CANAL ROAD BRIDGE
Pennsylvania Historic Bridges Recording Project III
Canal Road spanning Delaware Canal Diversion, Locks 22 and 23 in Delaware Canal State Park in Williams Township
Raubsville
Northampton County
Pennsylvania

HAER No. PA-617

HAER
PA-617

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

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

HISTORIC AMERICAN ENGINEERING RECORD

CANAL ROAD BRIDGE
(DELAWARE CANAL DIVERSION BRIDGE)

HAER NO. PA-617

LOCATION:	Canal Road spanning Delaware Canal Diversion, Locks 22 and 23 in Delaware Canal State Park in Williams Township, Raubsville, Northampton County, PA Bin # 48 7935 6450 5310
UTM:	18/483789/4497121
DATE OF CONSTRUCTION:	1900
DESIGNER:	Diversion Canal/Head Race and Bridge: United Engineering & Contracting Company, New York
BUILDER:	United Engineering & Contracting Company, New York
PRESENT OWNER:	Commonwealth of Pennsylvania, Department of Conservation and Natural Resources
PRESENT USE:	Vehicular Bridge
HISTORIAN:	Dr. Linda S. Phipps
SIGNIFICANCE:	The Canal Road Bridge is the earliest reinforced concrete deck arch bridge in the Commonwealth of Pennsylvania. Constructed over the head race leading to an early hydroelectric power station, it marks changes in land use and the development of such key infrastructures as electrical power generation and transportation networks. As part of the power station, the bridge has important historical links to the developing Portland cement industry of the Lehigh Valley.
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 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 Christine Pires (ICOMOS—Portugal); Dr. Linda S. Phipps and Dr. Richard Vidutis served as project historians under the supervision of Dr. Richard O'Connor (HAER Senior Historian). Professor Thomas E. Boothby, PhD, PE, RA (Pennsylvania State University, State College) was the Consulting Engineer; Jose C. Colon (Pennsylvania State University, State College), was the Project Engineer. Jet Lowe (HAER Photographer) took all large format photography. Justine Christianson (HAER Historian) prepared the documentation for transmittal to the Library of Congress.

Description

The Canal Road Bridge is located in the Delaware Canal State Park just south of Raubsville, Pennsylvania. It is the easternmost bridge of a pair linking Canal Road to an early hydroelectric power station. Canal Road now intersects with modern route 611, which runs north-south from Easton, Pennsylvania to Philadelphia, paralleling the canal.[1] The Canal Diversion runs adjacent to locks 22 and 23, known locally as the Groundhog Locks. With a 17' change in level, these locks offered the greatest lift of any locks along the canal. Branching off of the main line of the canal, just north of lock 22, the Canal Diversion, or head race, arcs to the south and east, directing water to the power station, which was constructed between 1900 and 1901. Its earlier, western counterpart spans the canal, proper, while the Canal Road Bridge spans the head race. The rectangular building housing the turbines stands directly southeast of the Canal Road Bridge.

The bridge is trapezoidal in plan and skewed at a 77-degree angle, with a span of 38.5'. The width of the roadbed is 25' from curb to curb, and the overall external width, from the outside of one parapet wall to the other, is 27'. The bridge has an average underclearance of 8.5' from the center of the Canal Diversion channel floor to the bottom of the arch at midspan.[2] The northeast end of the bridge has a single short, concrete wing wall, parallel to the canal. Galvanized iron pipe railings flank the western approach and run south from the southeast parapet wall.

In accordance with its utilitarian context, the form of the bridge is extremely simple. It is a filled spandrel concrete deck arch with an asphalt roadbed. Its spandrels and parapets are simple, unornamented masses. The bridge springs from a low segmental arch. Its abutments project slightly into the head race. Except for a chamfered crown moulding on the coping and a small rectangular marble plaque noting its date of construction (located on the inner face of the south parapet) the bridge has no adornment. The plaque states in capital letters and numerals, "ERECTED 1900." The word is arranged directly above the date. The two are separated by a low recessed arched cartouche, echoing the forms of the bridge. A bell flower hangs from the upper edge of the cartouche against a stippled background.

