the late 1920s and early 1930s, before the take over of the county roads and bridges by the state highway department in 1935. Many of the county bridges from this period are characterized by a rusticated stone veneer, evocative of the county's traditional architectural landscape of stone walls,

State Bridge NC-69 (1934), a hybrid T beam and deck girder bridge, has a stone veneer presenting the appearance of a stone arch bridge. The bridge was rehabilitated by DelDOT in 1999.



State Bridge NC-69 replaced this previous bridge in 1934.

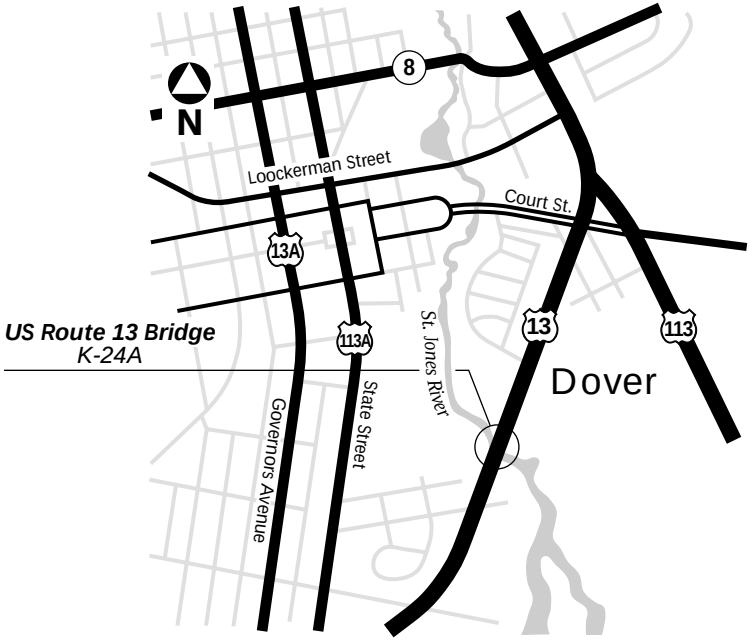
An underneath view of State Bridge NC-69 shows the reinforced concrete beams.



Plans from original 1933 drawings for State Bridge NC-69.

barns, and houses. Stone facing was a common period aesthetic treatment, and it continues in use to this day. Plans for the bridge are dated December 8, 1933, but no mention of the bridge's construction could be found in the Levy Court minutes or the New Castle County Engineer records. As a consequence of this gap in the records, the identity of the firm that built the bridge and the circumstances of the bridge's construction are unknown.

The bridge is a contributing resource in the Rockland Historic District, a mill village comprising of mills, residences, and resources related to the former grist and paper mills at Rockland. The mill sites are located approximately 300' south of the bridge at the crossing of Brandywine Creek.



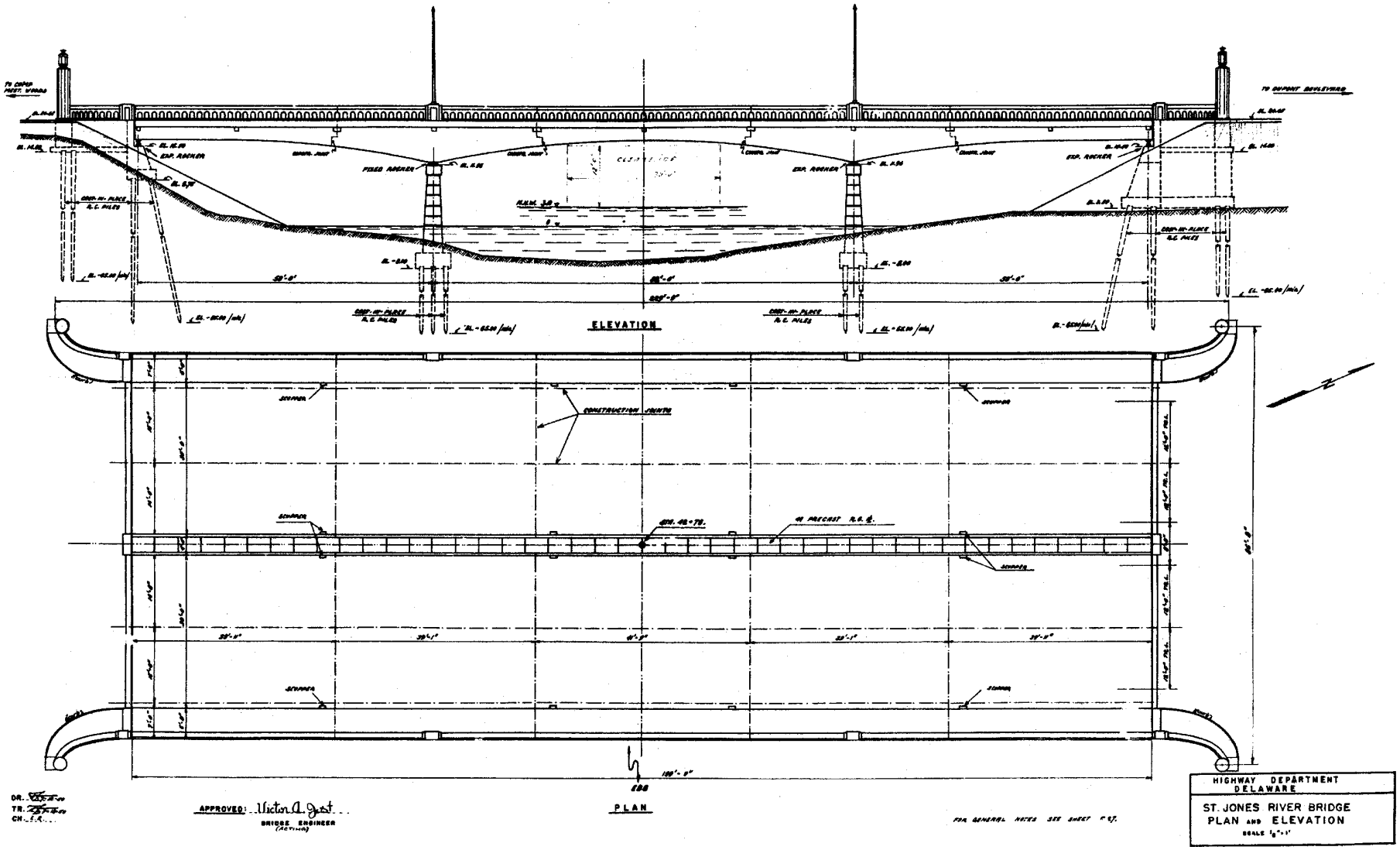
State Bridge K-24A (1951) on the Dover Bypass over the St. Jones River is an outstanding example of post-1940 advances in the application of T beam technology to longer span continuous structures.

