CAMPBELL'S BRIDGE
(Campbell's Mill Bridge)
Pennsylvania Historic Bridges Recording Project
Spanning Unami Creek at Allentown Rd. (State Rt. 4027)
Milford Square vic.
Bucks County
Pennsylvania

HAER No. PA-451

PHOTOGRAPHS

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HISTORIC AMERICAN ENGINEERING RECORD
National Park Service
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Location:	Spanning Unami Creek at Allentown Rd. (State Rt. 4027), Milford Square vicinity, Bucks County, Pennsylvania.
USGS Quadrangle:	Milford Square, Pennsylvania (7.5-minute series, 1973).
UTM Coordinates:	18/466330/4475180
Dates of Construction:	1906-07.
Designer:	A. Osear Martin, consultant for Bucks County; Dailey Construction Company (Wycombe, Pennsylvania).
Builder:	Dailey Construction Company.
Present Owner:	Pennsylvania Department of Transportation.
Present Use:	Vehicular bridge.
Significance:	Campbell's Bridge is part of a once larger body of early short-span reinforced concrete bridges in Bucks County. It is the oldest open-spandrel reinforced concrete arch bridge in the PennDOT system and may also be one of the oldest examples in the United States. Campbell's Bridge was listed in the National Register of Historic Places in 1988.
Historian:	Dr. Mark M. Brown, August 1997.
Project Information:	This bridge was documented by the Historic American Engineering Record (HAER) as part of the Pennsylvania Historic Bridges Recording Project - I, co-sponsored by the Pennsylvania Department of Transportation (PennDOT) and the Pennsylvania Historical and Museum Commission during the summer of 1997. The project was supervised by Eric DeLony, Chief of HAER.

I. Description

Campbell's Bridge is a open-spandrel reinforced concrete arch bridge with a 72'-0" clear span.[1] Located approximately 0.6 miles south of Milford Square, this single-lane bridge spans Unami Creek (formerly known as Swamp Creek) on a northwest-southeast alignment (Figure 1).

Two arch ribs rise 9'-6" from the spring line. Based on limited field measurements,

> the shape of the axis of the arch may be closely approximated by a circular arc of approximate radius 78'-4". The radial depth of the arch at the springing is 3'-0" and tapers toward the crown.[2]

The ribs support seven deck beams approximately twenty-four inches wide and of varying heights necessary to support the "camelback" profile of the deck surface. Weep holes consisting of small metal pipes are cast into at least two segments of the deck slab. At mid-span, the combined thickness of the road slab and the macadam surface might be as much as eighteen inches. The parapet height also varies: at the center of the bridge it is about forty-five inches. Spalling concrete has exposed sufficient reinforcing bars to reveal that each rib is reinforced with twelve corrugated square steel bars originally 3/4" or 1" in size. The twelve bars were arranged in two rows at the intrados and extrados, i.e., the upper and lower surfaces, of the arch ribs. Smaller bar sizes were used in the rest of the bridge, but the size can only be measured in the parapet, where it is 1/2". The roadway on the span is about sixteen feet wide.

The abutments almost triple the length of the bridge. Damage to the upstream side of the southeast abutment reveals rough coursed field stone under about twelve inches of concrete. This suggests that part of an earlier stone arch bridge's abutments may have been re-used.

A white marble plaque, dated 1906, is located in the upstream parapet wall at mid-span. It also records the bridge's name and those of the county commissioners, clerk, and solicitor.

II. History

Campbell's Bridge connects Milford Square with Trumbauersville, the principal town of Milford Township. The township was primarily settled by German immigrants and still retains much of its agrarian past. Unami Creek and its tributaries powered numerous saw and grist mills throughout the township. In 1904 Elmer Campbell purchased the property, which included a grist mill next to a stone arch bridge whose replacement would ultimately bear his name. Nearby Trumbauersville was once a cigar and horse-whip manufacturing center. Campbell's Bridge,

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[1] Most dimensions are taken an undated drawing in the bridge inspection file, BMS No. 09-4027-0210-0000, PennDOT District 6-0, Saint Davids, Pa. A few are based on a field inspection made by Dr. Dario A. Gasparini, P.E., Stephen G. Buonopane, and the author in July 1997.