With the exception of the marble plaque, the surfaces are of a uniform material, although there are occasional slight imprints on the parapet walls from the falsework used to form the concrete. Excepting a few minor cracks and patches, the concrete is in sound condition with no significant delaminations. Given the absence of drawings or other documentation that could provide insight into the internal structure of the bridge, the evidence offered by the patterns of cracks must be relied upon to infer the most likely disposition of steel reinforcement within the walls.

The bridge, like the walls of the head race that it spans, is of reinforced concrete. On the north wall of the bridge, one horizontal crack parallel to the crown moulding runs for approximately 4' along the northwest edge of the parapet wall about 2' from the top, suggesting that the concrete comprising this section was laid after that of the span

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[1] See map of "Williams Township," in Atlas of Northampton County, PA (Philadelphia: 1874).

[2] I am indebted for these measurements to Philip Kozak, Senior Civil Engineer, Pennsylvania Department of Conservation and Natural Resources for supplying me with a recent inspection report from his file. Nassaux-Hemsley, Inc., 2001 Bridge Inspection, Power Plant Bridge.

beneath it. A second crack, on the same wall, originates in the east abutment near the water line. It runs concentric to the arch ring from a point approximately 3' from the springing point, then it travels directly upward, rising vertically to the top of the parapet. This latter crack occurs at a point of maximum strain for a low segmental arch. The line traced by the crack most likely follows a bed of rebar along the arch below. Then, it moves up into the spandrel at a point where the surrounding concrete would be most vulnerable to strain.

Other significant cracks on the outer surface of the south wall suggest two parallel tiers of rebar supporting the arch ring within the concrete. One follows the line of the arch ring concentrically, paralleling the line of the arch from the outer edge of one abutment to the other across the entire span. A second line of smaller cracks along the intrados of the arch to the east further suggests the location of steel reinforcement along the arch ring. On the inner face of the south parapet, a crack descends from the lower right corner of the marble plaque, probably occasioned by uneven movement during expansion/contraction of the two different materials at that point. There is evidence of attempted repairs through patches of lighter colored concrete applied along these cracks.

Significance

The Delaware Canal, owned and operated by the Lehigh Coal and Navigation Company (hereafter referred to as LCNC), was constructed in the late 1820s. The canal and its towpath established a major venue for the transportation of anthracite coal and other goods along the Delaware River. Through linked canals, it became part of a network extending inland to the Allegheny Mountains and to ports on the Atlantic coast. With the ascension of railroads by the late nineteenth century, freight traffic and related revenues on the canal had declined significantly. In order to minimize its losses, the LCNC decided to exploit the canal as a source of hydropower. Twin locks (numbers 22 and 23), known as the Groundhog Locks, just south of Raubsville, Pennsylvania, offered conditions particularly suited to such uses.[3]

During the decades following the Civil War, Raubsville was a prosperous mining village. Local industries included a limestone quarry, limekilns, iron mines, an iron furnace, a paper mill, a brewery, a distillery, and numerous grist and saw mills. The Groundhog Locks offered a resource, water power, that fostered the development of local industries. The area was known locally as Uhlersville, after Peter Uhler who established a distillery just upstream from the twin locks.[4] After the Civil War, Uhler converted the distillery to a paper mill. Although now a minor local road, in 1900, Canal Road (also known as River Road) was the major north-south land route. It ran between the canal and the river before crossing the bridge over the canal by the present power station. At

[3] For a comprehensive history of the Delaware Canal, see Clayton P. "Bill" Yoder, Delaware Canal Journal (Bethlehem, PA: 1972). Ironically, the construction of the headrace for the power station caused such strong currents along the 6 mile stretch near the station that it often interfered with the delivery of coal and ore destined for local industries in Raubsville. See p. 169.