US Route 13 *(Dover Bypass)* over St. Jones River

State Bridge K-24A
Dover, Kent County
1951

The US Route 13 over St. Jones River bridge is a three-span, continuous, reinforced concrete T beam bridge with an overall length of 200' and individual span lengths of 58', 82', and 58'. The haunched continuous beams have the characteristic greatest depth over the piers where the negative moments are greatest. T beams bear on rocker bearings at the piers. The bridge is supported on bullnosed piers with horizontal scoring, and on concrete abutments with wingwalls. Because of its 78'-width, it has a longitudinal joint. The sidewalks are supported by cantilevered brackets. The concrete balustrades, accented with vertically scored posts, terminate in fluted limestone pylons supporting Moderne-style bronze luminaires.

Built in 1951, the bridge is an outstanding example of post-1940 advances in the application of the T beam bridge technology to longer span continuous structures, achieving economy of material and design. The bridge is the only pre-1957 example of its type and design in the state. The Delaware State Highway Department Bridge Division designed the US Route 13 over St. Jones River bridge as part of its Dover bypass project, completed in early 1952. The four-lane, median divided highway provided an alternative route around downtown Dover, and it was a link in the department's project



Plans for Bridge K-24A were prepared by the Delaware State Highway Department, Bridge Division.

to dualize US Route 13 from Wilmington south to the Maryland border.

The department desired an economical and aesthetically pleasing design for the by-pass crossing of the St. Jones River. State bridge engineer Victor A. Jost had been impressed with a Portland Cement Association journal article featuring a continuous T beam bridge built in 1943 over the Chattahoochee River near Atlanta. That bridge, designed by the Georgia State Highway Department, was a 15-span, 701'-long structure with graceful continuous beams that reflected a structural need for increased depth over the piers where the stresses were the greatest,

Non-extant concrete culvert, built by the Luten Bridge Company of York, between Summit Bridge and Middletown, New Castle County.

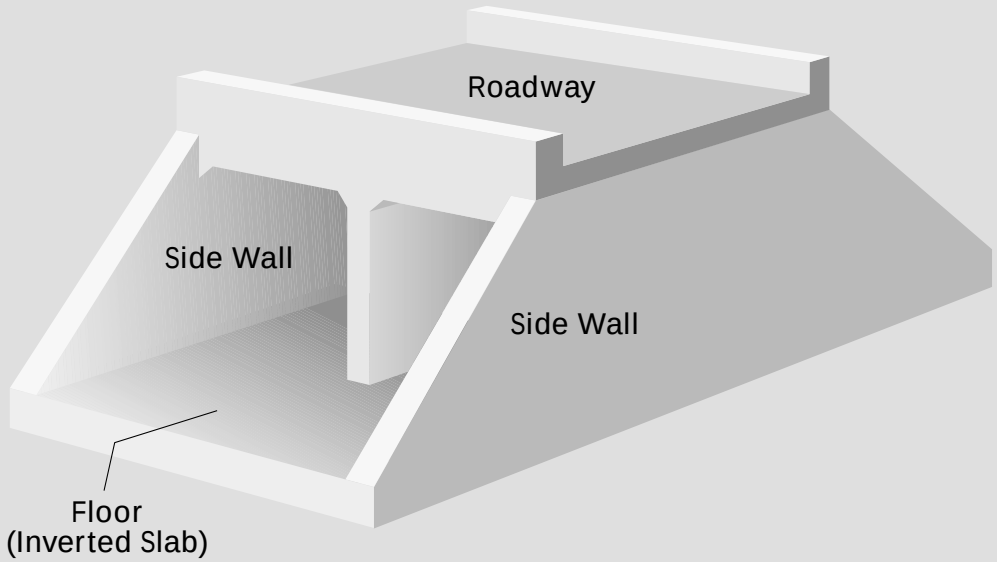
as well as an aesthetic design. The Georgia bridge had been designed by Clarence N. Crocker, who served as Georgia's state bridge engineer from 1933 to 1956. Georgia was an early advocate of the application of continuous designs to standard highway bridge types such as the steel multi girder and the reinforced concrete T beam. In early 1950, Delaware's Jost contacted Georgia's state bridge engineer arranging an exchange of plans and advice on stress analysis, false work, and concrete pouring sequences. Jost wrote that he found Crocker's information extremely helpful, and the St. Jones River bridge does, indeed, appear as a smaller version of the Chattahoochee River crossing. The contractor for the bridge was George & Lynch, Inc., Wilmington.

The fluted stone pylons, a distinctive feature of the St. Jones River bridge, were added by the state highway department to serve the dual function of ornamentation and roadway lighting. In a letter to the federal Bureau of Public Roads (BPR), state bridge engineer Jost justified the pylons stating that "...in urban areas, we feel that some attempt at ornamentation is justified, and, indeed, very desirable." Cut from Indiana limestone, the pylons were similar to a design that the department had developed in the late 1940s for its Cranston Heights Viaduct carrying State Route 2 (Kirkwood Highway) over Red Clay Creek in New Castle County.

