

WEAVERLAND BRIDGE
(Quarry Road Bridge)
Pennsylvania Historic Bridges Recording Project III
Quarry Road spanning Conestoga Creek
Terre Hill vicinity
Lancaster County
Pennsylvania

HAER No. PA-589

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

REDUCED COPIES OF MEASURED DRAWINGS

HISTORIC AMERICAN ENGINEERING RECORD
National Park Service
U.S. Department of the Interior
1849 C St. NW
Washington, DC 20240

HISTORIC AMERICAN ENGINEERING RECORD

INDEX TO PHOTOGRAPHS

WEAVERLAND BRIDGE

HAER No. PA-589

(Quarry Road Bridge)

Quarry Road spanning Conestoga Creek in East Earl Township

Terre Hill vicinity

Lancaster County

Pennsylvania

Jet Lowe, Photographer, summer 2003

- PA-589-1 NORTH APPROACH TO BRIDGE, LOOKING SOUTH ACROSS ROAD DECK.
- PA-589-2 PERSPECTIVE OF EAST ARCH SECTION, SHOWING FIVE PANELS MADE UP OF DIAGONAL SUSPENSION RIBS AND VERTICAL RIBS. THE ABUTMENTS, PIERS, WING WALLS, COPING AND DECK ARE OF CONCRETE.
- PA-589-3 INTERIOR DETAIL OF EAST ARCH SECTION.
- PA-589-4 EXTERIOR PERSPECTIVE OF EAST ARCH BY 45°.
- PA-589-5 BELOW DECK DETAIL OF CONCRETE SLAB DECKING.
- PA-589-6 PERSPECTIVE VIEW NW BY 310°. NOTE THE CONCRETE PIER EXTENDING FROM THE BRIDGE IN THE FOREGROUND. THIS WAS TO ALLOW MAXIMUM WATER FLOW DURING FLOODS AND RAINY PERIODS.
- PA-589-7 SOUTH APPROACH, LOOKING NORTH. THE GALVANIZED PIPING EXTENDS FROM THE ABUTMENTS ACROSS THE LENGTH OF THE ARCH.

HISTORIC AMERICAN ENGINEERING RECORD

WEAVERLAND BRIDGE
(QUARRY ROAD BRIDGE)

HAER No. PA-589

Location: Quarry Road (Township Route 894) spanning Conestoga Creek in East Earl Township, Terre Hill vicinity, Lancaster County, Pennsylvania

UTM: Terre Hill 18/409833/4442882

Date of Construction: 1916

Engineer: Firm of Frank H. Shaw

Fabricator: John T. Brubaker

Present Owner: East Earl Township

Present Use: Vehicular traffic

Significance: The tied-through reinforced concrete arch Weaverland Bridge, built in 1916, is a historically and technologically significant early and rare example in the State of Pennsylvania of a rainbow type tied bridge with diagonal members. It was determined in 1993 by the Pennsylvania Historic and Museum Commission to be eligible for the National Register.

Historian: Richard Vidutis, August 2002

Project Information: The Pennsylvania Historic Bridges Recording Project III is part of the Historic American Engineering Record (HAER), a long-range program documenting historically significant engineering, industrial and maritime sites in the United States. The National Park Service, U.S. Department of the Interior, administers the HAER program. The Pennsylvania Historic Bridges Recording Project III was co-sponsored during the summer of 2002 by HAER under the general direction of E. Blaine Cliver, Chief; and the Pennsylvania Department of Transportation (PENNDOT), Bureau of Design, Dean A. Schreiber, Director; and the Pennsylvania Historical and Museum Commission, Brent D. Glass, Executive Director and State Historic Preservation Officer. Ms. Kara Russell

of the Bureau of Design's Environmental Quality Assurance Division served as principal liaison.

The fieldwork, measured drawings, historical reports and photographs were prepared under the direction of Eric DeLony, Chief of HAER. The team consisted of: Architects-Todd A. Croteau, Project Leader (HAER Architect), Roland S. Flores, Field Supervisor (HAER Architect), Marcy Ann Giannunzio (University of Michigan, Ann Arbor), Katherine Marie Kozarek (University of California, Berkeley), Sara Kryda (Illinois Institute of Technology), Jenna Michelle Murphy (University of Detroit-Mercy), Sandra Christina Pires (ICOMOS-Portugal); Dr. Linda S. Phipps and Dr. Richard Vidutis served as project historians under the direction of Dr. Richard O'Connor (HAER Senior Historian), and Professor Thomas E. Boothby, PhD, PE, RA (Pennsylvania State University, State College), was the Consulting Engineer, and Jose C. Colon (Pennsylvania State University, State College) was the project engineer. Jet Lowe (HAER photographer) took all large format photography. Justine Christianson prepared all documentation for transmittal to the Library of Congress.

INTRODUCTION

The Weaverland Bridge (BMS No. 36721308944002), currently a vehicular bridge, is located in East Earl Township, Lancaster County, Pennsylvania and is owned by East Earl Township. The bridge carries Quarry Road (Township Route 894), a two-lane road, over Conestoga Creek in an area known as Weaverland. The bridge is situated within a rural area with a quarry to the south of the bridge and an altered vernacular residence to its north. In 1993, the Pennsylvania Historic and Museum Commission found the bridge to be eligible for the National Register. An exact twin of the Weaverland Bridge, Big Chickies Bridge (HAER No. PA-630), was also built in 1916 along Auction Road at Lancaster Junction over Big Chickies Creek in Lancaster County and is the subject of a HAER report.

The Weaverland Bridge is notable for having been designed by the firm of Frank H. Shaw. Frank H. Shaw, Lancaster County Engineer (1909-1917), along with his brother Percy A. Shaw, Designing Engineer, had a significant impact on reinforced concrete bridge construction in Lancaster County from approximately 1909 to at least the mid-1920s. During that time Lancaster County had about forty of the firm's bridges built in the county. It appears that in a number of cases the firm of Frank H. Shaw also supervised the construction of its designed bridges.

During the course of researching the history of the Weaverland Bridge, the original engineering drawings of the bridge by the firm of Frank H. Shaw were discovered at the Lancaster County Engineer's Office in Lancaster. Special thanks must be given to Mr. Robert Navitski, P.E., Assistant County Engineer, who found the drawings in the office's archives and provided access to the two volumes of Bridge Dockets that contain historic information on reinforced concrete bridges built in Lancaster County from 1908 to 1924. Today the bridge is owned by East Earl Township.

COUNTY AND LOCAL HISTORY

Development of Roads in Lancaster County

Lancaster County was one of the first inland communities to develop a large population center of Anglo-Americans outside of New England. Central to the growth of the county's populations were its roads, because they were its principle trade routes, along which such

villages as Lititz and Ephrata developed. The early roads of European settlers followed old Indian paths establishing trading routes between European and Indian settlements. One of the more important routes was French Creek Path, which ran through Berks County and Caernarvon Township in Lancaster County between Black Creek and the Conestoga Creek.¹ This area of East Earl Township developed as a consequence of a major road that approximately paralleled the Conestoga Creek and French Creek and connected the vast area between the Susquehanna and Schuylkill Rivers. Within this corridor, and lying along a route now known as Quarry Road that branches off the old Indian path, the settlement of Weaverland developed at a crossing over the Conestoga Creek. It is there, just south of the area's important trading center at Terre Hill, that the reinforced concrete bridge built by John T. Brubaker is located over the Conestoga Creek.