[4] See "Raubsville," in History of Northampton County, PA (Philadelphia and Reading, PA: 1877), pp. 245-246.

the turn of the century, hydroelectric plants, such as the one established at Raubsville by the Lehigh Power Company, offered a new source of income for the LCNC at a time when the business generated by the canal was declining. In 1900, the Lehigh Power Company was incorporated in New Jersey and, shortly thereafter, also in Pennsylvania.[5] On March 2, 1900, the Easton Free Press reported that the Lehigh Power Company had purchased 2 acres of property from the Uhlersville Paper Company in order to construct the power station.[6]

The turn of the century heralded an increased reliance by industry on electricity as an energy source necessary to production. Other electricity-dependent industrial developments in the vicinity included an electric trolley line that ran parallel to the canal, established in 1897 as the Doylestown and Easton Street Railway Company.[7] In 1902, the company constructed a coal-fired steam generated power plant near Raubsville to supply power for the trolley. A short spur connected the railway line with the canal, allowing for the transfer of freight between the two.[8] One of the more significant consumers of electricity was the burgeoning Portland cement industry, which relied on large amounts of energy to run its kilns.

Since the mid-nineteenth century, new artificial hydraulic cements, known generically as Portland cement, spurred demand. After the Civil War, production grew apace with the availability of low-priced steel. When combined, these two materials resulted in a strong new compound, reinforced concrete. Applications for this new compound seemed limitless. Within this field of fertile experimentation, demand for reinforced concrete grew exponentially. The rich deposits of limestone in the Lehigh Valley, a key ingredient in Portland cement, fostered an extensive industry relying on the transportation systems and the new power sources to run profitably. By 1900, this area, including Lehigh and Northampton counties (PA) and Warren County (NJ), led the nation in the number of Portland cement plants (11) and in their combined output. In 1899 alone, the region produced 4.1 million barrels of cement, nearly 53 percent of the national output.[9]

Thus, it is not surprising that, in August 1900, shortly after construction of the new hydroelectric plant was begun, the Easton Daily Express reported that the new plant near Raubsville was to deliver a significant proportion of its output to the "cement district" in Warren County, New Jersey, a couple of miles across the river.[10] Although

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[5] Articles of incorporation were filed with the Commonwealth of Pennsylvania on November 19, 1900 by the Lehigh Power Company. Earlier that year, they had also been filed in New Jersey, presumably because of that state's liberal tax structure with respect to corporations.

[6] See "Site for New Light Plant: Lehigh Power Company Purchased Land Near Raubsville," Easton Free Press, March 2, 1900. Yoder discusses the history of this area, pp. 33-38.

[7] For a concise history of this trolley line, see Benson W. Rohrbeck, Pennsylvania's Street Railways (West Chester, PA: 1997), p. 142.

[8] See Short Trolley Routes in the Lehigh River Valley (Allentown, PA: 1967), p. 57. The author is indebted to the staff of the Marx History Room of the Easton Area Public Library of Easton, Pennsylvania for providing access to their collection of local history materials such as this publication.

[9] Spencer B. Newberry, "The Production of Cement in 1899, Extract from the twenty-first annual report of the U.S. Geological Survey, 1899-1900," Cement I, no. 6, pp. 258-266.

[10] See "Progress at Raubsville," Easton (PA) Daily Express, August 1, 1900. The author is indebted to David Drinkhouse of the Drinkhouse Engineering Group of Easton, Pennsylvania for providing her with this reference and for sharing his insights into the history of the region and its industrial development.

initial plans included supplying power to Easton as well as to New Jersey, soon, the plans to sell power to Easton were abandoned. Instead, the Alpha Portland Cement Company, established in 1895, and a key Lehigh Valley manufacturer, contracted with the Lehigh Power Company for the total output of the station. In 1901, the Alpha Portland Cement Company built a new plant with ten 60' kilns in Alpha, New Jersey, 2 miles from the station. At the same time, Alpha moved its corporate offices from New Jersey to Easton, Pennsylvania.[11]

