University Avenue Bridge, Philadelphia: An Historic Structure Report

Thomas Clayton Jester
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UNIVERSITY AVENUE BRIDGE, PHILADELPHIA: AN HISTORIC STRUCTURE REPORT

Thomas Clayton Jester

A THESIS

in

The Graduate Program in Historic Preservation

Presented to the Faculties of the University of Pennsylvania in Partial Fulfillment of the Requirements for the Degree of

MASTER OF SCIENCE

1991

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FINE ARTS
For Jen
The key to our newest civilization seems to be the improved highway; may it be made not only commodious and permanent, but beautiful as well—especially bridges that carry it over streams and other obstructions, and constitute its most monumental features.

Wilbur Watson, *Bridge Architecture*, 1927
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INTRODUCTION

In 1925, the City of Philadelphia began planning a new bridge to cross the Schuylkill River. City engineers, working in collaboration with architect Paul Philippe Cret, designed the University Avenue Bridge, a five-span, metal-arch drawbridge with decorative lantern groups at the approaches.¹ Constructed in 1928, this automobile bridge's significance is due in part to its design, implemented as part of Philadelphia's City Beautiful Movement. It remains one of the few engineering structures directly associated with Philadelphia's City Beautiful past.

Despite the importance of industrial resources, historians have largely ignored Philadelphia's bridges, including the University Avenue Bridge. Moreover, no historical commission has recognized the University Avenue Bridge as a significant structure. Built by the City of Philadelphia and now owned by the Pennsylvania Department of


The primary published works on the University Avenue Bridge are: the newspaper collection in the Urban Archive, Paley Library, Temple University; Paul Cret, "Bridges," Architectural Progress 4, no. 11 (November 1930):6-7,19; Paul Cret, "The Architect as Collaborator with the Engineer," Architectural Forum 49, no. 1 (July 1928):97-104.
Transportation, the University Avenue Bridge is not listed on the National Register of Historic Places, nor has it been certified by the City of Philadelphia.

Prior to the 1970s, historic preservationists all but ignored industrial resources. As the field gained momentum in the late 1960s, in the wake of urban renewal, preservationists primarily focused their attention on buildings. Recognizing the need for a deeper understanding of our patrimony, preservationists later began devoting more time to industrial historic resources. Commensurate with this broadening scope of historic preservation, the late 1970s and early 1980s witnessed a dramatic increase in attention to historic bridges. The National Cooperative Highway Research Program stated that more than 50,000 bridges in the United States are historic resources. Because bridges represent an important facet of the nation's transportation and industrial heritage, historians have now begun to work with highway administrators and engineers to identify resources worthy of preservation and develop criteria for decision making.


3 One such project was undertaken in Pennsylvania, which is rich in historic bridges. Beginning in 1982, and extending over a three year period, the Pennsylvania Department of Transportation and the Pennsylvania Historical Museum Commission surveyed and evaluated bridges in the state to identify historic resources. The result was a list of more than 180 bridges which were listed on or eligible for the National Register of Historic Places. Among these significant highway bridges was
The University Avenue Bridge has never been the subject of a detailed investigation. This thesis seeks to inform future decisions made about the maintenance and preservation of this significant highway bridge. It examines the bridge by documenting the cultural and design context in which the bridge was built, it investigates the condition of the bridge, and it describes measures that can be taken to preserve it.

Chapter One establishes the historical significance of the University Avenue Bridge by documenting its historical and cultural context. This chapter also considers the design in terms of the collaboration between the fields of engineering and architecture, and discusses the prevalent theories of bridge design fostered during first three decades of the twentieth century. One of the figures who elucidated his theory of bridge design was Paul Philippe Cret, the architect of the University Avenue Bridge.


In addition to identifying and protecting historic engineering structures, many bridge engineers are devoting more and more time to techniques which may be employed to rehabilitate modern historic bridges. The Third Historic Bridges Conference recently convened in Ohio as a forum between historians and engineers who are often faced with challenging problems when rehabilitating historic bridges. The focus of this conference was concrete and masonry, materials which are associated with modern bridge construction. *Proceedings of the Third Historic Bridge Conference*, Department of Civil Engineering, Ohio State University, October 5, 1990.
Chapter Two assesses the condition of the University Avenue Bridge. Each of the visible conditions is discussed to determine the relative impact on the bridge's structure and character. The final section of this chapter demonstrates that maintenance of the bridge since its completion is effecting the integrity and performance of its materials. Deferred maintenance of the bridge hastens deterioration, which may someday lead to bridge replacement rather than bridge rehabilitation. In the absence of proper planning, the bridge's character defining fabric is disappearing. Since the bridge's completion, the City has replaced the original railing, installed fencing over the window frames on the main pier towers, and failed to care for the bronze elements. Past rehabilitations, too, failed to properly consider the impact of the work on the historic character of the University Avenue Bridge. The question that then arises is how does one appropriately maintain and rehabilitate historic movable bridges which must continue to operate as highways and cross over navigable waterways?

Chapter Three considers many options to preserve the University Avenue Bridge. First and foremost is the need for planning to prevent unnecessary deterioration of the University Avenue Bridge in the future. This chapter considers possible techniques for masonry cleaning, demonstrates the importance of an appropriate mortar mix for
repainting masonry joints, and discusses the bridge's important but deteriorating bronze elements. In the final section of this chapter, past alterations are documented to suggest how the integrity of the bridge might be preserved, and to prevent unsympathetic changes in the future. Finally, the preservation options are prioritized and given preliminary cost estimates.

The University Avenue Bridge is worthy of preservation and there are steps that can be taken to achieve that objective. Examination of this early twentieth century bridge should be useful both to individuals involved specifically with the University Avenue Bridge and to those who may be faced with the difficult task of preserving other historic bridges.
Building the University Avenue Bridge

In 1925, the City of Philadelphia appropriated $1,300,000 to construct a new bridge over the Schuylkill River. The site chosen to cross the river would connect west Philadelphia on line with 34th Street and south Philadelphia at Grays Ferry Road. The City commissioned architect Paul Philippe Cret to design the bridge in collaboration with engineers in the City's Bridge Division. The City erected a five-span, metal-arch drawbridge with decorative bronze lantern groups on the railing walls of the approaches. Two main piers, each having an operator's tower and small lantern plaza, connect the narrow intermediate piers, and the center span is the movable bascule which is electrically driven and balanced on a counterweight.