Box Culverts

Reinforced concrete box culverts were used initially on American highways in the first decade of the 20th century, and they have a history nearly identical to the development of slab bridges. A box culvert derives its name from its similarity to a box with open ends. It is distinguished from a slab bridge by a slab integral with the side walls and floor (invert slab). Box culverts are especially appropriate for minor or seasonal streams and locations where head-

Reinforced Concrete Box Culvert



room is limited. They require little expensive form or foundation work, and they can be placed in trenches. The cover (top) slab can either directly support the roadway or be placed under fill. The culvert is proportioned to carry both live load and the entire weight of the fill, if any. Box culverts may be single or multiple cell (one or more openings) with the single-cell span length rarely exceeding twice the height. Since the 1910s, box culverts have been found to be economical and practical under the majority of conditions for spans in the range of 8' to 15'. The technology has changed little since the early 20th century; the only noteworthy change is the increasing substitution of precast box sections for cast-in-place sections during the last 30 years.

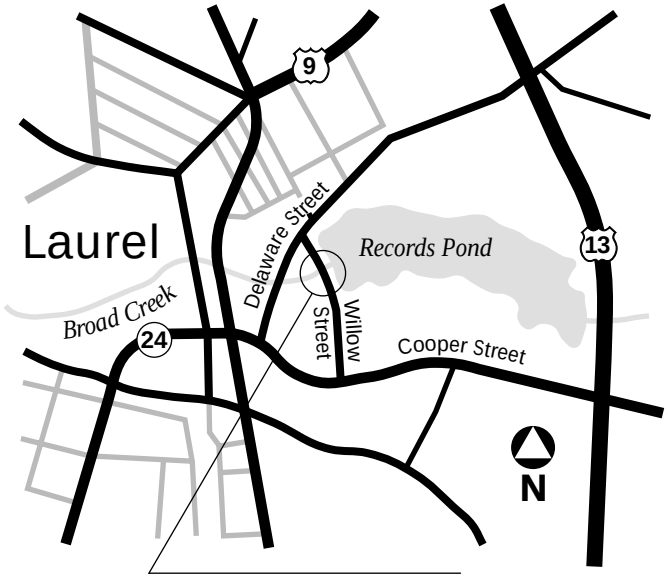
In Delaware, it is the early, unaltered box culverts and those historically associated with larger water control projects, such as the reconstruction of mill pond spillways and dams, that best represent the box culvert's technological significance. Two early examples are the ca. 1910 Willow Street over Records Pond box culvert (State Bridge S-329) in Laurel and the 1912 Hearn's Millpond Spillway box culvert (S-200H-1). Standard examples of 1920s to 1950s state highway department box culverts are the 1928 Road 460 over Barlow Branch Tributary culvert (NC-430), the 1933 Road 42 over Massey Pond Spillway culvert (K-42A), and the 1938 SR 24 over Burton Mill Pond Spillway culvert (S-709).

Willow Street over Records Pond Spillway

State Bridge S-329
Laurel, Sussex County
Designer/Builder: Unknown

ca. 1910

The four-cell, 33'-long, 16'-wide, box culvert carries Willow Street over the spillway of the Records Pond dam in downtown Laurel. The culvert openings are 16' high. It has a one-high rail concrete railing

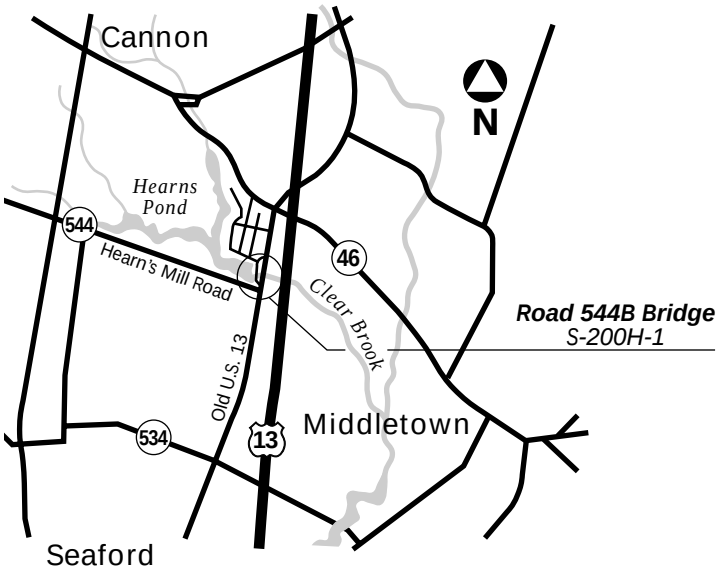


Willow Street Bridge
S-329

State Bridge S-329 is a ca. 1910 box culvert in Laurel, Sussex County. It spans the spillway of the Records Pond dam.

on the upstream side, and a two-high rail pipe railing on the downstream side. A W-beam guide railing has been placed to the inside of the pipe railing. Gates have been removed from the concrete gate frame on the upstream side of the culvert. A semi-circular sheet pile spillway has been added slightly upstream to maintain the pond's water level. Other than the culvert, dam, spillway, and pond, no other above ground evidence of the mills that once occupied this site remain.

The ca. 1910 box culvert is an early, technologically significant multi-cell example of its type. Combination spillway and bridge structures are not uncommon in the southern part of Delaware, and this is also one of the oldest surviving examples. Date of construction and builder are undocumented by available DelDOT records. The bridge appears to have been built under the auspices of the Sussex County Levy Court.



State Bridge S-200H-1 (1912) is a box culvert over the spillway to Hearn's Mill Pond.