During construction, the power station at Raubsville was severely damaged by floods along the Delaware River and the adjacent canal. The added expenses imposed serious financial problems for the fledgling company. In 1902, the directors of the Alpha Portland Cement Company bought a controlling interest in a new stock issued by the Lehigh Power Company. Out of 3000 shares issued, the directors bought 2700 shares, or a total of $270,000 of the $300,000 capitalization.[12] Efforts to bail out the power company were ineffective. By 1904, the Lehigh Power Company was forced into receivership and the station sold. The company was reorganized and the name changed to the Clymer Power Company.[13] Eventually absorbed by Pennsylvania Power and Light, the station operated until the mid-1950s when severe flood damage caused it to shut down permanently.[14]

The respective histories of industry and related infrastructures, like transportation networks and power stations, are particularly dynamic in this period. Yet, their significance is easily matched by the technological advancements represented by the modest little bridge near Raubsville. As one of the earliest surviving reinforced concrete arch bridges in the Commonwealth of Pennsylvania, the Canal Road Bridge heralded significant changes in technology and building construction. Its deployment of steel reinforcements and its understated but monumental forms suggest a new conceptualization of the strength of materials.

The technology underlying the Raubsville bridge relied on research begun shortly after the Civil War by European engineers hoping to find new ways to reinforce concrete with iron and steel. By the late nineteenth century, the modern perception of reinforced concrete as an elastic mass marked a shift away from empirical design and towards more precise mathematical predictions of the strength of materials and their projected behavior

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[11] In the following year, Alpha switched its legal incorporation from New Jersey to Pennsylvania. David F. Drinkhouse, "Chronology of the Portland Cement Industry Along the Delaware River...(1891-1994)," courtesy of David F. Drinkhouse.

[12] The company emblem on the stock certificates depicts the god Hermes, high above the earth, directing lightning bolts of electricity through his caduceus to the power station. The Alpha Portland Cement Company papers are in the Archives of the National Canal Museum, Hugh Moore Historical Park and Museums, Easton, Pennsylvania. The author is indebted to Lance Metz and the staff of the archives for allowing access to these papers. The Easton Free Press of December 12, 1899 had reported that the Lehigh Power Company was incorporated with an initial capitalization of $500,000, see "The New Power Company: Chartered to Build a Plant at Raubsville, Capital $500,000." According to the article, major investors included a New York banking firm and several New Jersey capitalists. None of these parties was specifically named.

[13] Ibid, Yoder, p. 35.

[14] Ibid. Floods caused by Hurricane Diane in August of 1955 so damaged the turbines that the power station finally was forced to cease operations. See p. 126.

under specific conditions of stress and strain.[15] The period from 1890 to the First World War marked considerable experimentation in reinforced concrete for structures such as bridges, tunnels and sewer systems.

By 1900, two lines of thought had evolved that would shape subsequent American developments. One derived from Joseph Monier's use of iron mesh (patented 1867, France) to reinforce large concrete flowerpots. Monier's son, Jean, soon extended his father's experiments into bridge design (patented 1873, France) by laying iron reinforcing bars in beds of mortar along the lengths of arched concrete spans. Monier's early works initiated refinements and adaptations by other engineers throughout Europe.

In 1890, Viennese engineer, Joseph Melan, offered an alternative to Monier's bridge designs. He advocated using parallel pairs of specially curved I-beams to reinforce concrete arch spans. In 1892, the Austrian Society of Engineers and Architects subjected his designs to a series of tests. They demonstrated that a Melan system arch could handle loads four times that of its Monier-based counterparts. Melan obtained a U.S. patent in 1893, establishing the Melan Arch Construction Co. in New York City in order to market his designs. Believing Monier-based bridge designs to be insubstantial, American engineers readily embraced Melan's system. Another Austrian engineer, Fritz von Emperger, further refined Melan's ideas. He advocated inserting a series of short struts, in a zigzag pattern, to connect the pairs of arched I-beams in order to stabilize them. The resemblance of this configuration to a Warren truss underscores the degree to which the Melan-related line of development consisted of a truss-like metallic structure designed to carry most of the stresses while encased within a protective sheath of concrete.