This chapter discusses the specific cultural milieu—the City Beautiful Movement—which engendered the resulting form of the University Bridge. It describes the design of the bridge as a collaboration between the fields of architecture and engineering and in relation to the aesthetic theories of bridge design fostered during this period. Finally, it traces the construction of this engineering structure during
1927 and 1928, and concludes with the bridge's eventual completion in 1933.

Planning a New Philadelphia Bridge

Planning for a bridge to cross the Schuylkill River and connect West and South Philadelphia began in 1917. That year, a preliminary study appeared in the May 27 issue of the Philadelphia Evening Bulletin and described a proposed "ornate" bridge (Illustration 1). A bridge crossing the Schuylkill from west to south Philadelphia was needed to facilitate access to south Philadelphia, a growing area of the city (Illustration 2).\(^1\) The proposed bridge would link Gray's Ferry Road on the east bank with a new road, University Parkway, on the west bank (Illustration 3).\(^2\) The preliminary study, conducted by Johnathon Jones, a City engineer, and Benjamin A. Haldeman, the city planning expert, recommended a double leaf bascule bridge of concrete and steel with three spans and viaduct approaches.\(^3\) Until 1917, the Schuylkill River was navigated by ships which passed

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\(^{1}\) Philadelphia Evening Bulletin, 27 May 1917, Urban Archive, Paley Library, Temple University. The Urban Archive at Temple University contains a collection of newspaper articles about the University Bridge, which document chronologically the bridge's history. Unless otherwise noted, newspaper citations refer to this collection.

\(^{2}\) Ibid.

\(^{3}\) Ibid.
under Schuylkill River bridges without lifting mechanisms. The University Bridge was the first proposed movable span. Larger ships with tall smoke stacks necessitated construction of a drawbridge.

Until 1925, lack of appropriations prevented construction of a bridge to connect South and West Philadelphia, but on November 12, 1925, the City Council authorized the construction of University Bridge, which was the name for the new span to be funded by loan bills. Rapid growth in West Philadelphia and increasingly heavy automobile traffic were cited as the primary reasons why the new bridge was necessary. Bridges spanning the Schuylkill River at Market, Chestnut and Walnut Streets regularly caused traffic "'bottlenecks,'" warranting the construction of a new bridge to alleviate traffic congestion.

The twentieth century ushered forward the age of the automobile. Joseph Gies, author of Bridges and Men, was certainly correct when he quoted Charles J. Merdinger, an engineer, who wrote that the automobile was to the twentieth

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4 Ibid.
6 Philadelphia Evening Bulletin, 17 March 1926. The City also strategically placed the bridge to "lessen the jam about the University of Pennsylvania during the football season." Philadelphia Evening Bulletin, 9 July 1928.
7 Ibid.
century what the railway had been to the nineteenth. As the automobile became the primary method for moving goods and people in Philadelphia, the need for highways increased. Based on the rapid growth of highways, bridges were required to complete the new system of transportation and were expected to be as modern as the new roads.

The fervor with which engineers and architects relished the necessity for new bridge forms is apparent in Charles S. Whitney's 1929 book *Bridges*, in which he stated:

> The importance of bridges in our modern system of transportation and communication, justifies the expenditure of great sums of money for substantial permanent bridges. The conditions which produced the stark temporary structures of the last century have changed. There is no longer reason for withholding beautiful forms.

It was in this book that the University Avenue Bridge appeared as the final illustration (page iii). Constructing a beautiful automobile bridge in Philadelphia would satisfy

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the transportation needs of planners and the proponents of civic improvement in Philadelphia.

From its inception in 1917, plans for the University Bridge became linked with the City Beautiful Movement, an attempt to beautify cities through civic design. Bridges such as the University Bridge became symbols of civic pride and part of a far-reaching city improvement program. Plans for the University Bridge called for it to be "more attractive than any of the existing Schuylkill spans." While Philadelphia's City Beautiful program focused on development of the Benjamin Franklin Parkway, bridges could also be key components of civic improvement schemes. In

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12 The earliest reference to the University Bridge's association with the City Beautiful movement is in 1927. However, plans for an "ornate" bridge indicate the City's initial commitment to erecting the University Bridge in connection with the proposal for the west and east river drives.

13 For the most comprehensive discussion of the City Beautiful Movement, see William Wilson, The City Beautiful Movement (Baltimore: Johns Hopkins University Press, 1989). Although some cities prepared complete city plans, attention to civic art was most common, to improve city environments. See The American Renaissance 1876-1917 (New York: The Brooklyn Museum, 1979), 87-91. Even though the death of the mature City Beautiful Movement is said to be 1917, when its most ardent supporter, Charles Mulford Robinson, died, cities completed "city beautiful" designs into the late 1920s when the University Avenue Bridge was constructed. A well published late work on the City Beautiful Movement is Elbert Peets's The American Vitruvius: An Architects' Handbook of Civic Art (New York: Architecture Book Publishing, 1922).


15 Evidence of the City's intention to include bridge design in City Beautiful planning is found in the Philadelphia Evening Bulletin, which described the bridge's importance:

This is one of six bridges over the Schuylkill planned by the administration, and is regarded in administration circles as an important part
1926, the Delaware River Bridge (renamed the Ben Franklin Bridge), was completed and featured a formal approach plaza in the tradition of City Beautiful planning.16

The City of Philadelphia expected the University Avenue Bridge to be one of the "most artistic spans in the United States."17 The bridge would connect with the proposed West River Drive along the Schuylkill River, another City Beautiful scheme which was never realized.18 The University Bridge would "harmonize with University of Pennsylvania surroundings." Philadelphia General Hospital and "river bank improvements."19


See also, Frank Chouteau Brown, "The Relation of the Monumental Bridge to the City Plan," Architectural Review 2, no. 3 (March 1913): 30-31.

16 The merits of Paul Cret's design for the Delaware River Bridge are described in Clement E. Chase, "The Delaware River Bridge," The American Architect 131, no. 2516 (March 1927): 329-335.


18 As late as 1931, Jacques Greber, a French planner and consultant to the City Planning Commission, hoped to construct the West River Drive as part of the "city's beautification and advancement." Beginning at the University Bridge, the logical and symbolic start of the "boulevard," this new road was Philadelphia's "second great opportunity" with the completion of the Parkway, according to Greber. Philadelphia Evening Bulletin, 22 June 1931.