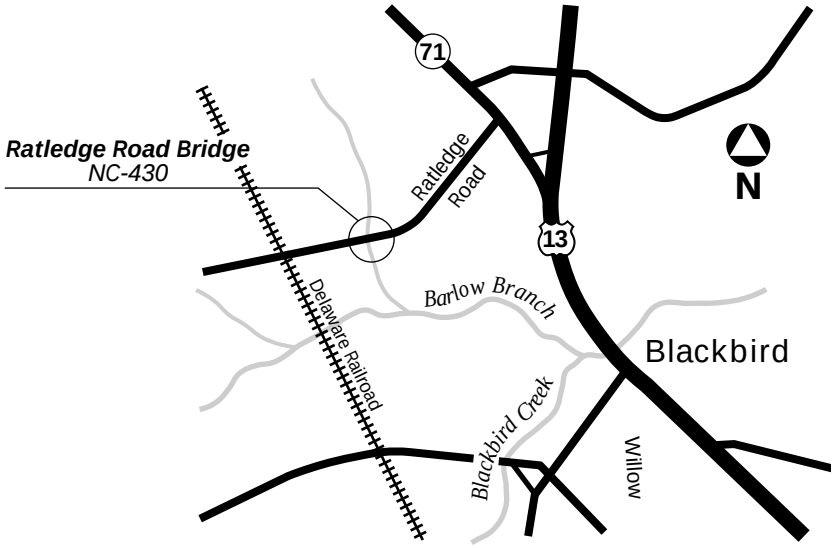
Road 544B *(Entry Lane)* over Hearn's Mill Pond Spillway

State Bridge S-200H-1
Hearn & Rawlins Mill, Sussex County
Designer/Builder: Unknown

1912

The two-cell, 11'-long, 14'-wide, reinforced concrete box culvert carries a single-lane, gravel road over the spillway to Hearn's Mill Pond. The road, which is closed to automobile traffic, is carried on top of the earth dam impounding the pond. The culvert has concrete curbs surmounted by replacement pipe railings. Metal I-beams are attached to the upstream side of the culvert and serve as tracks for wood-slat sluice gates controlling the water level in the mill pond.

The box culvert is an early example of its type in the state, and it is historically associated with the National Register-listed Hearn & Rawlins Mill located southeast of the spillway. The flour mill, built in 1879, is still operative. The dam, spillway, and culvert were constructed in 1912 as part of improvements to the mill's waterpower system. The raceways and waterpower system survive, although the mill was converted from waterpower to electric power in the mid 1980s. The culvert is an integral part of the historically significant mill complex with rare surviving machinery and waterpower system.



Ratledge Road *(Road 460)* over Barlow Branch Tributary

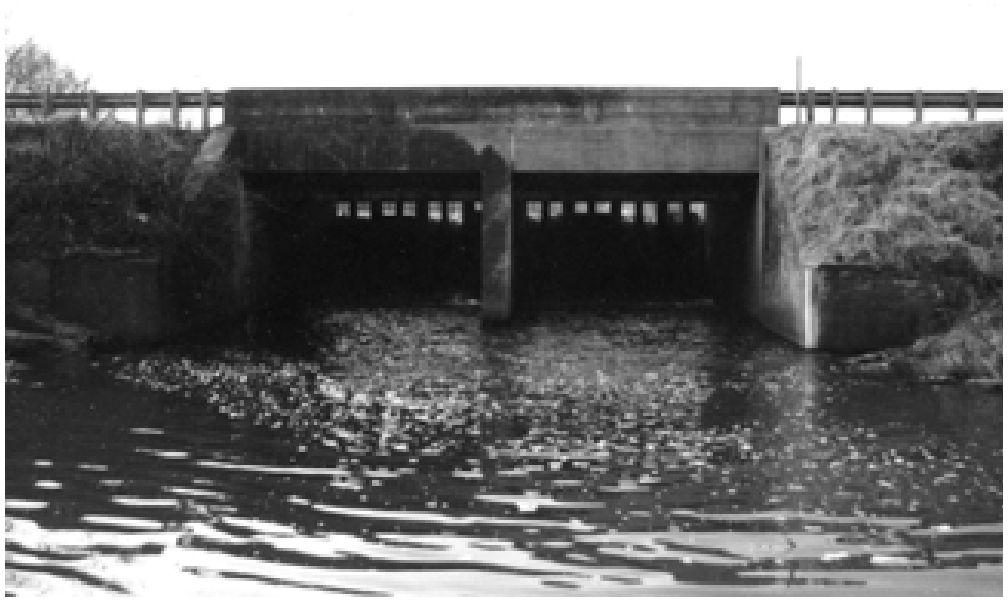
State Bridge NC-430
Southeast of Townsend, New Castle County
Designer/Builder: New Castle County Engineer

1928

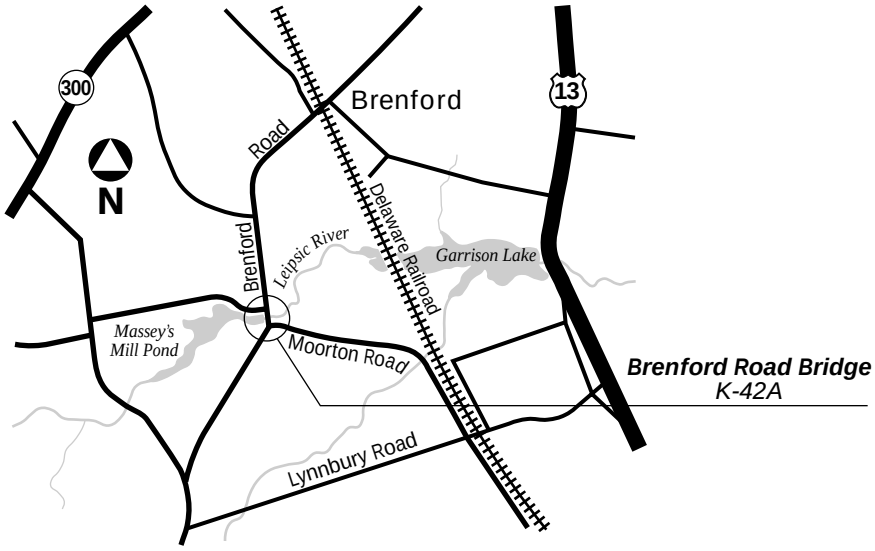
State Bridge NC-430 (1928), a box culvert designed by the New Castle County Engineer