Von Emperger's patent was "improved upon" by Edwin Thacher. In his history of concrete bridges in Indiana, James L. Cooper describes Thacher as a distinguished civil engineer who was educated at the Rennselaer Polytechnic Institute in Troy, New York.[16] As a young man, Thacher worked as a bridge designer for the Keystone and the King Iron Bridge companies, where he patented designs for metal truss bridges. Eventually, Thacher established himself as a consulting engineer in New York. During the 1890s, he experimented with designs for reinforced concrete bridges. By 1896, Thacher felt that he had developed a unique solution. He applied for a patent for arch ring reinforcements in which two parallel but separate tiers of rebars functioned independently of one another. His design offered greater flexibility for placing the rods with respect to the arch ring, whereas Melan's single set of bent I-beams could only be arranged next to one edge. For increased stability, Thacher often sank the rods deep into the abutments.[17]

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[15] See "Cement," "Concrete: Plain and Reinforced," and "Structural Theory," in Chapter 20, "Building Materials and Techniques," in Charles Singer et al, eds., A History of Technology: Volume 5 (of 7): The Late Nineteenth Century, c. 1850 to c. 1900 (Oxford, England: Clarendon Press, 1958).

[16] Cooper's book provides an excellent overview of the development of reinforced concrete bridge design in the United States. James L. Cooper, Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942 (Greencastle, IN: n.d.).

[17] Thacher's tendency to add stirrups or connecting rods between the two layers of re-bar led to a patent infringement suit from von Emperger in 1916. See Cooper, pp. 38-40, 41.

In 1901, Thacher established the Concrete-Steel Engineering Company to market his designs. An ad from the Engineering News Record of 1909 describes the company as "Specialists in Concrete-Steel Bridge Construction for the past 15 years," indicating Thacher's long experience in the field.[18] The ad includes images of Thacher's diamond-pattern reinforcing bar and a "Melan system" multispan bridge designed by the firm. A number of engineers, including Ernest Ransome, experimented with designs for reinforcing bars, or rebar, during these years. In order to lend the greatest tensile strength to the concrete, they sought to maximize the bond with the steel rods by texturing their surfaces so that the concrete could grip them as it set.

Despite Thacher's contributions to reinforced concrete bridge design, his work remained fundamentally conservative. Notwithstanding the forward-looking nature of his designs, they remained theoretically grounded in notions of redundancy. Thacher was never able to relinquish the idea that the steel must be able to bear the stresses alone.[19] By contrast, the principles underlying the Monier system were more closely related to the developments of elastic theory that pointed to the future of the technology. The latter offered a new way of conceptualizing "concrete steel" or reinforced concrete by recognizing the new material as not so much an aggregate of two distinctive components, but as an integral substance in which the two ingredients melded their respective strengths together.

In marrying the tensile strength of steel with the compressive strength of concrete, the resulting union, reinforced concrete, was stronger than the sum of its parts. Engineers such as Indiana's Daniel Luten exploited these ideas most profitably. Luten was among the most prolific of those who integrated elastic theory with economical and pragmatic design. By conceiving of reinforced concrete as a monolithic material, Luten's bridge designs were more economical than those of contemporaries like Thacher. Luten demonstrated that he could use significantly less metal in reinforcements and still attain a strong and safe structure. Royalties for patents issued to engineers such as Luten became important sources of revenue. Through his National Bridge Company, Luten marketed his designs nationally. The first decade of the twentieth century saw a proliferation of such patents by engineers. Like earlier metal truss bridges before them, reinforced concrete bridge designs were most effectively marketed to other engineers and to potential clients through trade catalogues.[20]

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[18] Cooper states that the company was established in 1901, but the advertisement suggests that it had been established in the mid 1890s. See Cooper.