The Collaborative Design for the University Bridge

When the City of Philadelphia decided to erect a bridge at University Avenue, engineers at the Department of Public Works in the Bridge Division commissioned consulting architect, Paul Philippe Cret, to work in collaboration with its engineers, Steven H. Noyes and John A. Vogelson. Cret's celebrated design for the anchorages and plaza on the Delaware River Bridge of 1926 may have contributed to his selection as the consulting architect for the University Avenue Bridge. The local chapter of the American Institute of Architects awarded him a medal for the Delaware River Bridge design, and many illustrated articles about the bridge had been published, making him a logical choice for the University Bridge commission. He ardently supported Philadelphia's City Beautiful plans, serving on the Parkway Commission and developing improvement studies for the banks of the Schuylkill River.


21 "Paul Philippe Cret, Advocate of the City Beautiful," *Integrity Spokesman* (April 1931): 1-2. In this article, Cret is described as one of Philadelphia's civic planners with a passion for making Philadelphia the City Beautiful.
Cornell University trained engineer John Vogelson supervised the design team for the University Avenue Bridge. Vogelson served as Chief Engineer of the City's Bureau of Surveys before becoming Chief Engineer at the City's Bureau of Engineering in January, 1925. Vogelson's supervising engineer on the University Avenue Bridge project was Stephen H. Noyes. At the time of the University Avenue Bridge's design, Noyes was the Division Engineer of Bridges. With Noyes, architect Paul Philippe Cret consulted to complete the design for the University Avenue Bridge.


Moving to Philadelphia in 1901, Vogelson was employed as an engineer with the Philadelphia Water Supply between 1901 and 1905. Similar jobs in New York City and Manila occupied Vogelson between 1905 and 1907, but he returned to Philadelphia to work at the Bureau of Water and became chief of the City's Bureau of Health in 1910, a post he held until 1922. Vogelson then became chief engineer with the Bureau of Surveys for three years before becoming chief engineer at the City's Bureau of Engineering in January of 1925. John William Leonard, *Who's Who in Engineering, 1922-1923* (New York: Who's Who Publications, 1922), 1311.


24 Ibid., 1555-1556. Born on November 26, 1881, in Newport, Rhode Island, Noyes was educated at Harvard University, from which he graduated in 1903. A cum laude graduate of Lawrence Scientific School in 1905, Noyes worked for the Pennsylvania Steel Company and Pennsylvania Railroad prior to joining the bridge division with the Philadelphia Department of Public Works.
Under the direction of Noyes and Vogelson, City of Philadelphia engineers designed the mechanical elements of the University Bridge, including the caissons, foundations, steel spans, bascule support, and drawbridge machinery (Illustrations 4). Simultaneously, Paul Cret designed the architectural treatment of the limestone for the abutments, main piers, intermediate piers, and approaches (Illustrations 5-8). Cret also designed the bronze lantern groups, doors, plaques, and cast iron railing.

Whereas the architect had once designed bridges in their entirety, primarily in the eighteenth and early nineteenth centuries, development of increasingly complex structural technologies nearly made the architect's role in bridge design obsolete. During the early twentieth century, however, architects often acted in a consulting capacity with engineers, to design bridge piers, balustrades, lamp brackets and posts, abutments, and anchorages. Firms such as Carrere and Hastings, Mckim, Mead and White, Wheelright and Haven,

25 The type of collaboration between Cret's office and the engineers varied from commission to commission. Cret nurtured his relationship with the firm of Modjeski and Masters and the City of Philadelphia engineers, with whom he designed many bridges. Compensation for a collaboration took one of three forms: a flat fee, a smaller flat fee plus reimbursement for drafting, overhead, and travel, or reimbursement of costs plus 100%. Paul Cret to F. Julius Dreyfous, 6 January 1933, Box 8b, Cret Collection, Special Collections, University of Pennsylvania.
27 Ibid.
Palmer and Hornbostel, and individuals like Cass Gilbert, Edward H. Bennett and Paul Cret designed the architectural treatments of many bridges.  

Architects' involvement in the design of monumental bridges during the first three decades of the twentieth century enjoyed wide support, even among engineers.  

Opponents of this collaboration were strict modernist engineers who questioned the addition of ornament and detailing on bridges.  

Balancing utilitarian needs—the domain of the engineer—and the need for harmony, proportion, and ultimately, beauty—which the architect provided—bridges, most agreed, required design collaboration.  

28 For Carrere and Hastings and Palmer and Hornbostel's bridge work, see "Our Four Big Bridges," Architectural Record 25, no. 3 (March 1909):147-160; McKim, Mead and White's design for the Arlington Memorial Bridge in Washington, D.C., and Edward Bennett's Chicago River bridges are found in Wilbur J. Watson's Bridge Architecture (New York: William Helprin, 1927); Wheeler and Haven designed the Anderson Bridge in Boston. See Brown, "The Relation of the Monumental Bridge," 30.  


31 Aesthetics is the primary subject of Charles Evan Fowler's Ideals of Engineering Architecture (Chicago: Gillette Publishing Co., 1929). The height of interest in monumental, collaborative bridge
Paul Cret was particularly outspoken about the importance of nurturing the relationship between the two fields. Writing in the introduction to *A Decade of Bridges: 1926-1936*, he described the relationship between the engineering and architectural professions as it pertained to bridge construction:

The present method of collaboration between the two professions can be equally successful. In this collaboration, the engineer's part is undoubtedly the more important. The architect may play second fiddle, but musicians know that the disparaging implication of these words is entirely unjustified, and that each part is vital to the score....The architect's special training in form appreciation qualifies him to choose the construction scheme most likely to give distinction and significance to the work. This is not a question of "trimming", of adding ornament, but a sensitive perception of the character and spirit proper to a certain use of materials.  

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designs occurred in the late 1920s. With the publication of Watson's *Bridge Architecture* (1927), Whitney's *Bridges* (1929), and Fowler's *Ideals of Engineering Architecture* (1929), the call for beautiful automobile bridges responded to an apparent dearth of such bridges. As the debate ensued about the architect's role in bridge design, or if a "bridge architecture" even existed, articles were published in both architectural and engineering journals. One of the best is by an unknown author, titled "Bridge Architecture," in *American Architect* 124, no. 2435 (December 1923): 545-554. This article features the Washington Memorial Bridge in Wilmington, Delaware, for which Vance W. Torbert served as the architect and Benjamin Davis as the engineer.