Dependence on the Indian paths for travel and commerce was insufficient by the 1720s as the growth of European settlements increased. In southern Lancaster County the establishment of numerous mills beside creeks and rivers created nuclei of economic activity and settlement growth. Evolving economic interests required dependable river crossings and improved roadways for unhampered access to the mills. The power to approve roads and bridges was given to local residents by the Lancaster County Court in 1729 when Lancaster County was formed from Chester County.² East Earl Township was taken from Earl Township, which was one of the original townships organized in 1729 in Lancaster County.

The new roads approved by the citizens usually started from points along old established roads. Often they joined the sites of prominent landowners and their economic ventures, such as mills and furnaces, with major roads. The sites were located by water crossings to make use of the available waterpower, rather than transportation since few of the waterways in Lancaster County were navigable. By the 1740s, many short connecting roads had been constructed, and by 1760, road building had increased dramatically. By the first half of the eighteenth century, the Weaverland Valley had already developed a road system that joined local farmsteads, but a structural crossing over the Conestoga Creek was not yet developed. The increase in road construction was a response to the importance of the Borough of Lancaster as the county's main

¹ Lancaster County Historic Transportation Cultural Resource Study, Lancaster County Board of Commissioners and Lancaster County Planning Commission, October 1997, p. 19.

² *Ibid.*

distribution point for trade and supplies moving along the Appalachian Ridge from New York to North Carolina. By the late eighteenth century, a radiating network of roads joining people and goods from county communities and even more distant ones surrounded Lancaster. By the early twentieth century, Lancaster County could boast of having passable roads reaching all areas of the county.³

Development of Manufacturing in Lancaster County

Lancaster County has a large number of streams and rivers that made it a suitable place for the construction of water mills. The first mills in the territory were built on Chickies Creek in 1719 and on the Big Conestoga Creek in the late 1720s.⁴

In colonial Lancaster County, mills were usually located at the beginning and end points of roads that crossed waterways. Gristmills served a small number of local farmers and also provided a social meeting place for the local mill customers. Some mill sites were very active centers that even had their own post offices. Besides evolving into locally important economic and social centers, mills represented sizeable investments of capital, local resources, and employment of specialized labor. Mill owners usually were some of the wealthiest residents of the local community as evidenced by the substantial buildings that were usually constructed for the mill and the owner.⁵

Weaverland and the Bridge Site

The site where the Weaverland Bridge is situated was once a busy location containing processing mills, living quarters, a store, a post office, and eventually an electric generating plant. Today there is no evidence of any of these facilities.

The word Weaverland comes from the German “Webers Tahl” or Weber’s Dale. Swiss Mennonite and German Reformed settlers were the first Europeans to settle and map out this

³ Ibid., p. 22-30.

⁴ Mary H. Yeager, “Historic Bridge-Building in Lancaster County,” Journal of the Lancaster County Historical Society XLI, no. 6 (1937): 135.

⁵ Lancaster County Historic Transportation Cultural Resource Study, pp. 30-33.

land south of Blue Ball where the Mennonites formed their first congregation in 1730. By 1740, settlers had built a log building that was used as a German school and for purposes of worship. In 1766, George Martin sold the Mennonites 1 acre of land where a stone meeting house and draw-wheel were erected.⁶

The Weaverland site functioned primarily as a mill processing location during most of its history and was one of many mills situated along the Conestoga Creek. In 1738, Jacob Bayerele occupied 390 acres of land in the Weaverland Valley and gained title to it in 1739. He eventually purchased it in 1745. In a 1748 mortgage, Bayerele stated that there was a gristmill, a sawmill and an oil mill one mile upstream on the property. In 1754, he sold the tract of land to two brothers Peter and Michael Shirk, and by 1753, they were running grist and saw mills. Also in 1753, a road had been laid out from Ream's Mill to Shirk's Mill. The Shirk family continued building and operating various mills in the region for over one hundred years, including grist, saw, oil, hemp and carding mills.⁷ The first map to show a crossing over the Conestoga Creek appeared in 1824 and indicated that D. Shirk owned land adjacent to it. An interesting feature on the map is what may be a mill run supplied by a dam.

In 1844, David Shirk advertised that his property was for sale on the Conestoga Creek near Landis' store. The 9 acres of property offered for sale included a two-story dwelling house, a three-story gristmill with two pairs of burr stones and two pairs of chopping stones, and a sawmill with a circular saw and hemp mill built in 1830. Bridgens 1855 map shows Oberholser's store north of the river crossing and a grist and sawmill to the southeast of the crossing still being supplied by a mill run from a dammed area on the river. In 1858, Shirk's property once again was advertised for sale with 18 acres. The mill, described as having two overshot water wheels (9'-6" x 6'-8") and three sets of stones, produced twenty-five barrels of flour per day. The property was eventually sold in 1860 to Abraham Rupp who operated the mills with his son Christian for about twenty years.⁸ Bridgens 1864 map includes Abraham Rupp's grist and saw mill, which appears to be next to the southeast quadrant of the river crossing. By 1875, a saw and

⁶ M.G. Weaver, "Spring Grove, Weaverland and Blue Ball. Settlement and Development," Journal of the Lancaster County Historical Society XXXV (1931): 149.

⁷ R. Harold Barton, "East Earl Mill" (Site number 165), in Mills and Bridges of Lancaster County, Pennsylvania. Vol. 1 ("Number 1 to 188"), Vol. 5. ("Indices by Name of Mill, Township Location and Name of Stream"), and Notebooks; Weaver, p. 162.

⁸ Ibid.

a flour mill are indicated on Everts and Stewart's map, five years after the construction of the crossing's first bridge.

In 1888, Eli Martin became the owner of the land, and he had a new gristmill built on the site of the old mill.⁹ By 1899, the Weaverland crossing had become an important center that supported a number of facilities as indicated by the array of structures included on Graves and Steinberger's map of 1899.

From 1889 to 1914, Martin's Mill became the location of the Weaverland Post Office and a station since the iron bridge carried a trolley line to Terre Hill. The trolley company built a rotary at Martin's Mill to operate the gristmill machinery. Martin's gristmill may have been the first mill in the locality to use electric power. The last miller at the site was Leroy Sensenig. After the milling operations ceased, the Pennsylvania Power and Light Company gained access to the land and raised an existing dam, which probably was the one indicated on the 1824 and 1855 maps, to 20' and used the mill as a substation, naming it the Terre Hill Station.¹⁰

Earlier Crossings at the Weaverland Site

A high iron bridge of unspecified type was built by the Continental Bridge Company in 1870 at Isaac Rupp's Mill on the road described as leading from the Earl School House to Fairville (now Terre Hill).¹¹ The extreme length of the bridge was 58' with a roadway width of 10.5' and placed 9.5' above the low water mark. It cost \$1,976.60 to construct.¹² The iron bridge was placed over an old ford, which was on the public road leading from the farm of Captain Henry Hambright, west of Terre Hill, to Martin's Mill Station, on the Terre Hill trolley road, which crossed the stream just above the mill.

The cost of servicing the iron bridge eventually proved too expensive and led to the construction of the concrete truss span bridge. The Bridge Dockets records a total of four repair

⁹ Ibid.

¹⁰ Ibid.

¹¹ Bridge Dockets, Commissioners' Office, Lancaster County Court House (small volume), p. 113 [Lancaster Court House, Lancaster City, has two undated volumes of Bridge Dockets distinguished only by size (relatively one small and one large volume), but both have bridges arranged by the name of the creek or river they cross. The numbering system for the bridges is flexible in that they are assigned different numbers throughout the history of the bridge].