[19] As Thacher explained, "...the steel must be capable within its elastic limit of taking the entire bending moment of the arch without aid from the concrete...Though the steel can never take the entire bending moment under normal conditions, it is a comfort to an engineer to know that if...any part of the concrete should be of poor quality...his work will still continue to stand and do its duty." See Edwin Thacher, "Concrete-Steel Bridge Construction," Engineering News 42, no. 12 (Sept. 21, 1899): pp. 179-185. See especially, p. 179. For a more extensive overview of Thacher's ideas and the work of the Concrete-Steel Engineering Company, see Edwin Thacher, "Concrete and Concrete-Steel in the United States," in Transactions, American Society of Civil Engineers, International Engineering Congress 1904, Paper No. 70.

[20] Persons using a patented design would be charged a fee. For a comprehensive discussion of Luten's unique contributions see Cooper, chapters 2 and 3.

Determining the place of the Canal Road Bridge within this development is somewhat problematic, but there are important clues in the forms of the bridge itself. The patterns of cracks offer the most useful means of determining the underlying structure. Although they are open to interpretation, they appear to present three possibilities. First, this could be a Melan system bridge using a single bent I-beam, although the cracks along the southeastern rim of the arch appear to eliminate this possibility. Secondly, this could be a von Emperger refinement of a Melan design with linked tiers of bent I-beams. However, the fact that the fracture patterns are not consistent across the spandrels also tends to eliminate this as a possibility. The presence of cracks parallel to the arch on the north wall, but not along the rim of the arch, further argues against this second possibility. Along the south wall, a fracture runs from one abutment to the other along a line parallel to the arch but 2' to 3' above it. This line suggests an independent line of reinforcements at that level. Varying rates of expansion of the metal and the concrete encasing it would have caused a separation of materials. This line could also suggest a traditional single tiered Melan arch. The additional cracking of the rim along the intrados would tend to discount that possibility. The lower one runs along the bottom edge of the arch. The upper tier runs from the outer edges of the abutments in an arc concentric to the lower tier approximately 2' to 3' above it. Based on those additional cracks, the third and most likely possibility is that the bridge incorporates two layers of rebars, although their precise configuration remains a mystery. It is tempting to suggest that perhaps Thacher's Melan-based system of dual-tiered reinforcing bars may have inspired the engineers designing the Canal Road Bridge.

In fact, Thacher advised against using segmental arches for reinforced concrete bridges in a long article published in the 1899 Engineering News. He recommended that engineers restrict pressures from live and dead loads to the center third of the arch ring. He further insisted that engineers strive to isolate the concrete from tension and to direct it to the steel reinforcements. Given these guidelines, Thacher asserted that attaining these conditions was nearly impossible in any structures employing a segmental arch for their span.[21]

Thacher's opinions were well supported by historical precedent. The relative strengths and weaknesses of these two arch shapes were fully understood by Roman engineers. In long masonry spans such as aqueducts, Roman engineers relied on repeating semicircular arches to carry roadbeds and water channels across valleys and riverbeds. These stable, repetitive structures efficiently minimized the lateral stresses that run through any arch by directing them more vertically downward. The juxtaposition of identical arches meant a neutralization of any lateral stresses by equal and opposite forces.

Segmental arches, by contrast, direct their forces at a line tangential to the curve of the arch. This line of force more directly affects the masonry in the adjacent abutments. As James Cooper explains, segmental rings generate two times as much pressure at the crown as a semicircular arch, but they exert much less pressure on the haunches, only a third more than at the crown. At the abutments, however, because of their inclined springpoints, segmental arches transfer much greater lateral pressure to

[21] Thacher, pp. 179-185.

these areas. This condition becomes a problem only in those structures requiring long spans, or where constructing especially strong abutments is difficult. The Diversion Canal, with its reinforced concrete walls and its earthen embankments, should have provided an ideal situation for such a bridge.[22] Yet, even at Raubsville, the impact of these forces is easily visible in the cracks that run along the line of the arch into the abutments. As live loads are transferred along the roadbed over the crest of the arch, the ends of the arch are subjected to the greatest pressure. These areas most readily fracture.