32 Wilbur J. Watson, *A Decade of Bridges* (Cleveland: J. H. Hanson, 1937), Introduction.
This collaboration was not limited to masonry bridges, but could include pylons, abutments, balustrades, and approaches of suspension and concrete bridges as well.

Cret's design for the University Avenue Bridge is monumental but reserved, with decoration used sparingly to accent many of the bridge's elements. Cret was well known for his modern interpretation of classicism, described by some scholars as stripped classicism. Treatment of the limestone harmonizes with both the bronze elements and the steel spans between the piers. Most of the surfaces are planar with simple cornices. Geometric detailing is used on the operator's towers and lantern shafts of the main piers.

Philadelphia's University Avenue Bridge is a five-span metal-arch bridge that crosses the Schuylkill River (Illustration 9). In addition to the two abutments on the river edges, there are two intermediate piers and two main piers, between which the movable bascule spans open. Constructed of concrete and faced with dressed limestone, bronze lanterns flank the approaches.

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33 A less well proportioned, nearly identical bridge was constructed in Port Clinton, Ohio, in 1933. With the University Avenue Bridge's wide publication, this bridge virtually copies Cret's design. See David Simmons, "Interesting Art Deco Bridge in Port Clinton," Ohio County Engineer 63, no. 3 (August 1983).

34 Cret's own form of classicism, which coalesced in buildings like the Pan American Union Building, the Federal Reserve Bank, and the Folger Shakespeare Library, all in Washington, D.C., has a distinctly "modern strain." Perhaps best known for his monumental public buildings, Cret also prepared campus development plans for Brown University, the University of Pennsylvania, and the University of Texas at Austin. O'Gorman, Drawing Toward Building, 181.
Each of the main piers is identical in design. The inside pier walls support the bascule span, and horizontal steel plates are supported by the sides of the pier wall and a central pier wall. Below the spans are four bronze rings and a projecting stone beltcourse (Illustration 10). The sidewalls of the piers, flanking the spans, each have two bull's eye windows. A narrow cornice caps the top of each wall. The downstream treatment of the remaining walls are the battered (a receding upward slope) shafts of the lantern towers, extending beyond the pier wall. A similar battered treatment is also found on the upstream wall, forming the shafts of the operator's houses' towers.

Outside pier walls of each main piers are similar at the outside areas of the wall, each having bull's eye windows and battered lantern and operator house shafts. However, the treatment of the stonework is different below the spring line (the transverse horizontal line on the pier where the span begins). Under the span, the central pier structures are flanked by two segmental arches, below which are four bronze rings and a stone beltcourse.

The downstream elevations of the main piers are symmetrical. A central panel with a bronze door encased by a projecting frame comprises the base. Each bronze door has a central, wire-mesh glass panel covered with a geometrical pattern of bronze (Illustration 11); circular medallions and
a curved handle frame the perimeter of the door. A carved stone tablet, a cornice capped by a balustrade, the lantern towers, and the hexagonal lanterns comprise the remainder of this elevation (Illustration 12). Each lantern pane has a flowery base pattern, an open glass pane, and another pattern in the shape of a serpent capping the panel. At each corner, slender posts are capped by figurines and finials.

Treatment of the upstream main piers is less ornate. Above the bronze doors, which are identical to the downstream design, is a large area of limestone, at the top of which are stone gutter spouts. The tops of these walls form the bases of the operator's houses and three sides of the octagonal tower face these elevations. Flanking two of the stone columns in the center of this tower are bronze railings at the corners of the operator's houses' bases.

Each operator's house is octagonal in shape (Illustration 13). Stone columns form the corners, between which are windows, except at the entrance, where a symmetrical staircase with a bronze railing flanks the doorway. Each bronze window frame has two sections, the central panel of which is decorated. The perimeter of the operator's house is embraced by a low, stone railing wall. At the center of the staircase is a bronze plaque, and a bronze lantern hangs above the entrance. Above the stone columns is a decorated stone beltcourse and cornice. Capping
each corner above the cornice is another decorated stone projection, and the entire Operator's House is surmounted by a drum with a cornice and carved, central panel with a serpent.

Between each main pier and its respective abutment is an intermediate pier, which is detailed with a projecting stone beltcourse and four bronze rings. Identical in design, these piers are battered and rounded on the upstream and downstream (east and west) elevations. The treatment of the stonework on the north and south elevations is plain. The four bronze rings and beltcourse form the only decoration.

Each of the two abutments supports the first span at its respective approach, and below each of the spring lines, the stonework is plain. Battered lantern towers flank the central section of the abutment towers. The north abutment is formed by a projecting, curved section, whereas the south abutment is formed by a single plane.

As seen from street level, each of the approaches have limestone railing walls with carved panels in their end blocks. The lanterns are placed on a limestone base, the top sections of which are octagonal in shape (Illustration 14). The bronze lanterns have an octagonal base, eight flowering leaves, a spiraling cylinder section, and eight lights. Each light is decorated with a triangular pattern at the base and with a swag at the upper end. Finally, the
lantern is capped by a small roof with a rounded cornice. Textured, opalescent glass fills each lantern pane.

Cret described the design for the University Avenue Bridge in the November, 1930 issue of Architectural Progress. He wrote:

This type of bridge, on account of the heavy piers housing the machinery and supporting the watch towers of the operators, is an interesting problem for the architect. Here again, the juxtaposition of steel members and masonry requires the greatest simplicity of treatment of stone work, if one is to avoid a lack of unity in composition. The up and down stream treatment of the piers are necessarily quite different, and the study of a motif satisfactory both when seen from the river or from the roadway supplies that element of difficulty which makes the life of an architect as edged by traps as our most famous golf courses.

Cret's description of the University Avenue Bridge design echoes the design philosophy he developed with each new bridge commission. He never forgot the diminished but still important role of the architect in bridge design. His modest attitude and less historical vocabulary aided his ability to create unified structures in conjunction with engineers.

35 Paul P. Cret, "Bridges," Architectural Progress 4 (November 1930): 6. A manuscript of this article, dated October 7, 1930, is also located in Box 17 of the Cret Collection, Special Collections, University of Pennsylvania.
Throughout the 1920s, Cret published several articles elucidating his philosophy about each profession's role in bridge design, perhaps to ensure that the architect would not be forgotten, but also to publicize his own accomplishments. His most detailed account of the collaborative process appeared in the July, 1928 issue of *Architectural Forum*. Titled, aptly enough, "The Architect as Collaborator with the Engineer," Cret's article was written primarily for other architects in the face of rising specialization within the design professions. Since the University Avenue Bridge was included in this article, it is particularly illuminating about the nature of the design collaboration from which the contractor constructed the University Avenue Bridge.