¹² Ibid.

expenditures from 1891 to 1909 that amounted to \$896.42, fully one-fourth the cost of the new concrete bridge that was to be built in 1916.¹³

DESIGN AND DESCRIPTION

Development of the Reinforced Concrete Bridge

The reinforced concrete bridge was first developed in Europe and was slow to be accepted in America. In 1876, Jean Monier of France invented the first concrete metal arch by imbedding wire netting in the concrete of the arches. In 1884, R. Wunsch of Hungary, invented the Wunsch system of concrete metal arch building. It consisted of an arched lower and straight upper member of metal imbedded in concrete and connected with vertical members deeply imbedded in piers and abutments. In 1892, Joseph Melan of Austria-Hungary developed the concrete metal arch known as the Melan system, which was patented in the United States in 1893. The Melan system consisted of arched ribs filled with concrete and rigidly connected to abutments, beams and girders. Melan bridges were built throughout Europe, but there were as many as twenty-seven in the United States by 1899.¹⁴

In 1894, a German born engineer working in America by the name of Fritz von Emperger, claimed that concrete and steel could be used successfully and complimentary in the construction of bridges.¹⁵ Tests in Austria proved that such a combination would indeed produce a strong structure. The faith in the miraculous qualities of this combination of materials lead to the belief that steel would be permanently preserved if set in concrete and that the bridge would actually strengthen by degree.¹⁶ In 1902, Daniel B. Luten, a prominent American designer of reinforced concrete bridges, described the advantages of bridges built from such materials:

¹³ Ibid., and (large volume) p. 154.

¹⁴ Edwin Thacher, "Concrete-Steel Bridge Construction," Engineering News XLII, no. 12 (September 21, 1899): 181. Carl Condit dates Melan's patent in the United States to 1894, American Building Art: The Nineteenth Century (New York: Oxford University Press, 1960), p. 249.

¹⁵ Fritz von Emperger, "The Development and Recent Improvement of Concrete-Iron Highway Bridges." Transactions, American Society of Civil Engineers XXXI (1894): 703.

¹⁶ Thacher, p. 170. Daniel B. Luten explained that since steel gives off carbonic acid, which is the cause of rust, "concrete by its absorption of carbonic acid gas grows continually stronger with age, and the suitability of concrete-steel for bridge construction becomes most evident; as traffic grows heavier, the bridge grows stronger, quite a contrast from any other form of bridge erected." Daniel B. Luten, "Concrete-Steel Bridges," Municipal Engineering XXIII, no. 3 (September 1902): 156.

A concrete arch, properly constructed, is practically indestructible. As it grows older it grows stronger: it is not affected by weather; it requires neither painting nor repairing; it has no plank floor system to be continually out of order; it is made of materials that can usually be purchased in the immediate vicinity, and labor as well as materials may be, to a large extent, the home products of the town or county; and it is a handsome bridge structure—for not only is the arch form especially adapted to artistic treatment, but concrete is a material that can be molded into many forms of ornament at small cost.¹⁷

In 1904, M.A. Considere designed and built the first recorded example of a reinforced concrete bowstring bridge in France that appears to have been directly based on a metal bowstring bridge. In America, the first known example to be built was designed by Howard M. Jones, engineer for the Cumberland River Bridge Commission in Nashville, Tennessee, who considered European concrete bridges to be too complicated. He produced a bridge with concrete trusses without diagonals as deck spans on the approaches to the bridge, and placed the deck above the arches that rested on existing piers.¹⁸ By 1912, James B. Marsh had received a patent for his reinforced concrete fixed through arch “Rainbow” bridge. Unfortunately, Marsh’s rainbow design received limited acceptance and never became an industry standard. Nevertheless, variations of the Marsh design, in particular the tied through arch, can be found throughout the country, two of which were built in Lancaster County.

The beginning of the twentieth century marked the advent of construction with reinforced concrete in the United States. Engineers were fascinated with its potential as a building material and believed it to be almost indestructible, resulting in bridges that would be practically maintenance and replacement free.¹⁹ Indeed, this relatively new construction material provided exceptional compression strength at a low cost compared to metal, which always needed the upkeep of painting and even replacement of its metal parts. During the first two decades of the twentieth century, concrete met the needs of municipalities that were looking for replacement bridges that offered economy, strength, and attractiveness.²⁰ In 1908, the best example to spur those views in Pennsylvania was the construction of Philadelphia’s Walnut Street Bridge. The

¹⁷ Daniel B. Luten, “Highway Bridges of Concrete,” *Municipal Engineering* XIX, no. 6 (December 1900): 388.

¹⁸ Frances A. Jones, “Benson Street Concrete Bowstring Bridge,” HAER No. OH-50, *Historic American Engineering Record* (HAER), National Park Service, U.S. Department of the Interior, 1986.

¹⁹ Thacher, p. 180.

²⁰ John Lyle Harrington, “Recent Developments in Bridge Superstructures,” *Proceedings of the Engineers’ Society of Western Pennsylvania* 46, no. 3 (Mar. 1930): 63.

233' long concrete structure set an example in its size, beauty and park setting for all engineers of the day who were fascinated with concrete as a construction material.²¹

For engineers building with concrete during this time period, the main problem was how to use the qualities of concrete's compressive strength along with its low-tension resistance irrelevant to a structure. Influential engineering writers F.E. Turnaure and E.R. Maurer advised engineers that the solution lay not in choosing between concrete and steel, but in using both together.²² Although steel was expensive, it had high tensile strength, especially in the form of bars, but needed to be made more heat resistant and durable. Concrete seemed to support steel in ways that made its expense affordable, because it greatly slowed steel's corrosive process while itself being durable and fireproof. Concrete was much cheaper because, unlike steel, which had to be produced at a mill, it could be mixed at the work site. Turnaure and Maurer compared current prices for concrete and steel and concluded that encasing steel rods, beams, or columns in concrete would significantly alter the actual cost per unit of strength in bridge building. The savings would come from the use of steel reinforcing rods instead of using fabricated steel members. But by the 1930s, it was becoming clear that concrete structures suffered from a litany of problems, including discoloration, streaking, and cracks, and that poor workmanship made it difficult to correct errors in installation.

The Rainbow Arch Bridge

James B. Marsh (1856-1936) designed the type of arch bridge employed over the Conestoga Creek at Weaverland and received a patent for it in 1912. The patent application stated that the object of the invention was "to construct an arch bridge of reinforced concrete in such a manner as to permit a limited amount of expansion and contraction both of the arches and of the floor." James B. Marsh's patented design used rainbow arches that would expand and contract along with the bridge floor under varying conditions of moisture and temperature. Marsh built hundreds of these bridges in the 1910s to 1930s mostly throughout the Midwest.

²¹ Helen P. Ross, "Walnut Lane Bridge," HAER No. PA-504, Historic American Engineering Record (HAER), National Park Service, U.S. Department of the Interior, 1998, revised and expanded by Justin M. Spivey, 2001.

²² F.E. Turnaure and E.R. Maurer, Principles of Reinforced Concrete Construction, 2nd rev. ed. (New York: John Wiley & Sons, 1913), 4-5.

Another feature that was attractive was the completely flat floor in contrast to older bridges, which sometimes had a hump in the middle.