The one-cell, 10'-long, reinforced concrete box culvert is finished with paneled parapets that extend over the U-shaped wingwalls. The 1928 Road 460 culvert is a complete example of the standard box culverts built by New Castle County during the 1920s and early 1930s, before the county bridges and roads were taken over by the state highway department in 1935.

Plans were prepared by the Office of the County Engineer with notes that they could be used with Bridge #419 as well. The plans illustrate how the standardized box culvert type was used to build a large number of similar structures during the county's early 20th century bridge and road improvement campaign. Like many reinforced concrete box culverts, the Road 460 culvert was considered an economical and permanent means of replacing a previous timber bridge.



State Bridge K-42A (1933)



Brenford Road *(Road 42A)* over Little Duck Creek *(Massey's Mill Pond Spillway)*

State Bridge K-42A Massey's Mill Pond, South of Smyrna, Kent County
Designer/Builder: Delaware State Highway Department/ George & Lynch

1933

The two-cell, 32'-long, reinforced concrete box culvert is finished with paneled concrete parapets. The culvert spans the spillway of Massey's Mill Pond. Brenford Road is carried atop the earthen dam impounding the pond. Concrete tracks on the upstream side of the culvert are used to hold and guide the spillway's wood sluice gates.

The culvert is complete and is a representative example of the standard box culverts designed by the Delaware State Highway Department from the late 1910s to the 1950s. It was built in 1933 as part of a federal-aid project to construct a one-lane, 9'-wide concrete road between Brenford and Seven Hickories, a distance of about three miles. Financed with funds appropriated by Congress under the Emergency Relief and Construction Act as a supplement to the existing federal-aid highway programs, the project was part of nationwide efforts to provide work relief for the unemployed during the Great Depression. Timeliness was essential because the funds had to be expended by July 1933. The state highway department awarded the contract to George & Lynch of Dover in January 1933, and the project was completed by May of that year.

The culvert replaced a timber bridge and

State Bridge S-709 (1939-40), a combination spillway and box culvert.

spillway at the same location. Combination bridges and water control structures are not uncommon in southern Delaware. In the early 20th century, as rural mills declined, the counties and state often took over and repaired or improved the dams and spillways, such as this one at Massey's Mill, as part of efforts to control flooding and maintain sources of water for irrigation or recreation.

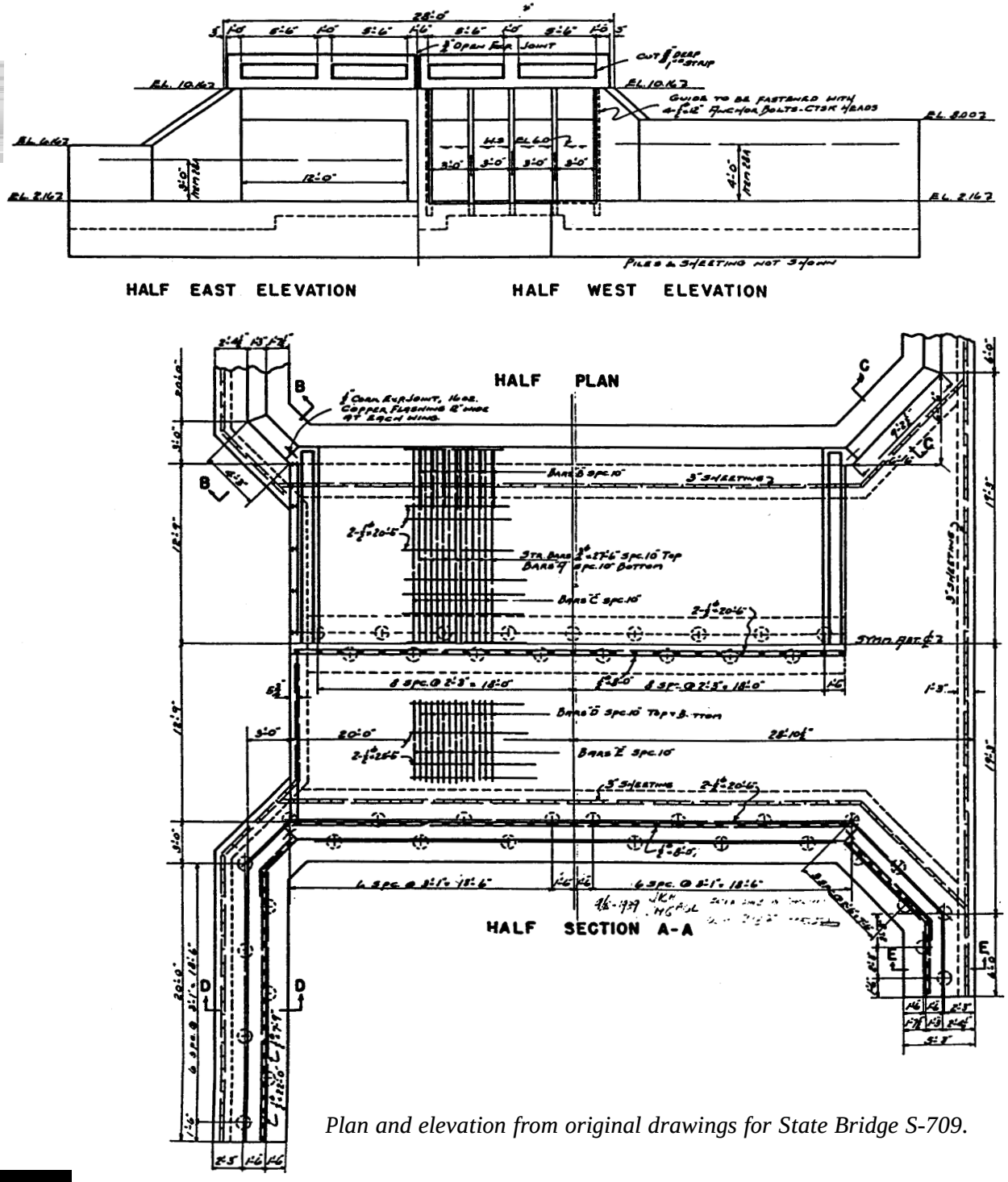
In June 1996, the Massey's Mill Pond dam broke and over 100' of the earth dam and roadway to the north of the culvert were washed away. The culvert was not damaged. The lost section of dam and roadway was rebuilt.