Cret first described the history of the separation between the fields of architecture and engineering. A "'division of labor'" caused by specialization, he believed, prevented unity in design when, in reality, the two fields were interdependent. In Cret's mind, engineers alone were not capable of creating beautiful bridges. He contemplated the position of the architect when "mechanics" and "mathematical calculation" were becoming more prevalent in the design fields with the use of steel. Resolving that the two professions were complementary, he suggested engineers and architects were not at odds, even though the former was
concerned with mathematical construction and the latter was prone to an "aesthetic ideal."

For Cret, without the art of Architecture, one would produce mere construction. To create beautiful buildings and bridges, he believed, "The architect and the engineer must perform a sort of duo, each contributing his share of the special knowledge in the creation of a structure which is to be both a mechanical unit and an aesthetic unit." Using both the Delaware River Bridge and University Avenue Bridge to illustrate his theory, Cret detailed how an architect should arrive at a harmonious bridge design.

An architect had to follow several rules when working on a bridge design: first, acknowledge "the influence of the mechanical design," second, have "no fear of simplicity," and third, be prepared to "eliminate."36 Finally, it was the task of the architect, when designing a bridge, to "interpret--to clothe, if you will, but to clothe in a vesture that reveals rather than in a garment that conceals."37


37 Ibid. In 1938, engineer Aymar Embury accused Cret of concealing the structure when he designed the anchorages for the Delaware River Bridge. Embury also describes the relationship of the architect and engineer from the engineer's perspective, rejecting classicism as a basis for
While city engineers could have designed the University Avenue Bridge without the assistance of an architect, the unity of composition and proper proportions were the architect's province. In fact, Cret's design for the University Avenue Bridge conformed to his tenets of bridge design as well as his evolving "modern" style. The University Bridge piers and approaches are balanced around the steel spans, acknowledging the mechanical design. Ornament is used sparingly on the shafts of the piers and abutments, creating a modern quality. Cret's modern, simplified details include the recessed, geometric designs for the lantern shafts, the cornices of the piers and abutments, and the bronze lanterns and doors.

In a November, 1930 article in Architectural Progress, Cret reiterated the need for an architect in bridge design:

"[t]he bridge may well be calculated to bear its load, it may be economically designed, it may even involve some strikingly new principle; unless it receives the appropriate aesthetic study, it will never rank among those works which are considered types."

Concerning his Market Street Bridge (1928) in Harrisburg, Pennsylvania, Cret wrote:

the design of steel bridges' abutments and piers; see Pencil Points 19, no.2 (February 1938):117.

If the concrete piers are sometimes faced with stone, it is only because concrete in certain locations needs this armoring. The features of the operating device of the bascule have been made the point of interest of a pier. All this is in accord with the tendencies of architecture in our days. The problem in this type of architectural study is one which requires the forgetting of many formulae, and one of self-effacement. 39

In fact, facing stone on the University Avenue Bridge may well have been used to protect the reinforced concrete, but Cret chose limestone for another reason, too. Stone facing accorded him the opportunity to include an architectural element. Had the City of Philadelphia decided against making the University Avenue Bridge "ornate," a reinforced concrete design might have been executed without stone facing.

Cret's first collaboration with an engineer on a bridge design was for Philadelphia's Delaware River Bridge in 1922. 40 During the next fifteen years, he designed bridges in Washington, D.C., Clark's Ferry and Harrisburg, Pennsylvania, and as far west as Cairo, Illinois. 41 Cret's largest concentration of bridges is in Philadelphia, where he worked on the Henry Avenue Bridge (1927), the unbuilt Welsch Bridge (1927), the Green Lane Bridge (1928), the unbuilt

39 Ibid., 19.
41 White, Paul Philippe Cret, 43-45.
Cresheim Bridge (1929), and the Tacony Bridge (1929). As a bridge designer, Cret stands among the most prolific architects of his generation.

**Constructing the University Bridge**

Before Cret began work on studies for the University Avenue Bridge late in 1925, a "Bridge across the Schuylkill river, at or near the line of University Avenue; [was] authorized by ordinances approved December 12, 1924 & November 24, 1925." The completed design met The Art Jury approval on March 25, 1927.

The specifications were then prepared for bidding by the Bureau of Engineering in the Department of Public Works on May 24, 1927. Titled the "Proposal and Specifications for University Bridge Over Schuylkill River 1927," this document called for construction not to exceed $1,889,825.00. Included in this document was a photograph of the proposed site, dated March 15, 1927.

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42 Commission List, Cret Collection, Special Collections, University of Pennsylvania.
43 University Avenue Bridge, Drawing #12210, Bridge Section, Department of Streets, City of Philadelphia.
44 Ibid.
45 "Proposal and Specifications for University Bridge Over Schuylkill River 1927," Bridge Section, Department of Streets, City of Philadelphia, 10
After the bidding period ended, the City of Philadelphia selected Dravo Contracting Company of Pittsburgh, Pennsylvania to erect the proposed bridge. A contract was signed between the City of Philadelphia and Dravo Contracting Company on June 9, 1927. Completed at a cost of $1,311,569.22 dollars, construction of the bridge began by October, 1927 (Illustration 15).46

On October 6, 1927 the first caisson had been built, and by November 16, 1928, much of the superstructure was completed (Illustrations 16-26).47 By October 9, 1929, the movable bridge was operating (Illustrations 27-29).48

It appears that the University Bridge was constructed in its entirety by Dravo Contracting Company. Company records from this period are unlocated, but a company history, entitled A Company of Uncommon Enterprise: The Story of Dravo Corporation 1891-1966, suggests that the firm was solely responsible for the bridge's construction.49 Like other contracting firms, Dravo sub-contracted some its work. Although the firm had at one time produced bronze, Newman

46 Dravo Contracting Company was incorporated on December 16, 1921. The predecessor firm, Dravo-Doyle, had been incorporated at the turn of the century. In 1920, the Dravo Bronze and Manufacturing Company was formed and installed in Dravo's building at 302 Penn Avenue in Pittsburgh. A Company of Uncommon Enterprise: The Story of Dravo Corporation 1891-1966 (Pittsburgh: Dravo Corporation, 1974), 32.