James B. Marsh, a civil engineer from Des Moines, Iowa, was an American pioneer in designing bowstring concrete bridges. In the mid-1890s, Marsh began experimenting with the use of concrete in bridge construction. He produced two basic bridge designs with the arch rising above the deck, one for a fixed arch and one for a tied arch. On August 6, 1912, he received a patent (United States Patent number 1,035,026) for his innovative design for the fixed arch. The fixed arch design contained wear plates at the points where the bridge floor came into contact with the beams and abutments. In contrast to the tied arch, which rested on the abutments, the fixed arch continued below deck level and was attached to the abutments. The tied arch allowed construction even if the ground was not solid enough to deal with the horizontal forces produced by the arches as they spread their loads towards the abutments. Rather than relying on the foundation to restrain the horizontal forces, the girder itself “tied” both ends of the arch together. A tied arch bridge rested on abutments and caused a vertical load on the abutments. Both types of Marsh arches allowed for the expansion and contraction of the bridge parts during changes in temperature.²³

The tied arch bridge has a number of defining structural aspects: it is used where the supporting rock foundation cannot resist the arch thrust; the horizontal thrust of the arch is taken entirely by the tie; the tie arch is always used as a through span; the deck floor is always carried by hangers; and where there are a multiple series of tied arch spans, they are always a succession of individual tied arches.²⁴

The deck of a tied through arch bridge may be either a slab span or a girder span. The reinforced concrete slab span is one of the simplest and least expensive technologies used in bridge construction. A simple slab bridge can be composed of a single or multiple slabs. An individual slab typically ranges from 20' to 50' in length. In a single slab bridge the slab rests directly on the abutments. If multiple slabs are used, joints are visible where the slabs come together. In a continuous slab bridge, the slab is poured as one unit so there are no visible joints.

²³ Edwin Cordes, “Spring Street Bridge,” HAER No. WI-37, Historic American Engineering Record (HAER), National Park Service, U.S. Department of the Interior, 1987.

²⁴ Ibid.

For longer spans, intermediate supports of timber, concrete, or steel in a wide range of shapes are used. Slab bridges are used for short span bridges where headroom is limited and were a common highway bridge type in the 1930-40s. A simple slab bridge is easily distinguished by its flat underside.²⁵

Though similar in appearance to a slab bridge, the concrete girder bridge is distinguished by a series of longitudinal concrete beams on its underside. The girders can be an integral part of the slab, known as monolithic construction, or they can be poured separately. Each girder is typically of a uniform dimension throughout its length. Crossbeams are sometimes placed between the girders to provide extra support. The same supports used for slab bridges are also found on girder bridges. Since less concrete is required in the construction of a girder bridge than in the flat slab, it is typically used for longer spans such as the one at Weaverland.²⁶

Marsh's designs brought a number of innovative features to the building of reinforced concrete through arch bridges that resulted in the elimination of many time consuming tasks involved in traditional concrete construction. In the construction of a Marsh arch design, complete trusses were employed for the reinforcement in the arches. The metal truss work was assembled on the ground and then lifted into place. Angle irons, eight to a side, were attached to the arch. They served as the hangers for the deck. Steel trusses were also used for the bottom chords, which supported their own formwork thus eliminating costly and time-consuming formwork arrangements beneath the bridge. Next, large steel I-beams were welded to hangers across the width of the bridge to which formwork attached. At this point, the concrete deck was poured. After the deck concrete had cured, the arches and hangers were cast in concrete.²⁷

The chief advantages of the Marsh building system for engineer designers, fabricators, and municipal treasurers were ease of construction and economy of resources. Technologically the advantages rested in the ability to construct a reinforced concrete bridge with minimal weight and floor thickness, yet allowing for unlimited headroom below the deck. Since all tension is exerted on the vertical hangers, horizontal web members are eliminated. Finally, the whole span

²⁵ Ibid.

²⁶ Ibid.

²⁷ Ibid.

is protected from the weather by an outer layer of concrete. The end result is an aesthetically pleasing structure that provided a strong and economical crossing.²⁸

Construction of Concrete Bridges in Lancaster County, 1908-1924

In 1908, Lancaster County began replacing its wooden and iron bridges with reinforced concrete spans in response to increasing automobile traffic over local roads. This shift in materials usage coupled with the rising popularity of reinforced concrete in building is the context within which the Weaverland Bridge was constructed.

Construction of the Weaverland Bridge can be better understood in the context of the history of concrete bridge construction in Lancaster County as recorded in the Bridge Dockets (both small and large volume) of the Commissioners' Office that are now archived at the County Engineer's Office in the Lancaster County Court House. The two books are retained at the County Engineer's Office as documents of Lancaster County's historic bridge building activities. Unfortunately, the two volumes are suffering some deterioration so not all the pages appear to be present or intact. For example, it is quite clear that a number of photographs of the bridges were taken the year they were constructed, but the photographs are missing. Nevertheless, the information contained there can be gathered into a revealing table of statistics of bridge construction in the county from 1908 to 1924.²⁹ This was the height of concrete bridge building in Pennsylvania; in fact, Lancaster County alone built at least twenty concrete bridges (that does not even take into account the number of bridges the state also constructed in the county). Table 1 tabulates statistics for the twenty reinforced concrete bridges built from 1908 to 1924 by Lancaster County. The data was taken from both small and large volumes of Bridge Dockets located at the Lancaster County Court House in Lancaster. It should be noted that the information in the Bridge Dockets is incomplete. It includes only twenty reinforced concrete bridges, but the firm of Frank H. Shaw alone designed at least forty bridges. Also, the identical twin bridge to the Weaverland Bridge built over the Big Chickies is missing from both volumes.

²⁸ Ibid. According to Eric DeLony, Chief of HAER, the primary advantage of the Marsh arch system was that it eliminated the need for falsework. The formwork for the concrete hung from the metal trusswork instead. (September 13, 2003).

²⁹ The two volumes of Bridge Dockets do not contain concrete bridge information beyond 1924.

Table 1 shows that the constructor of the Weaverland bridge, John T. Brubaker, built his first concrete bridge in 1913 and continued his involvement with concrete bridge construction and maintenance until 1924. In 1913, Brubaker built a concrete bridge over Peters Creek on the road from Wick's Mill to Peach Bottom; in 1914, he repaired a concrete bridge that was built by J.S. McIlvain; in 1916, the Weaverland Bridge; in 1917, a bridge over Big Beaver Creek near Carnargo; and in 1918, together with F.A. Heart, a structure over Pequea Creek along Beaver Valley Pike. The last entry in the Bridge Dockets for Brubaker was to repair the Weaverland bridge, for which he received \$210.³⁰ In all, Brubaker worked on five bridges from 1913 to 1918.

The next most prolific constructor of Lancaster County bridges was Paul D. Kauffmann, who built three Lancaster County bridges in 1917. Judging from the extant documents found in the Bridge Dockets, the majority of bridges were built over Pequea (seven) and Conestoga (five) creeks during the sixteen-year period recorded in the volumes.