State Route 24 over Herring Creek *(Burton Mill Pond Spillway)*

State Bridge S-709
Southwest of Rehoboth, Sussex County
Designer/Builder: Delaware State Highway Department/Walter Roach & Sons
1939-40

The 1939-40 State Route 24 culvert is a two-cell, 26'-long, 39'-wide, reinforced concrete box culvert with paneled concrete parapets. The culvert forms the spillway to Burton Mill Pond, and the highway is carried atop the earth dam that impounds the pond. Wood sluice gates are built into the upstream side of the culvert. An invert slab is downstream.

The culvert was chosen for its historical and technological significance as a complete example of the combination spillway and culvert structure frequently built in southern Delaware by the state highway department from the 1930s to the 1950s. The culvert was designed by the department's bridge division under the supervision of State Bridge Engineer Arthur G.



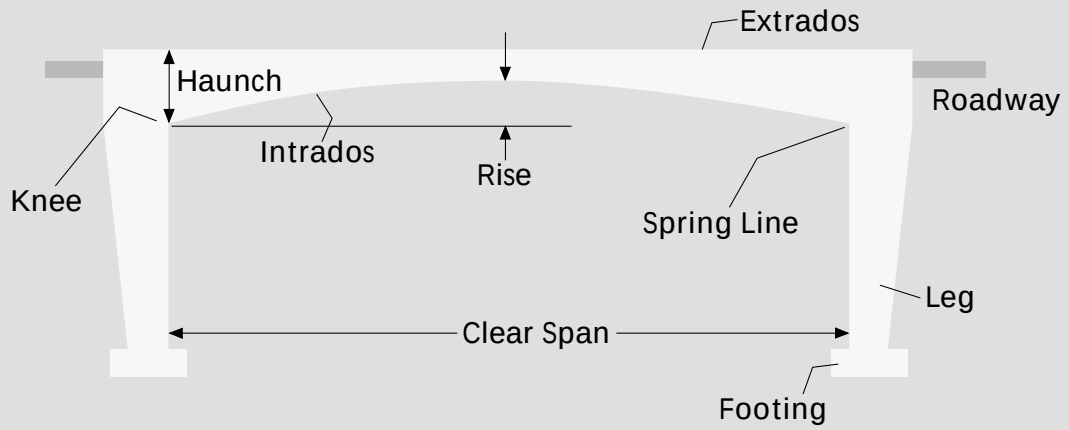
Plan and elevation from original drawings for State Bridge S-709.

Livingston as part of a federal-aid project involving the widening and concrete paving of approximately nine miles of State Route 24 from Harmon School to Midway. The department reported to the federal Bureau of Public Roads that "in addition to carrying a rather heavy volume of summer traffic to beach points, this project serves a substantial area of average farm land. [It] extends through the town of Millsboro [which] provides a railroad shipping point for local farm produce." The contract for the work was awarded to Walter Roach & Sons of Georgetown. Work commenced in June 1939 and was completed in July 1940. The culvert replaced a previous timber bridge and spillway constructed by the state highway department in 1927 and widened in 1932.

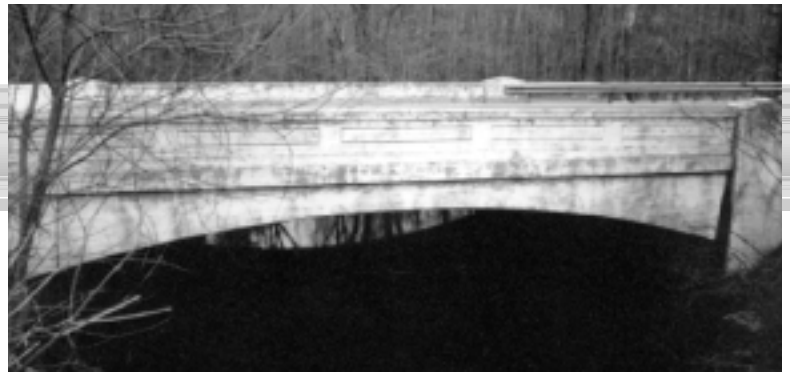
Rigid Frame Bridges

The reinforced concrete rigid frame bridge, where the top member and the verticals are integral and the legs perform useful work in supporting the loads, remains one of the most efficient uses of both steel and concrete. The technology was developed in Europe during the last part of the 19th century, and it was not utilized in this country until the early 1920s when it was used by Arthur G. Hayden, designing engineer of the Westchester County Park Commission, on the Westchester County (New York) parkways. The technology requires expensive and restrictive form work to erect, but is an efficient use of material, and it reduces the amount of work in ground because the mass of the abutments is reduced. The bridge type, which results in well proportioned spans with clean lines, was favored for use on parkways and in park settings. The intrinsic form of the rigid frame with its typical shallow arch lent itself well to settings where an aesthetic bridge was desired.