[2] Stephen G. Buonopane, to author, 1 August 1997.

however, was also a link on the Allentown Road that connected the Lehigh Valley with Philadelphia.[3]

On 3 August 1903, a cloudburst washed out two stone arch bridges across Unami, then called Swamp, Creek.[4] Ten days later the county commissioners decided to replace the bridges with reinforced concrete arches. At their next meeting they approved the plans for "two reinforced concrete arch bridges over the Swamp Creek in Milford Township, one at Achey's Mill and one on the road from Milford Square to Trumbauersville." Doylestown architect A. Oscar Martin estimated the cost of both bridges ($5,028 for Campbell's Bridge) and provided drawings for Achey's Bridge. The contract for both bridges was awarded to the Dailey Construction Company in the amounts of $4,960 and $3,180 for Campbell's and Achey's bridges.[5] Only one other company, Nelson Construction, bid on both bridges, in the amounts of $6,200 and $4,200. Oddly, while the Nelson Construction Company provided the plans and specifications for Campbell's Bridge, it was not the lowest bidder. The York Bridge Company, on the other hand, bid an incredible $9,350 for the much shorter, and still extant, Achey's Bridge.[6] Swift action to put the bridges back in service might well have been prompted by the need to ensure that farmers could get the fall harvest to Campbell's, Achey's, and other grist mills located on the north side of the creek. The completion date of Campbell's Bridge is somewhat uncertain, but in late May of 1907, the county commissioners petitioned the Quarter

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[3] William W. H. Davis, *History of Bucks County, Pennsylvania,* vol. 1 (Piperville, Pa.: A. E. Lear, Inc., 1905), 433-6; Greenhorne and O'Mara, *Historic Resources Assessment, Campbell's Bridge* (1994), 18.

[4] This paragraph is based on Bucks County, Pennsylvania, *Commissioners' Court Minutes* (Commissioners's Office, Bucks County Courthouse, Doylestown, Pa. — hereinafter cited as *Minutes*), 295 (13 Aug. 1906), 298 (quotation, 20 Aug. 1906), 303 (6 Sep. 1906), 332 (28 Dec. 1906), 316 (12 Nov. 1906); and ibid., *Bridge Book*, vol. D (microfilm roll Nos. 11-12, Clerk of Courts, Criminal Division, Bucks County Courthouse, Doylestown, Pa.), 56 (23 May 1907), 56-7 (11 Jun. 1907). The author is grateful to local historian Richard Helm for his observations about the fall harvest.

[5] The Dailey Construction Company, or at least its representative, Albert J. Thompson, was based east of Doylestown in Wycombe, Pennsylvania. See Bucks County, *Minutes*, 289 (25 Jun. 1906).

[6] The Achey's Bridge, located just east of Milford Square, is on private property and not in the PennDOT system. While it does not look the same as Campbell's Bridge, Dr. Dario A. Gasparini, P.E., professor of civil engineering at Case Western Reserve University, considers Achey's Bridge to share the same structural conception. Where Campbell's Bridge has ribs which are only connected to the deck slab at selected points, the connection between the "ribs" of Achey's Bridge and the deck slab is continuous. Nevertheless in both bridges, the engineers had learned how to exploit reinforced concrete's potential and open up the space under the deck near the abutments. In doing so, the engineers not only saved the cost of a substantial amount of concrete, but they also used the reinforcing bars more efficiently. Consequently, both can be properly described as open-spandrel bridges. In addition, the smaller span of the Achey's Bridge makes the use of pierced ribs impractical. While similar in engineering conception, the visual impression of the two bridges is quite different. The form work, and therefore the surface texture, of Campbell's Bridge was quite rough and angular. Achey's Bridge has a smoother finish (which might be attributable to a stucco coat) and an almost faceted look. These differences are curious because both bridges were constructed by the same company.

Session Court to appoint bridge inspectors. A satisfactory inspection report was filed the following month.[7]

III. Early Bucks County Reinforced Concrete Bridges

Campbell's and Achey's bridges were not the only early reinforced concrete bridges built in Bucks County. Eleven bridge petitions or other actions were recorded between 1904 and 1920 in Milford Township alone. Of these eleven entries, at least seven deal with the construction of reinforced concrete arch bridges. Between mid-May 1906 and mid-April 1907, Dailey Construction had at least three contracts for reinforced concrete bridges. Nelson Construction had at least one contract.[8] It seems likely that an examination of bridge records for other townships and for the county commissioners would reveal Bucks County built many more reinforced concrete bridges before 1920. Two other factors would have contributed to an heightened interest in concrete in Bucks County. Important cement manufacturing plants were located nearby in Portland and Coplay. Furthermore, noted Doylestown citizen Henry Chapman Mercer was a strong advocate of reinforced concrete construction, which he used in his house, in the Mercer Museum, and in the Moravian Pottery and Tile Works.[9]

A. Oscar Martin's name appears frequently throughout the county records. Martin is connected to seven projects in Milford Township, from 1904 to 1920, and at least six different bridge projects throughout the county in 1906 and 1907. Variously described in the *Bridge Book* as "an architect of Doylestown" or an "architect and engineer," Martin started studied architecture at Drexel Institute in Philadelphia in 1892. His preparation included learning carpentry from his father and perhaps as many as two years studying architectural drawing. By 1905 he had received several important commissions in Doylestown including the German Reformed and Methodist churches.[10] The suggestion that Martin was the county engineer can not yet be confirmed, but the extent of his activities as designer, estimator, and construction superintendent makes it clear that he was a *de facto* architectural and engineering consultant.[11]

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[7] Arguing for a 1906 completion date for both bridges are payments ($150 and $100) made to Oscar Martin for supervision of the bridges. See *Minutes*, 334 (31 Dec. 1906).