47 Construction Photographs, Maintenance Records, University Bridge, #12 1/2, Bridge Maintenance Unit, Department of Streets, City of Philadelphia.

48 Ibid.

49 A Company of Uncommon Enterprise, 34.
Manufacturing Company of Cincinnati cast the extruded bronze lamps for the University Avenue Bridge (Illustrations 30-31).\textsuperscript{50}

To complete many of the bridges constructed between 1920 and 1930, including the University Avenue Bridge, Dravo designed and built twelve "whirler derrick boats and three floating plants for mixing concrete..." Illustrations 32-33).\textsuperscript{51} In addition to bridge construction, Dravo also built dams, ships and subway tunnels. During the 1920s, Dravo was also responsible for the South Street Bridge and Twin Arch Bridge for the Pennsylvania Railroad, both in Philadelphia.\textsuperscript{52}

Construction of the bridge's spans progressed ahead of schedule, and it became clear that it would be completed before the approaches. The Philadelphia Evening Bulletin reported on July 9, 1928, that the City hoped to "forestall a situation of the city possessing a bridge, but not useable because traffic cannot reach it."\textsuperscript{53} Lack of funding delayed

\textsuperscript{50} I am indebted to Mark Luellen for this reference. The Western Architect 39, no. 10 (October 1930): Plate 152.

\textsuperscript{51} A Company of Uncommon Enterprise, 32.

\textsuperscript{52} Ibid.

\textsuperscript{53} Philadelphia Evening Bulletin, 9 July 1928. The city planned to use the new University Bridge during the 1932 Democratic National Convention which was held at the Philadelphia Convention Center, completed in 1931, but it was not possible; Philadelphia Evening Bulletin, 26 April 1928.
the completion of the approaches until 1933, during which time the bridge lay idle for almost four years.

The bridge's designers and builders also faced various physical obstacles that had to be overcome to complete the University Avenue Bridge. Six railroad lines passed between the bridge and University City, an area which was lower in grade than the final height of the bridge's approach spans. In order to complete the bridges approaches and cover the foundation concrete, builders infilled the area surrounding each abutment (Illustrations 34). When the City appropriated funding to construct the bridge, none had been allocated to complete the approaches necessary to open the bridge. What had once been the pride of the City became an embarrassment and the subject of amusement in the local papers as delays continued. A story in the *Philadelphia Evening Bulletin* was typical:

*It is a monument commemorating an investment of $1,300,000 of city funds, an investment that will lie idle for another year. There isn't anything wrong with the bridge. From an engineering and architectural viewpoint it is a fine bridge... But one can't cross this bridge when one comes to it, for the simple reason one can't even approach it.*\(^{54}\)

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\(^{54}\) *Philadelphia Evening Bulletin*, 17 December 1928.
To speed completion of the University Bridge, the City abandoned its original plan to extend the new University Avenue to the intersection of Woodland Avenue and 39th Street. Instead they connected University Avenue with Vintage Avenue (Illustrations 35).\(^5\) Vintage Avenue passed directly in front of the new Convention Hall and extended to 34th Street. Workers finally completed the eastern approach in 1931, and began the western approach in May, 1932 (Illustrations 36-37).\(^5\) With its dedication ceremony held on May 10, 1933, the University Bridge was placed into service, linking West and South Philadelphia (Illustration 38).\(^5\)

The plans for the West River Drive that Cret, Greber, and others envisioned for the banks of the Schuylkill River were never executed. With its bronze lantern towers, the University Avenue Bridge remains one of the few monumental bridges in Philadelphia, constructed in the spirit of City Beautiful planning to improve the urban environment. Once an unusable monument with no approaches, now it is a living monument to the era of design collaboration between the City's respected engineers and one of Philadelphia's most revered architects, Paul Cret.

\(^5\) Philadelphia Inquirer, 26 April 1931, and Public Ledger, 26 April 1931.
\(^5\) Philadelphia Evening Bulletin, 10 May 1933.
CHAPTER 2

Condition Assessment Method, Bridge Condition, and Maintenance History

Once the historical documentation was completed, a condition assessment was undertaken, to determine the condition of the University Avenue Bridge and facilitate preparation of a preservation plan. To make informed decisions about how to preserve the bridge, it is necessary to understand not only its current condition, but also the changes it underwent and the maintenance it received during its history. This chapter describes the condition assessment method, examines the existing conditions found on the University Avenue Bridge, and discusses the changes made to the bridge (maintenance history) since its completion in 1933. This information is crucial to understand the mechanisms of deterioration, and to understand what materials were used in past repairs and rehabilitations, which affect intervention decisions. It also suggests where recurring problems exist and assists in developing conservation priorities for the bridge.

The condition assessment clearly demonstrated that maintenance has been inadequate, and that acts of vandalism to the bridge have gone largely unchecked. Finally, many changes to the University Avenue Bridge have been
unsympathetic to the bridge's structure and integrity of its design.

**Condition Assessment Method**

After initial visits to the bridge to determine the bridge's overall condition, a condition assessment form and condition key were developed (Appendix B). With the exception of the intermediate piers and superstructure, which were not accessible, the condition of each abutment and main pier was recorded by visual inspection. Inspection of each element was non-destructive, including sampling for the mortar analysis. Non-destructive testing and inspection was necessitated by the nature of the permission granted to investigate the bridge.

Data on the bridge's condition was collected by visual means on the fenders of the main piers and on the north and south shore of the Schuylkill River for each abutment. Because of the height of each pier and abutment and the limitations of the survey method, the data on the lower sections of each element is most accurate. In some instances, however, binoculars were used to record the condition of the the upper pier and abutment levels, and in other situations by looking over the bridge spans a condition was confirmed on the upper section.
Although each survey form in Appendix B illustrates the location of every condition found on a particular elevation, each condition is described individually in this chapter. This format enables the assessment and preservation plan found in the next chapter to prioritize preservation options and reduce the number of drawings needed to illustrate the bridge's condition. Following the elevation forms are individual forms describing each element and its condition. Many of these forms are also keyed to photographs.

**University Avenue Bridge Condition**

Field survey revealed that the condition of the University Avenue Bridge is reasonably good considering its infrequent maintenance, the age of the structure, and the harsh environment in which it is located. Most of the materials the bridge is constructed of continue to perform well in light of the absence of substantial maintenance. However, the survey conditions described below indicate active deterioration of many of the materials.