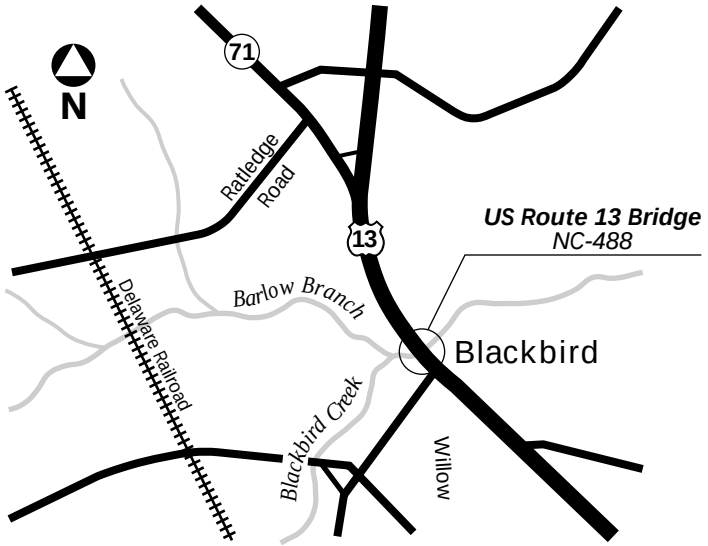
Reinforced Concrete Rigid Frame Bridges



The Delaware State Highway Department first introduced rigid frame technology in the early 1930s with bridges like the 1931 US 13 Northbound over Blackbird Creek bridge (State Bridge NC-488N). Delaware State Bridge Engineer A. G. Livingston favored the design from the mid 1930s to the early 1940s, and it continued to be built to a limited extent into the 1950s. The 1948-49 Curtis Mill Road over White Clay Creek bridge (State Bridge NC-231) in Newark, which is a ribbed, three-span continuous example, is noteworthy as one of the nation's earliest examples of a variation in rigid frame design.



(ABOVE) State Bridge NC-488N (1931) on US 13 over Blackbird Creek was the Delaware State Highway Department's first rigid frame bridge. (BELOW) State Bridge NC-488N as it appeared in the 1932 Annual Report.



US Route 13 Northbound *(DuPont Highway)* over Blackbird Creek

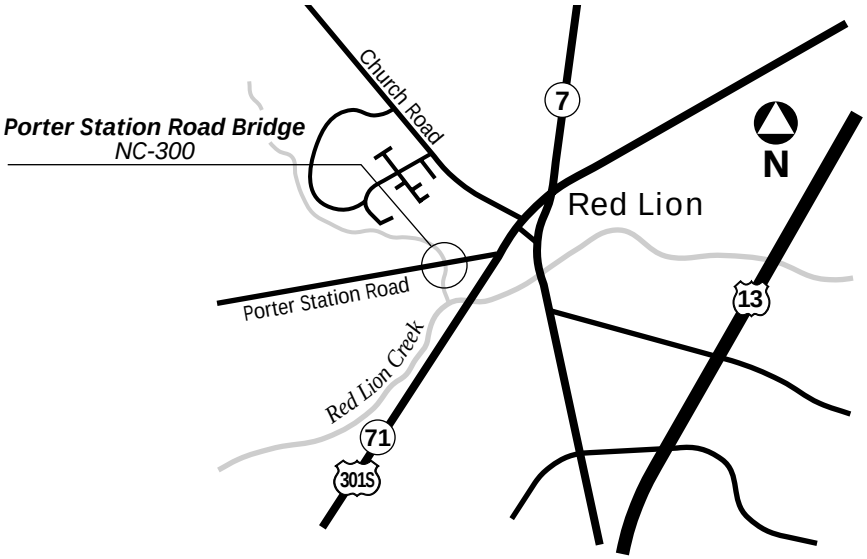
State Bridge NC-488N
North of Blackbird, New Castle County
Designer/Builder: Delaware State Highway Department/Vincent Schiavi

1931

The US Route 13 Northbound bridge is a one-span, 47'-long, 41'-wide, reinforced concrete rigid frame bridge. It is finished with paneled concrete parapets, and pilasters at the abutment corners are accented with diamond-shape panels. The bridge has U-shaped wingwalls also finished with concrete parapets. The rigid frame's slightly arched profile to the soffit provides maximum depth at the knees where the bending moment is greatest and the stress pattern is most complex. In 1988, the bridge was strengthened by the addition of a concrete bent at midspan.

The bridge was built in 1931 as part of efforts to convert US Route 13 to a dualized highway between Dover and Wilmington from 1927 to 1933. US Route 13 was one of the nation's first dualized US-numbered highways. Dualization consisted of separating two or more lanes of opposing traffic with grass median. The 4.76 mile long section from Reynold's Corner to Fieldsboro was dualized from 1931 to 1933 under a federal-aid contract awarded to contractor Vincent Schiavi of Buffalo, New York. Schiavi subcontracted the bridge construction to William F. Anderson.

The bridge was designed by the state highway department's bridge division under the direction of State Bridge Engineer Arthur G. Livingston. It is the oldest extant rigid frame bridge in Delaware. Livingston's orig-



(Above) State Bridge NC-300 (1934) is an early and complete example of the rigid frame bridge type.