Concrete Bridge Type	Span/Width (ft.)	Date	Builder	Cost	Township(s) [// = between]	Waterway Crossed	Road carried	Location	Bridge Docket Page	Photo (sm); (lg)
1-span(?)	70/16	1908	Ferro-Concrete Co.	\$3,603.50	// Warwick & Elizabethtown	Hammer Creek	?	B.H. Snavely's Mill	281 (sm); 308 (lg)	Yes; yes
1-span, girder	63/18	1910	Nelson Merydith Co. (Chambersburg)	\$4,334.57	West Earl	Conestoga Creek	Farmersville to New Berlin	Burkholder's Mill*	125 (sm)	Yes
2-span	77/20	1910	A. Buchanan (Chambersburg)	\$6,308.99	// Strasburg & W Fallow (Chester Co.)	?	?	Ferguson's Mill	373 (lg)	No
?-span, girder/slab (?)	?	1911	Heppler & Gilbert (Coatesville)	\$1,107.33	// Coleman & Little Britain	W Branch Octoraro Creek	Pine Grove to Union	?	367 (lg)	Yes
1-span	40/16	1913	John T. Brubaker	\$1,795.15	Fulton	Peters Creek	Wick's Mill to Peach Bottom	Dorsey's Mill	489 (sm)	No
1-span	140/16	1913	Nelson Merydith Co. (Chambersburg)	\$15,738.68	// Martic & Conestoga	Pequea Creek	?	at mouth of Pequea Creek	464 (sm)	No
2-span	100/14	1913	J.S. McIlvain	\$2,502.50	Salisbury	Pequea Creek	?	Amos Hess's Mill	421 (lg)	No
3-span, girder on 2 piers	131/17	1914	J.S. McIlvain; repaired by John T. Brubaker	\$4,365.75	East Earl	Conestoga Creek	Blue Ball to Reading	Samuel Gehman's Mill; or Aaron Martin's Mill (sm Dock. Bk)	111 (sm); 150 (lg)	Yes; yes
2-span arch	79/19.8	1916	John T. Brubaker	\$3,630.19	East Earl	Conestoga Creek	Quarry Rd.	Eli Martin's Mill	113 (sm)	?

³⁰ Bridge Dockets, Commissioner's Office, p. 113 (small volume).

³¹ Information in the Bridge Dockets in the small (sm) volume and in the large (lg) is incomplete because some fields were not entered and some photographs have been lost. Where that information was absent, the cells in the table are marked by a "?".

1-span arch**	62,3/15,11	1916	J. Miller Eshleman;	\$2,276.97	// Rapho & Penn	Big Chickies Creek	Colebrook Rd. to Lancaster-Petersburg Rd.	Lancaster Junction	48 (lg); 228 (sm)	?, ?
girder	28,5 /?	1917	John T. Brubaker	\$1,179.50	Eden	Big Beaver Creek	?	near Carnargo	27 (sm)	No
1-span(?)	131/?	1917	Paul D. Kauffmann	\$5,691.00	// Warwick & Ephrata	Cocalico Creek	?	?	51 (sm); 122 (lg)	No; yes
3-span, girder	131/18,5	1917	Paul D. Kauffmann	\$10,213.00	West Earl	Conestoga Creek	Talmage Rd.	Kafroth's Mill	170 (lg)	Yes
3-span	134/21,5	1917	Paul D. Kauffmann	?	West Earl	Conestoga Creek	Farmersville Rd.	Wenger's Mill	?	?
2-span, girder (50' each)	100/?	1918	John T. Brubaker & F.A. Heart	\$10,475.94	// Strasburg & W Lampeter	Pequea Creek	Beaver Valley Pike	?	445 (sm)	No
2-span, girder (?)	?	1920	J. Miller Eshleman	\$10,072.36	// Strasburg & Providence	Big Beaver Creek	New Providence to Lancaster	Mylin's Mill	1 (sm)	Yes
1-span(?) girder steel	?	1920	Pearthree	\$12,447.29	// Martic & Conestoga	Pequea Creek	?	Martic Forge	459 (sm)	No
2-span	?	1921	Solomon Butts & Geo. H. Calder	\$12,990.00	// Pequea & Providence	Pequea Creek	?	near Pequea Valley Tavern	447 (sm)	No
2-span	?	1922-1923	Swangler-Feckler Construction Co. (Lebanon)	\$9,248.77; F.H. Shaw supervised construction (\$1,533)	// Leacock & Paradise	Pequea Creek	?	?	425 (lg)	No
3-span, girder	?	1924	Ferro-Concrete Co.	\$13,104.00	// Leacock & Paradise	Pequea Creek	Paradise to Intercourse	?	426 (sm)	Yes

* Percy A. Shaw's article on this bridge in the Engineering News-Record refers to the location as Rupp's Mill, not Burkholder's Mill.

** Data on the Big Chickies Bridge (an exact twin of the Weaverland Bridge designed by the Shaw firm) was missing from both volumes of Bridge Dockets but is included in this list of reinforced concrete bridges.

Percy A. and Frank H. Shaw

In 1916, Frank H. Shaw (1872-1950), Civil, Hydraulic and Sanitary, and Water Works Engineer, a member of the American Society of Civil Engineers, had an engineering business located at the Breneman Building at 53 Duke Street, Lancaster City. His home residence at that time was listed as 206 Ruby Street. Advertisements by Shaw in the Lancaster City Directory for the year of construction of the Weaverland Bridge indicate a wide range of engineering services, including surveys of subdivisions, cities, boroughs, farm and topographic; and water works, sewage, bridges, railways, tanks, bins, and buildings.³²

The Weaverland Bridge that Brubaker was contracted to build may have been designed by Percy A. Shaw, the brother of Frank H. Shaw. An article, authored by Percy in 1911 on the construction of a reinforced concrete through transverse girder bridge, states that he was its

³² Lancaster City Directory (Lancaster: R.L. Polk & Co., Publishers, 1916), p. 112.

engineering designer and was located in Reading.³³ It is not known how long Percy worked with Frank on the firm's construction projects, but the possibility exists that Percy may have been a designer of other bridges created by the company. The name of the firm (Frank H. Shaw) and Frank's time consuming travels to sell the firms' wares and reputation while managing offices in different cities probably caused Frank to become the better recognized of the two brothers.

Frank Shaw moved to Lancaster County around 1905 from Massachusetts and became an inspector of the first concrete bridge built by the Ferro-Concrete Company of Harrisburg in 1908. In 1909, he began advertising his own engineering firm in Lancaster and at the same time was appointed Lancaster County Engineer, a position he held until 1917; from 1911 to 1913, he was also the county's superintendent of water works. After relinquishing his position of County Engineer in 1917, he continued working for the county as a consulting engineer. Frank Shaw's interests were not limited to bridge building but extended to all aspects of reinforced concrete construction. His imprint on the county includes sewer works along Lancaster's Water and Clay Streets and a water tower now found on the Franklin and Marshall College campus; his water system works are in Elmira, New York and in Reading, Pennsylvania; he also laid out street railway lines in cities in the East. During his career, he contracted building works in East Orange, New Jersey (1919-20), Houston (1923-24), and Washington, DC (1935), where he also had offices. It is for the design and construction of concrete bridges, however, that Frank Shaw, with apparent help from his brother Percy, is best remembered in Lancaster County.³⁴

During his tenure as county engineer, Frank, possibly with the help of his brother Percy, designed and developed at least forty reinforced concrete bridges; two of the trusses are still in service today along with half-a-dozen cantilevered through girder bridges.³⁵ Although Percy's influence and impact on Lancaster County's infrastructure as a designer is subsumed in Frank's reputation, it may have been substantial. Percy noted in his 1911 article that he was the

³³ Percy A. Shaw, "A Reinforced Concrete Through Girder Bridge," Engineering News-Record 64, no.26 (December 23, 1911): 744-5.

³⁴ R.L. Polk, Lancaster City Directory (Lancaster: R.L. Polk & Co., 1905); Lancaster County, Commissioners' Court Minutes, 1916-1920, 5 April 1909, Lancaster County Archives, Lancaster; "Frank H. Shaw is Dead at 78," obituary in Lancaster New Era, 15 May 1950; "Frank H. Shaw Dies; Was Former Water Works Supt.," obituary in Lancaster Intelligencer Journal, 15 May 1950; M. Luther Heisey, "The Water Supply of Lancaster," Journal of the Lancaster County Historical Society 41, no.1 (1937): 34.