Staining of the limestone, in a variety of types, forms the most prominent form of deterioration on the bridge. Green staining represents the largest proportion and is found on the limestone in varying color intensities below each of the bronze elements. On most elevations, the staining is more
intense nearer a bronze element and dissipates on the masonry further away from the metal elements. Where water runoff follows a distinct pattern down the limestone, the staining intensity continues to the lower levels of the masonry. The green staining does not appear to have greater intensity on a particular orientation, but, rather, is more intense on the street elevation of each of the abutment lanterns. There is also a larger area covered by green staining below the abutment lanterns when compared with the area below the main pier lanterns which are located at a higher elevation than the abutment lanterns.

Associated in some cases with the green staining is black staining. Particularly on the masonry below the street elevations of the abutment lanterns, black staining and particulate matter are interspersed in the same areas as the green staining. Other areas which exhibit black staining include the undersides of both the carved limestone swags and emblem on the west elevations of the main piers and the limestone gutter spouts. Black staining is also prominent on the back walls of each abutment and along the lower pier wall's projecting cornice.

The least prominent form of staining is red in color. Iron Oxide staining is found on the limestone below the metal fencing which has been installed on the main piers to protect the bridge transformers. Rust staining is also evident on
the upper levels of the south abutment's back wall cornice, below the area where the steel spans meet the wall. From a distance, rust staining covers a small percentage of the intermediate piers, each of which is supporting the steel spans at four points.

Another recorded condition was biological growth. Green in color, this growth is soft, strand-like and easily scraped off the limestone. Each area which exhibited biological growth is surrounded by trees or shaded throughout most of the day. Some biological growth was found on the limestone of each of the main piers near the fender level, but the most concentrated biological growth is located on the west and east elevation of the northwest abutment lantern. In this location, ivy roots are also attached to the limestone. This condition is also apparent on the back wall of the south abutment.

One of the most aesthetically disturbing conditions is graffiti, which covers almost every elevation of each pier and abutment in varying degrees. Color, intensity, and area covered vary, but it is clear that vandalism is a serious problem. As one might expect, the most accessible areas are most affected, especially on limestone surfaces below the abutment lanterns and on the street elevation of the operator's houses. No paint is evident on any of the bronze lanterns, but painted graffiti covers the upper portion of
the bronze plaque on the operator's house on the south main pier.

Efflorescence is another condition found on the University Avenue Bridge, resulting from the migration of soluble salts to the surface of the limestone. The primary location of these deposits is on the main piers. In addition to deposits on the lower and middle sections of the end elevations of these piers, efflorescence is also present on the pier walls under the steel spans and in vertical areas where the limestone meets the span it supports. On the north abutment, efflorescence is evident on the back wall at the cornice level.

Salts are also present in areas where erosion of the limestone is occurring. Called salt fretting, this erosion is found on the limestone facing and steps of each of the operator's houses. Another location salt fretting is on the end of the northeast abutment railing wall. Finally, some erosion of the limestone is evident on the corners of the main piers' bases. Otherwise, the condition of the carved limestone is good, with little evidence of extensive weathering.

Two types of spalling affect the condition of the University Avenue Bridge. The largest spalled areas are on the back walls of the abutments. On the upper levels between the cornice of the limestone facing and steel spans, there
are extensively spalled areas of reinforced concrete. Spalling of the limestone facing occurs primarily on the main piers, and most of the spalling is located near a masonry joint and is relatively minor in nature.

Small cracks, approximately 1/16" wide, are evident at various locations on the University Avenue Bridge. No regular pattern is apparent with the exception of the cracks which surround most of the screw caps where the bronze rings were originally mounted. At these locations, small fissures radiate from the screw caps.

To facilitate preparation of a preservation plan, it is necessary to determine which elements of the original design for the University Avenue Bridge are missing. During the course of the condition survey, missing fabric was identified, including elements that had been removed or broken.

While missing limestone elements could have been described as cracking, this survey recorded these elements as original fabric which had been lost. Several of the corners of the main pier bases were missing small pieces of limestone facing. However, the largest sections of missing limestone facing were on the main pier wall where the corners of the projecting beltcourse are missing. In each case, the structural integrity has not been compromised.
An overwhelming percentage of the masonry and its detailing remain intact on the main piers, the operator's houses, and the abutments. However, the southwest abutment railing wall is missing a section of limestone facing, and debris is visible in the open void. Other missing fabric on the University Avenue Bridge includes the bronze rings on each of the pier walls, the textured, opalescent glass in every lantern on the bridge, and several of the bronze swags that ornament the lanterns. Finally, the original railing has been removed from the spans which cross the bridge. The only remaining section of the original railing is located on the south approach to the bridge and is flanked by concrete walls. This railing section is heavily corroded and has not been painted for some time.

The overall condition of the bridge's pointing is very good, but some localized areas show joint failure. Deteriorated mortar is evident in some of these locations, while in others the mortar has fallen out leaving the joints completely open. Many of the joints without mortar have voids of at least 1/2" in depth. Another pointing condition evident on the bridge is poor repointing with mortar lapping onto the face of the stone, making the masonry units susceptible to spalling and cracking. This condition is particularly evident on the front elevations of the Operator's houses. Although the original mortar contained
Portland Cement, some replacement mortar appears harder than the original.

The University Avenue Bridge features a number of bronze elements. Each approach is flanked by dual bronze lanterns, and each of the main piers have dual bronze lanterns. Additionally, bronze lanterns hang from the operator's houses. Other important bronze elements include the doors at each end of the main pier bases, the window frames on the operator's houses, the window frames of the bull's eye openings, and the plaques on the operator's houses and approach railing walls. All of these these elements exhibit corrosion. The bronze lanterns and plaques exhibit the most advanced corrosion; Runoff from corrosion products on the masonry suggests these bronzes are unstable. Neither the window frames and bull's eye windows nor the main pier doors show signs of advanced corrosion.

The largest bronze elements, the lantern groups, all exhibit a relatively even layer of green corrosion products. Under the protected areas which are not exposed to adequate natural water washing, black scabs and pitting are evident. Because none of the lanterns retain their glass, the lantern interiors are also deteriorated and exhibit rusting.

Bronze doors on the piers form the second largest bronze elements. Green patina does not cover each door completely. The central, geometrical panel are black in color with spotty
green patches, and the outside section of the door is more uniformly green. This varying condition may be explained by the use of different metals to construct the door, or by varying degrees of protection from the elements. Replacement iron door handles have caused rusting on each door.