(Below) State Bridge NC-300 replaced this small culvert in 1934.

inal contract correspondence for the US Route 13 Northbound bridge indicates that the rigid frame bridge type was chosen over a reinforced concrete deck arch as the design would allow for a savings of approximately 40 yards of concrete. In a letter to the federal Bureau of Public Roads, he noted that "this is a new type of construction to be built in Delaware," and he requested comments on the plans as the BPR's engineers could be expected to have had broader experience with rigid frame bridges in other parts of the nation. The US Route 13 Northbound bridge marks the introduction of an important new bridge technology into the state following its rise to national attention during the 1920s.

Porter Station Road *(Road 383)* over Red Lion Creek

State Bridge NC-300
Southwest of Red Lion, New Castle County
Designer/Builder: Delaware State Highway Department/Olivere Paving and Construction Company

1934

The Porter Station Road bridge is a one-span, 13'-long, 27'-wide reinforced concrete rigid frame bridge. It is finished with concrete balustrades, and it is supported on concrete abutments with U-shaped wingwalls. The bridge is significant as an early and complete example of the rigid frame bridge type introduced in Delaware by the state highway department bridge department in the early 1930s. State Bridge Engineer Arthur G. Livingston prepared the design for the bridge that was built as part of a state-aid project to improve

State Bridge NC-231 replaced an 1861 covered bridge.

1.37 miles of road between Red Lion and Porter Station. The contract was awarded to the Olivere Paving and Construction Company of Wilmington; Julian T. Jones is listed as subcontractor. The rigid frame bridge replaced a timber multi girder bridge with stone abutments. This short-span rigid frame design was employed for a number of other state highway bridges during the late 1930s.

Curtis Mill Road *(Paper Mill Road/ Road 13)* over White Clay Creek

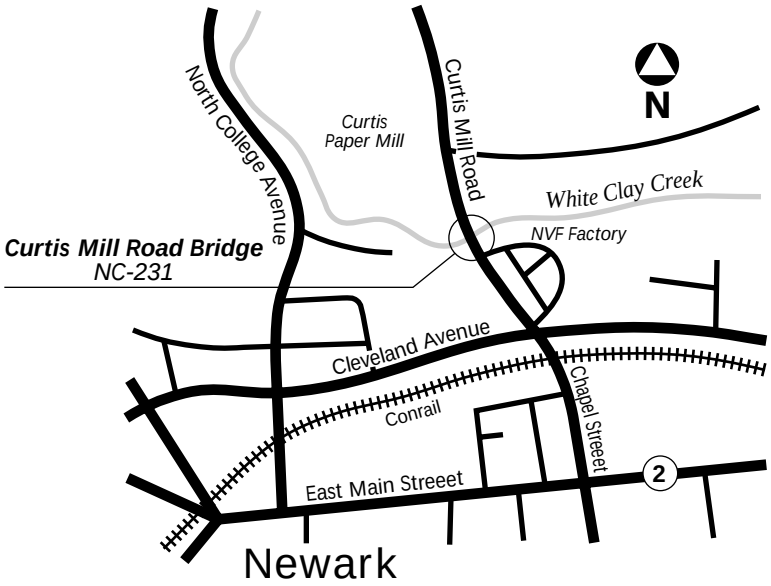
State Bridge NC-231
Newark, New Castle County
Designer/Builder: Delaware State Highway Department/James Julian, Inc.

1948-49

The three-span, 160'-long, ribbed, reinforced concrete rigid frame bridge has a 118'-long center span flanked by two, 21'-long spans cantilevered from the frame legs. The ribs have reinforced-concrete diaphragms and an integral slab deck. The cantilevered design eliminated the necessity of expensive abutment work. The 39'-wide bridge is finished with Moderne-style concrete balustrades with vertically scored, stepped posts above the piers and wingwalls. The frame legs (which are the substructure) are tapered and accented by vertical scores. Reinforced concrete backwalls were built to support the fill of the approach roadways.

Built in 1948-49, the Curtis Mill Road bridge is an early application of continuous reinforcing and ribbing to the rigid frame bridge type, used to achieve longer spans with an economy of material. It is representative of mid-20th-century refinements to the rigid frame technology, which was introduced in the United States in the 1920s, and first introduced in Delaware by the state highway department in the early 1930s. It is the only pre-1957 example of the ribbed and cantilevered design identified in Delaware and is among the oldest examples of its design in the nation.

The state highway department's bridge division under the direction of State Bridge Engineer Arthur G. Livingston prepared the design of the Curtis Mill Road bridge from 1938 to 1941. Construction was delayed until 1948-49 by World War II. Livingston, who served as state bridge engineer from 1918 to 1948, appreciated the aesthetic qualities of rigid frame bridges and first introduced the bridge type to state highways in the early 1930s. In 1938 he began planning an in-



The Curtis Mill Road bridge (State Bridge NC-231) is the state's only identified example of a ribbed rigid frame bridge.

Curtis Mill Road bridge is finished with Moderne-style concrete balustrades with vertically scored, stepped posts above the piers and abutments. Characteristic of rigid frame bridges, the bridge has a shallow arched profile with the superstructure and legs constructed as a single cast-in-place unit. The frame legs (which are the substructure) are tapered and accented by vertical scores.

novative ribbed rigid frame bridge to replace the 1861 covered bridge at Curtis Mill Road in Newark. State records show that he corresponded with engineers of the federal Bureau of Public Roads, the Portland Cement Association, and with George Rice, a consulting engineer from Baton Rouge, Louisiana, asking for assistance with stress analysis, proportioning, and placement of reinforcing steel. By the late 1930s, rigid frame bridges were common, but in general were used only for single-span applications of from 35'- to 85'- long. Multiple span applications required difficult and sophisticated stress analysis because of the indeterminate nature of rigid frame structures, and were not often attempted. In the 1940s and 1950s, engineers demonstrated a growing confidence in the design calculations necessary to build continuous, indeterminate structures of both steel and reinforced concrete. ■