³⁵ Justin M. Spivey, "Big Conestoga Creek Bridge No. 12," HAER No. PA-500, Historic American Engineering Record, National Park Service, U.S. Department of the Interior, 1998, pp. 2, 6; the two trusses in use today are Weaverland Bridge and Big Chickies Bridge.

“Designing Engineer” (residing in Reading) of a reinforced concrete through girder bridge at Rupp Mill in Lancaster County.³⁶ Therefore, it seems very likely that he may have designed other bridges as well for the Shaw firm. Frank held the positions of County Engineer, Superintendent of Water Works, consulting engineer, and supervisor of construction for Lancaster County, while also running a private engineering construction firm. It can also be assumed that Frank Shaw was trying to sell his company’s wares to other regions of the country at the same time, as seen in the fact that soon after he quit his position of county engineer in 1917 he continued his career as a civil engineer by opening offices in other cities, perhaps in part based on his established reputation in Lancaster County. At least in 1910, Percy worked out of the Reading office and may have designed many of the bridges for which Frank H. Shaw, or the company of Frank H. Shaw, became famous. Frank Shaw’s obituary proclaimed a unique place for him in history for his management and supervision of bridge construction projects in Lancaster County. It stated: “the first concrete bridges ever built in Lancaster bear his name as the engineer.”³⁷

Percy A. Shaw’s Engineering Article

Percy A. Shaw’s article, “A Reinforced Concrete Through Girder Bridge,” is a valuable piece of evidence explaining the reasoning employed in selecting the bridge type as well as providing a description of the techniques employed in constructing the bridge. It can be assumed that comparable approaches were used in the later bridges designed and supervised by the Shaw firm.

Percy’s designed Conestoga girder bridge can shed some light on the bow arch built six years later at Weaverland. The Conestoga girder and the Weaverland slab deck show similarities. The descriptions of how the bridge was built are worth discussing as it provides insight into the early years of reinforced concrete bridge building in Lancaster County as envisioned and practiced by the Shaws. The firm probably practiced these evolving designs and building methods throughout the years they designed bridges and supervised their construction.

³⁶ Shaw, pp. 744-745.

³⁷ “Frank H. Shaw is Dead at 78,” obituary in Lancaster New Era, 15 May 1950.

a. Type and Style of the Conestoga Bridge

For the Conestoga Bridge Percy chose a single clear span (63' x 18') roadway instead of two girder spans "in order to secure the largest possible waterway, and thus provide against the stoppage of drift brought down by the stream during floods, which are frequent in that vicinity."³⁸ Abutment and wing walls from the old bridge were utilized by reinforcing them with a shell of reinforced concrete 12" to 16" thick. Parapet walls were cast monolithic with the wing walls, but not reinforced. They had deep panels to save weight and to reduce the cost of form work, reflecting Percy's belief that ultimately "the span depends for whatever beauty it possesses on the bold, clean lines of the massive concrete work."³⁹

b. Bridge Movement

Movement dynamics of the bridge of expansion and contraction due to temperature changes and setting of the concrete were allowed for by resting the span at each end on a half-inch of Hydrex felt and compound while the girders and parapet walls had a heavy coating of the compound between them.

c. Stress Formulas and Concrete Mixtures

Stress limits and concrete mixtures for the bridge were employed as follows:

Stress limits:	Live load:	100 lb. per sq. ft. (equivalent to: 15-ton road roller with axles 11' apart, 6 tons on a 4' wide front wheel, and 4.5 tons on each rear 20" wheel 5' apart center to center).
	Dead load:	weight of bridge plus 9" of crushed stone on the roadway.
	Unit stress:	16,000 lb. in tension 12,000 lb. in compression.
	Concrete compressive strength:	600 lb.
Concrete mixtures:	spans and wing walls:	1:2:4
	abutments and wing wall foundations:	1:3:6

³⁸ Shaw, p. 744.

³⁹ Ibid.

d. The Crew

The contractor employed one foreman, one assistant foreman, one engineer, two to four carpenters, and five to twelve laborers.

e. Sequence of Construction and Form Work

First the abutment and wing wall reinforcing shell was placed, then the parapet walls, and finally the formwork for the span was erected before the concrete was poured. Timbers, securely braced to prevent washing out and resting on the ledge in the streambed, were used for supports for the span framework.

f. Concrete Work

The crew mixed the concrete with a batch mixer mounted on a truck with a boiler and engine. The reinforcement bars in the span, with the exception of the compression bars, were put in place and securely wired. The concrete was then poured in one continuous operation for the entire span—both floors and girders—in layers from one end of the bridge to the other with no concrete having set when new work was set upon it. The pouring of the concrete ran for fifty-six continuous hours starting at 7 a.m. on September 2 and ended on September 4 in the afternoon. After forty-eight hours, all the forms, with the exception of those supporting the heavy weight of the span, were removed and the concrete surfaces given a final finish. After three weeks, the forms supporting the span were finally removed. Construction of the Conestoga Bridge commenced June 27, 1910, and was completed September 13, 1910, for a total of sixty-six days of construction work.

g. Cost of the Conestoga Bridge to Lancaster County

The table below lists the work items contracted by the County of Lancaster with the Shaw construction company for the building of the Conestoga reinforced concrete bridge. It is assumed that labor costs are subsumed in the prices charged by the Shaw firm for materials and in removing the old bridge and excavation work. The most expensive materials contained in a reinforced concrete bridge are concrete and reinforcement steel. The cost of the concrete and steel bars came to \$3,985.88, or 92 percent of the total cost budgeted by the county for this bridge.

Percy's information about bridge building—the reasoning involved in choosing the bridge type, the descriptions of construction methods, and a breakdown of the costs involved—provides a window into the history of reinforced concrete construction in the early 1900s in Pennsylvania.

Table 3.
Conestoga Bridge Construction Items and Costs

Construction Items	Units	Cost per Unit	Total
Removing old bridge			\$125.00
Concrete (1:2:4)	241.4 cu.yd.	\$11.50	\$2,776.10
Concrete (1:3:6)	49.3 cu.yd.	\$9.00	\$443.70
Steel reinforcing	25,536 lb.	\$0.03	\$766.08
Above mean low water earth excavation	69.5 cu.yd.	\$0.45	\$31.28
Below mean low water earth excavation	10.5 cu.yd.	\$2.10	\$22.05
Rock excavation	38 cu.yd.	\$1.60	\$60.80
Crushed stone for road bed	40 cu.yd.	\$1.60	\$64.00
Wainwright curbing	140 ft.	\$0.206	\$28.82
Name stone			\$10.00
Extra work			\$6.74
GRAND TOTAL			\$4,334.57

Patents and Local Access to Bridge Building

To explain the relationship between Frank H. Shaw and the state agencies that contracted him and his bridge designs, we have to understand the historic context—the history of patents and the process of selecting a particular bridge to be built—that eventually led to the system of favored relationships that Shaw enjoyed. At this time, there was a debate between the independent contractors, such as Daniel B. Luten, who presented standardized designs, and state engineering offices, where engineers produced their own designs.

Starting in the 1890s in the United States, patents for concrete bridges began to be secured; for example, in the 1890s, Joseph Melan, Fritz von Emperger, Edwin Thacher, Indiana’s Daniel B. Luten, who had over forty by 1916, and James B. Marsh, who patented his unique concrete bowstring bridge, all held patents. These patents were for different styles and what ensued was a debate about how bridges should be built in the United States: should they be offered by independent companies or by governmental offices that determined standard types, shapes and styles?