[8] Little else is currently know about either of these companies. The scheduled reopening of the Bucks County Historical Society's Spruance Library after an eighteen-month rehabilitation will undoubtedly help future researchers.

[9] Bucks County, *Bridge Book*, vol. D, Milford Township index; ibid., *Minutes*, 278-357 (14 May 1906 to 22 Apr. 1907); Cleota Reed, *Henry Chapman Mercer and the Moravian Pottery and Tile Works* (Philadelphia, Univ. of Pennsylvania Press, 1987), 114-116.

[10] Davis, *History of Bucks County*, 3:482-3.

[11] Jeff Marshall, Bucks County Conservancy, conversation with author, 23 Jul. 1997. The papers of A. Oscar Martin are included in those of his son, Fred F. Martin, in the Bucks County Historical Society's Spruance Library, Mercer Museum, Doylestown, Pa.

Campbell's Bridge is part of a once larger body of early short-span reinforced concrete bridges in Bucks County. As the oldest open-spandrel reinforced concrete arch bridge in the PennDOT system, it may also be one of the oldest examples in the United States. Campbell's Bridge was listed in the National Register of Historic Places in 1988.

IV. Engineering Significance of Campbell's Bridge

At the beginning of the twentieth century, reinforced concrete was still a new and poorly understood material in the United States.[12] Most early efforts to exploit the potential of concrete were based on the long established traditions of masonry construction. Both unreinforced concrete and stone are strong in compression and weak in tension, properties suited to the arch form, which carries loads mainly in compression. While reinforced concrete arches might be shaped like masonry arches, they do not behave in the same way. Engineers developed three general approaches to deal the with the tension created in concrete arches by live loads: (1) massive unreinforced concrete, (2) heavy systems of structural steel, (3) and the selective placement of reinforcement in areas under tension. Omitting reinforcing required more concrete. Heavy steel systems were expensive, labor intensive, and essentially defeated the potential advantages of concrete. Selective reinforcement represented a compromise that both saved on material, reduced the fabrication costs of heavy steel work, and exploited the properties of both materials. In the early days of American experimentation with concrete, reinforced or massive, it was not clear which approach would become general practice.

The first reinforced concrete arch bridge in the United States was Ernest L. Ransome's 1889 Alvord Lake Bridge in San Francisco's Golden Gate Park. Ransome gave the twenty-foot span a masonry-like finish, but sought to place twisted reinforcing bonded with the concrete where the concrete would be in tension. A second approach was Joseph Melan's system as championed in the United States by Fritz von Emperger. Recent structural analysis of Emperger's 1894 Rock Rapids, Iowa, Arch Bridge reveals an overuse of structural steel. In this system, the steel and concrete need not be bonded together. In a modification of the Melan system, Emperger replaced the I-beams used at Rock Rapids with latticed arch members, such as those in the 1904 Frankford Avenue Bridge spanning Poquessing Creek between Philadelphia and Bucks counties.[13]

Around 1900, virtually on the eve of the construction of Campbell's Bridge, Edwin Thacher and Daniel B. Luten returned to Ransome's ideas. Thacher patented deformed

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[12] This section based on Carl W. Condit, *American Building Art: the Nineteenth Century* (New York: Oxford Univ. Press, 1960), 248-54; ibid., *American Building Art: the Twentieth Century* (New York: Oxford Univ. Press, 1961), 195-207; and U.S. Department of the Interior, Historic American Engineering Record (HAER) No. IA-89, "Structural Study of Reinforced Concrete Arch Bridges," 1996, Prints and Photographs Division, Library of Congress, Washington, D.C.

[13] See U.S. Department of the Interior, HAER No. PA-471, "Frankford Avenue Bridge over Poquessing Creek," 1997, Prints and Photographs Division, Library of Congress, Washington, D.C.

reinforcing bars intended to increase the mechanical bonding between the steel and the concrete. In addition, he placed the reinforcing at both the intrados and extrados of the arch — the pattern used at Campbell's Bridge. Luten developed a closed-spandrel tied arch where the reinforcing was bent to the section of the arch that would experience tension.

Campbell's Bridge represents an early example of the convergence of these pioneering experiments. The deformed reinforcing bars mechanically bonded the steel and concrete to create a composite material. Reinforcing placed at the inner and outer edges of the arch reveal a more sophisticated understanding of the forces in play. Opening the spandrels substantially reduced the amount of concrete, moved engineers further away from masonry models, and pointed toward the economical construction of large-scale bridges.

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FIGURES

Figure 1 Elevation and plan of Campbell's Bridge, n.d. Source: BMS No. 09-4027-0210-0000, bridge inspection files, PennDOT District 6-0, Saint Davids, Pa.