In 1900, despite the suggestions published by Thacher a year earlier, the engineers in charge of building the Raubsville plant erected a segmental arch bridge. Given the short span and the conditions of the Diversion Canal, the designer may have felt the increased lateral stresses of the segmental arch were negligible. This form may have seemed the most economical solution given the nature of the structure as a utilitarian supplement to a power station. The relative insignificance of the bridge is suggested by the treatment of the power plant by the professional press. Designs for the turbines, generators, and related power equipment by the Ohio-based Stillwell-Bierce-Vail Company were the subject of a full-page article in the October 5, 1901 Engineering Record. Illustrations provided cross-sections of the building that depicted the relative locations of the turbines, the generators, the draft tube and their relationship to the canal. A site plan included the small bridge over the head race, but it did not furnish any information about the design of the bridge or the nature of its construction.[23]

A New York firm, the United Engineering and Contracting Company, was subcontracted to construct the buildings, and to perform the excavation and related masonry work, including the Diversion Canal and bridge.[24] This company appears to have been well known in New York construction circles. Subsequent jobs executed by the firm included the crosstown (Manhattan) section of the Pennsylvania Railroad tunnel, begun in 1903. This tunnel complex ran from New Jersey to Long Island, under the Hudson River to Pennsylvania Station in Manhattan and, from there, beneath the East River to Long Island.[25] The company also constructed the approaches to the Williamsburg Bridge, several sections of the I.R.T. subway in New York, as well as dry docks and a pumping station for the New York Navy Yard.[26] All of these projects involved reinforced concrete construction for structures similar to the power station in

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[22] Cooper, p. 13.

[23] "The Plant of the Lehigh Power Company at Raubsville, Pa.," The Engineering Record, 44, no. 14, (Oct. 54, 1901): p. 317.

[24] The Easton Daily Express of August 1, 1900 reported in "Progress at Raubsville," that the "United Engineering & Construction Company" of New York was subcontracted to do the work. Yet, there is no listing for such a company in the New York City business directory for that year. Instead, the "United Engineering & Contracting Company" appears, with an address at 21 Park Row. Nor is there any reference to the United Engineering and Construction Company in historical newspapers indexes. However, there are numerous citations for the United Engineering & Contracting Company. The Easton reporter most likely confused the name.

[25] Its president was David L Hough. See obituary for one of the company's supervising engineers, "Frederick J. Dieterich, Retired Engineer a Supervisor at Raising of the Maine," New York Times 8 April 1939.

[26] "Government Contract Case," Wall Street Journal, April 14, 1914, p. 5.

their predominantly utilitarian functions. Their in-house engineers most likely designed the Raubsville bridge.[27]

The United Engineering & Contracting Company had offices in the Park Row Building at 17-21 Park Row, the world's tallest building at the time. Little is known of the firm and its staff, but its civil engineers were probably familiar with many of the most recent innovations in reinforced concrete technology, given its successes in procuring such large, prestigious jobs. During the period of construction of the Raubsville plant, the Concrete-Steel Engineering Company (1901) also took up residence in the Park Row building. Engineers Edwin Thacher and William Mueser directed the Concrete-Steel Engineering Company.[28] This proximity may not be directly significant to the Canal Road Bridge. Yet, the presence of such leading engineers as Joseph Melan, Fritz von Emperger, and Edwin Thacher in turn of the century New York meant that the United Engineering and Contracting Company would have had ready access to some of the most advanced ideas in reinforced concrete bridge technology.

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[27] According to the Easton Daily Express, August 1, 1900, Mr. Madigan (presumably one of the engineers of the firm) oversaw the works at Raubsville. It is not known if this is the same William M. Madigan who worked with Thomas A. Edison in 1889 on the design for turbines for another power station that was later absorbed by General Electric. Madigan became an executive in the latter concern and retired from that company. See "William M. Madigan," the New York Times, June 5, 1950, 23:1.

[28] See ad for Concrete-Steel Engineering Co. published in the 1909 Engineering News Record and reproduced by Cooper, Artistry and Ingenuity, p. 39. The history and various addresses of the Park Row Building are given in a brief on-line summary by the New York City Landmarks Commission, see http://www.ci.nyc.ny.us/html/designation/summaries/parkrow.html

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