A number of methods were used in the early days to pick the best bridges. Before an impartial system of bridge selection evolved, a debate raged in America pitting the independent contractor and his design against the state’s designers. In a few words, the state wanted to

produce standardized designs that had been developed by a few engineers employed by the state, while independent contractors complained that they and their patented designs were being shut out of the business of bridge design and construction. Engineers working for the government drafted bridges with detailed and standardized specifications that left almost no room for the designer and consequently for any innovation. This method produced bridges that were costly, excessively heavy, but were designed to counteract the unaccomplished job skills of companies whose low bids won the contract.

A method employed in Europe involved picking a bridge design that showed the best planning knowledge and building techniques but which did not necessarily come from the lowest bidder. Unfortunately, this approach did not always guarantee that those evaluating the best engineered design were technically qualified to do so or that governmental officials were not motivated by corruption to be partial.

What eventually developed in the United States was a method that Americans believed emphasized ingenuity in design and construction and resulted in a bridge that supposedly was better and cheaper. This method had a mandatory general plan prepared by the regional engineer, consisting of how a bridge should perform by presenting sets of specifications for loadings and capacities, external dimensions, and the structure's principal architectural features. These specifications, dimensions and features applied to all bidders. The bidders, in reference to the mandatory plan of the regional authority, were required to submit drawings specifying the thickness of bridge parts and detailing reinforcement schemes. The contractors were also required to guarantee their work, the construction materials used, and their design for one year. The whole process was meant to produce an economical and expertly designed and built bridge.

Consequently, this method produced a unique relationship of consultation between elected officials, the regional engineer, and the contractor. In the case of Frank H. Shaw, it developed into a special relationship between an authorizing governmental agency and the county engineer as the preferred provider of bridge designs. The county acquired forty of Shaw's bridges, and he occasionally supervised construction. The relationship suggests that he held a monopoly over whose designs the county would choose. Further research into this subject should be carried out to compare the percentage of bridges built by Shaw with his competitors. Shaw's special status, developed from a close relationship with the county, gave him a unique opportunity to create a

historic legacy of bridge design and construction that exists to this day. The close and favored relationship may have limited access to the market by other contracting firms wishing to make their contributions to the infrastructure of Lancaster County through new designs and construction methods.

Selection of the Contractors for the Weaverland Bridge

The Weaverland reinforced concrete bridge was constructed at Eli Martins's Mill at Weaverland in 1916 at a cost of \$3,630.19. It was designed by the firm of Frank H. Shaw and built by John T. Brubaker.⁴⁰ On July 28, 1916, a petition was submitted to the Lancaster County Commissioners that stated that "a County Bridge has long since been erected according to law, over the Conestoga Creek, on the public road at Eli Martin's Mill in East Earl Township, in the County of Lancaster; that said Bridge has been worn out; that your petitioners did proceed to have said bridge rebuilt, and entered into contract with John T. Brubaker for the rebuilding of the same, and that the said bridge is now completed agreeably to the said contract."⁴¹ The petition went on to ask the Honorable Court to appoint three individuals to inspect the bridge and workmanship and to report their findings in the next Quarter Sessions of Lancaster County. The court appointed Richard Blickendorfer, Augustus Rhoads, and Joseph Eibel to inspect the bridge. Written findings of the inspection team were not found but a map created April 26, 1916, before the bridge was built, proposed changing the crossing from the previously old diagonal one to a direct and shorter one.⁴² Perhaps because of the importance of the Eli Martin mill, the change in road direction for the new bridge crossing began at the mill. Also, it can be inferred from the dates on the "Petition of the County Commissioners..." and the map from the "Order and Report of Inspectors..." that the bridge was built sometime between April 26 and July 28, 1916.

⁴⁰ Robert Navitski, P.E., Assistant County Engineer, found the drawings in the archives of the Lancaster County Engineer's Office, Lancaster Court House, Lancaster City; Bridge Dockets, (small volume).

⁴¹ "Petition of the County Commissioners for the Appointment of Inspectors, etc., of the Bridge over the Conestoga Creek at Eli Martin's Mill, (Weaverland), East Earl Township, Lancaster County, Pa," Bridge #31, Min 88, April 1916. Document prepared by J.R. Kinzer, Attorney-at-Law, 39 East Grant St., Lancaster, PA.

⁴² Order and Report of Inspectors of Bridge Over Big Conestoga Creek at Eli Martin, Bridge No. 31, April 26, 1916. Collection of the Lancaster Historical Society.

Description of the Weaverland Bridge

The Weaverland Bridge consists of two spans with the main portion being the tied through bow arch bridge with a slab deck 58'-10" long and 19'-9" wide. The abutments, piers, wing walls, coping, and deck are of concrete.⁴³ The north end rests on a concrete abutment while the southern end is on a concrete pier 22' x 4'. The section extending the bridge roadway southward is a slab girder about 18'-8" long resting on the pier and a concrete abutment. The abutments are U-shaped and tied together by reinforced concrete ties. They are topped by galvanized wrought iron pipe that extend from heavy concrete capped end posts that decorate both ends of the main section. A handrail and guard extend the top rung of the galvanized piping along the entire arch.

The main 58' arch section of the bridge consists of two parallel arches with vertical suspenders from which a concrete slab deck is hung. Within the arch's five panels, diagonal suspension ribs (cross beams) are employed, a very unusual feature for a bow arch bridge and one that made the Shaw version distinguishable from the Marsh design. The use of these diagonal elements may have been incorporated into the design in order not to infringe on Marsh's 1912 patent for the Rainbow bridge. The rebar system of bars and stirrups shows that the four vertical ribs hang from the arch and are tied into four transverse girders onto which the slab roadway is placed.

Much like the Conestoga Bridge at Rupp's Mill discussed above, the Weaverland Bridge sought to provide a maximum opening over the main channel of the Conestoga Creek at the Weaverland crossing. The southern slab extension of the Weaverland Bridge was to allow for the occasional expansion of the river flow during rainy seasons or floods to run around the south side of the pier, but during normal times, the main body of water flows under the rainbow arch. Here, as for the Conestoga Bridge, a slab girder was employed "in order to secure the largest possible waterway" with what appears to be a standard size of approximately 20' x 60'.⁴⁴ Bridges over small rivers or creeks with small apertures can become sizeable obstructions to a river's flow, often forming a weir of driftwood blocking the flow through the apertures.

⁴³ Order and Report of Inspectors of Bridge Over Big Conestoga Creek at Eli Martin, Bridge No. 31, April 26, 1916. Collection of the Lancaster Historical Society; Bridge Dockets, Commissioner's Office, p. 154 (large volume).

⁴⁴ Shaw.

In the case of the Weaverland Bridge, the rainbow arch was not modified to produce one span to cross the approximately 75' wide river. There are two possible reasons for the situation at the Weaverland crossing, either: a 75' girder slab was considered impractical as an engineering solution or an economic one; or the rainbow arch bridge with diagonal elements was one of a number of readily available and previously designed structures that Shaw offered as solutions for particular crossings and budgets. An exact twin of the Weaverland Bridge was built the same year, 1916, at Lancaster Junction in Rapho Township also over the Conestoga Creek, but it was a single span that did not employ an extension slab to bridge Big Chickies Creek. As if hidden from all but a few local inhabitants, the twin bridge at Lancaster Junction apparently was unknown to the general public. In 1946, Lancaster's The Sunday News described the Weaverland Bridge thirty years after it was built as "Fancy ideas with new concrete-steel construction has turned to plain straight lines since the bridge replaced an old iron in 1916. It is located at Rupp Mill on the road leading from the Earl School House to Fairview, and *the only one of its kind here.*"⁴⁵

SIGNIFICANCE

The tied-through reinforced concrete arch Weaverland Bridge, built in 1916, is a historically and technologically significant early and rare example found in the Commonwealth of Pennsylvania of a rainbow type tied bridge with diagonal members. Perhaps in attempting to avoid any problems with patents issued to J.B. Marsh, the Shaws created a concrete bridge that has unique features found in the previous era's iron bridges with their diagonal elements in the arch. In 1993, the Pennsylvania Historic and Museum Commission determined the Weaverland Bridge eligible for the National Register.

⁴⁵ The Sunday News (Lancaster, PA), May 12, 1946, p. 10.

BIBLIOGRAPHY

Barton, R. Harold. "East Earl Mill" (Site number 165), vol. 1, nos. 1-88. In Mills and Bridges of Lancaster County, Pennsylvania. Collection of the Lancaster County Historical Society (hereafter cited as LCHS).

_____. "Indices by Name of Mill, Township Location and Name of Stream." In Mills and Bridges of Lancaster County, Pennsylvania, vol. 5. Collection of LCHS.

_____. Notebooks. Collection of LCHS.

Bridge Dockets. Commissioners' Office, Lancaster County Court House. One large and one small volume. Found in the Lancaster County Engineer's Office, Lancaster, Pennsylvania.

Bridgens, H.F. Map of the Three Earls Lancaster County, Pa. Philadelphia: Wagner & McGuigan, 1855. Available at the Library of Congress, Washington, DC.

Bridgens, H.F. and Assistants. Bridgens' Atlas of Lancaster Co. Pennsylvania. Lancaster: D.S. Bare, 1864. Collection of the Lancaster County Courthouse, Office of the Recorder of Deeds.

Eshleman, H.F. Map Showing Location and Date of the Earliest Highways Leading from the Delaware and Schuylkill Rivers to the Susquehanna River and Its Branches. 1907.

Everts and Stewart. Combination Atlas Map of Lancaster County Pennsylvania. Compiled, Drawn and Published from Personal Examination and Surveys. Philadelphia: 1875.

"Frank H. Shaw is Dead at 78." Obituary in Lancaster New Era, 15 May 1950.

"Frank H. Shaw Dies; Was Former Water Works Supt." Obituary in Lancaster Intelligencer Journal, 15 May 1950.

Graves and Steinberger. Atlas of Surveys of the County of Lancaster, State of Pennsylvania. Boston and Philadelphia: Graves and Steinberger, 1899.

Harrington, John Lyle. "Recent Developments in Bridge Superstructures." Proceedings of the Engineers' Society of Western Pennsylvania 46, no. 3 (Mar. 1930): 63.

Jones, Frances A. "Benson Street Concrete Bowstring Bridge." HAER No. OH-50. Historic American Engineering Record, National Park Service, U.S. Department of the Interior, 1986.

Lancaster City Directory. Lancaster: R.L. Polk & Co., Publishers. Vols. 1905, 1916-1924.

Lancaster County Historic Transportation Cultural Resource Study. Harrisburg: Pennsylvania Department of Transportation, 1995.

Luten, Daniel B. "Concrete-Steel Bridges." Municipal Engineering XXIII, no.3 (September 1902): 156.

_____. "Highway Bridges of Concrete." Municipal Engineering XIX, no. 6 (December 1900): 388.

Marsh, James B. Reinforced Arch Bridge Patent, Patent No. 1,035,026. Patented August 6, 1912.

Marsh, James Barney. "Spring Street Bridge." HAER No. W1-37. Historic American Engineering Record, National Park Service, U.S. Department of the Interior, 1987.

Order and Report of Inspectors of Bridge Over Big Conestoga Creek at Eli Martin. Bridge No. 31. April 26, 1916. Collection of LCHS.

"Petition of the County Commissioners for the Appointment of Inspectors, etc., of the Bridge over the Conestoga Creek at Eli Martin's Mill, (Weaverland), East Earl Township, Lancaster County, Pa." Bridge #31, Min 88, April 1916. Petition prepared by J.R. Kinzer, Attorney-at-Law, 39 East Grant St., Lancaster, PA. Document archived in Record Group MG-15, Folder 15 (Mills and Bridges of Lancaster County, The R. Harold Barton Collection, 1637-1916), LCHS.

Ross, Helen P. "Walnut Lane Bridge." HAER No. PA-504. Historic American Engineering Record, National Park Service, U.S. Department of the Interior, 1998. Revised and expanded by Justin M. Spivey, 2001.

Scott, Joshua. Map of Lancaster County Pennsylvania Respectfully Dedicated to the Inhabitants by Joshua Scott. Lancaster, 1824. Available at the Library of Congress.

Shaw, Percy A. "A Reinforced Concrete Through Girder Bridge." Engineering News-Record, 64, no. 26 (December 23, 1911): 744-5.

Spivey, Justin M. "Big Conestoga Creek Bridge No. 12." HAER No. PA-500. Historic American Engineering Record, National Park Service, U.S. Department of the Interior, 1998.

The Sunday News. Lancaster, PA. May 12, 1946, p. 10 (Photograph of Bridge No. 18).

Thacher, Edwin M. "Concrete-Steel Bridge Construction." Engineering News XLII, no. 12 (September 21, 1899): 179.

Turnaure, F.E. and E.R. Maurer. Principles of Reinforced Concrete Construction, 2nd rev. ed. New York: John Wiley & Sons, 1913.

USGS New Holland Quad, 1908 Edition (surveyed in 1905 and 1906).

von Emberger, Fritz. "The Development and Recent Improvement of Concrete-Iron Highway Bridges." Transactions, American Society of Civil Engineers XXXI (1894), 703.

Weaver, M.G. A layout of the Weaverland Valley about 1740; draft prepared in 1933.
<http://www.genealogygoldmine.com/martin/>.

Weaver, M.G. "Spring Grove, Weaverland and Blue Ball. Settlement and Development." Journal of the Lancaster County Historical Society XXXV (1931): 149-167.

Yeager, Mary H. "Historic Bridge-Building in Lancaster County." Journal of the Lancaster County Historical Society XLI, no. 6 (1937): 133-158.

ADDENDUM TO:
WEAVERLAND BRIDGE
(Quarry Road Bridge)
Pennsylvania Historic Bridges Recording Project III
Quarry Road spanning Conestoga Creek
Terre Hill vicinity
Lancaster County
Pennsylvania

HAER No. PA-589

PAPER COPIES OF COLOR TRANSPARENCIES

HISTORIC AMERICAN ENGINEERING RECORD
National Park Service
U.S. Department of the Interior
1849 C St. NW
Washington, DC 20240

HISTORIC AMERICAN ENGINEERING RECORD

INDEX TO PHOTOGRAPHS

ADDENDUM TO:
WEAVERLAND BRIDGE
(Quarry Road Bridge)
Quarry Road spanning Conestoga Creek in East Earl Township
Terre Hill vicinity
Lancaster County
Pennsylvania

HAER No. PA-589
(Page 2)

Photographs HAER No. PA-589-I through PA-589-7 were previously transmitted to the Library of Congress.

INDEX TO COLOR TRANSPARENCY

The color xerographic copy was made from a duplicate color transparency.

Jet Lowe, Photographer, summer 2003

PA-589-8 (CT) PERSPECTIVE VIEW NW BY 310°.