Plaques on the staircases of the Operator's houses are corroded and exhibit an even green layer of corrosion products, some black scabbing, and white streaking and buildup. These plaques are also covered with painted graffiti in some locations. The same conditions hold true for the approach railing wall plaques.

**Maintenance History**

Creating a maintenance history was important to determine how and when changes to the University Avenue Bridge were made. Examination of the maintenance records and inspection reports indicate the alterations, replacements, and repairs that were made to the University Avenue Bridge. This information suggests what practices and materials have compromised the integrity and performance of the bridge's materials.

Until it was transferred to the Commonwealth of Pennsylvania in 1961, the City of Philadelphia owned the University Avenue Bridge and was responsible for its
maintenance. Following transfer of ownership to the Commonwealth, major repairs, rehabilitation, and maintenance of the bridge became the responsibility of the Pennsylvania Department of Transportation. Routine maintenance and minor repairs, such as greasing the machinery, are still performed by the City of Philadelphia's Bridge Maintenance Unit of the Department of Streets and the University Bridge Supervisor (Operator). 2

The first alteration to the bridge which affected the original design was the removal of the bronze rings located on each of the main piers in 1931, two years before the bridge was opened. 3 Records give no explanation for the rings' removal nor do they indicate that they were ever reinstalled. Today only the screw caps remain. Other repairs made during the bridge's first two decades (1930-1950) included repair of the lamps, replacement of the submarine cable connecting the

1 The City of Philadelphia transferred the bridge to the Commonwealth of Pennsylvania under State Highway Act #615 on 18 September 1961. Donald Huddle to T.J. McCarthy, 21 December 1973, Bridge Maintenance Records, Bridge Maintenance Unit, Department of Streets, City of Philadelphia, hereinafter cited solely as Bridge Maintenance Records.

2 Beginning in 1930, the City of Philadelphia began logging minor maintenance to the University Avenue Bridge. Until 1977, only the year of the repair is listed, but after that year the City's bridge maintenance unit recorded both the date and year. Also important are major repair projects which were traced by examining correspondence about the University Avenue Bridge.

3 Bridge Maintenance Card, Bridge Maintenance Records.
operating towers, painting, cleaning, and stone pointing.

During the 1950s, the first major repair to the University Avenue Bridge was completed: the first replacement of the bridge deck. Attempts to maintain the deteriorated concrete deck proved fruitless, and Whiting-Turner Construction Company replaced the "spongy" sub deck in 1959 at a cost of $104,029.36 dollars.⁴ In 1959, an inspection report described cracking in the stonework on the main river piers adjacent to the cross girders.⁵

The next modification to the bridge occurred in 1960 and 1961. Ross Electric Construction Company overhauled the electrical system after they determined that the existing system was beyond repair. Ross renewed the bridge's electrical system with new motor generator power units.⁶ To avoid navigation delay and expensive repairs to the submarine cable, Ross constructed an overhead cable between the operator's towers.⁷

Installation of this cable necessitated the erection of

⁴ John L. Keenan to Chief Engineer of Highways, 25 July 1958, Bridge Maintenance Records
⁵ Inspection Report Bridge 12 1/2, 4 December 1959, Bridge Maintenance Records. See also, Inspection Report--Bridge 12 1/2--University Avenue Over the Schuylkill River, 21 September 1962.
⁶ Howard Mintzer to David Smallwood, 1 September 1960, Bridge Maintenance Records.
⁷ David Smallwood to R. Beatty, 2 November 1960, Bridge Maintenance Records.
metal cable supports on the tower roofs, which the City of Philadelphia repaired in 1960. The City of Philadelphia also repaired the roof of an unspecified operator's tower in 1965.8

Other maintenance work which occurred in the 1960s included railing repairs, lamp replacement, glass replacement, and the repair of unspecified metal doors.9 Finally, the City of Philadelphia rehabilitated the electrical system again in 1969 at a cost of $101,952.16 dollars.10 A detailed inspection report, conducted in October of 1968, recommended, among other items, painting of structural steel, repointing the masonry around the storeroom and operator's house, and replacing the bituminous road surface.11

Several collisions into the original cast-iron railing occurred in 1971, damaging more than 120 linear feet of the railing.12 By 1974, the Commonwealth of Pennsylvania had replaced approximately 200 feet of the original railing with temporary railing, necessitated by

8 "Job Orders Completed on University Avenue Bridge," Bridge Maintenance Records.
9 Ibid.
10 Louis Einhorn to P.J. Marzullo, 6 September 1969, Bridge Maintenance Records.
11 Physical Inspection Report of University Avenue Bridge (1968), Pennsylvania Department of Transportation, Bridge Maintenance Records.
12 Howard Mintzer to Joseph Wade, 26 November 1971, Bridge Maintenance Records.
other car accidents and prompting the installation of concrete guard rails at the existing curbs.13

Inspectors noted spalling as a particular problem during the 1970s. As early as 1972 the top of the back wall of the north abutment was deteriorated the full width of the roadway. To prevent injury, the Commonwealth of Pennsylvania installed a steel plate (10 feet by 4 feet) over the hole.14 In a 1975 report, inspectors reported similar spalling on the south abutment in the stringer beam bearing areas.15 Missing face stones on the tower piers in several unidentified locations were also reported.16

The University Avenue Bridge was partially reconstructed in 1983, and the engineering firm A.G. Lichtenstein and Associates served as consultants on the project.17 The scope of the work they carried out involved repairs on the superstructure, substructure, fender system and working machinery. During the first phase of the Stage I contract, the approach spans, the

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14 Donald Huddle to Joseph Wade, 23 March 1972, Bridge Maintenance Records.
15 Donald Huddle to Joseph W. Shea, 10 December 1975, Bridge Maintenance Records.
16 Donald Huddle to Joseph Winchester, 29 April 1975, Bridge Maintenance Records.
17 John Wierzbicki of A.G. Lichtenstein and Associates, Inc., Langhorne, Pennsylvania, provided me with the construction drawings and proposal for this 1983 project.
...
east and west portions of the bascule span roadway, the fender system, and the substructure were repaired. In the second phase of the Stage I contract, the center portion of the bascule span was repaired, the center locks were realigned and repaired, and the bascule span was balanced.

Substructure repair in this phase of the contract addressed several sections of the limestone facing on the main pier which were loose, unstable, and penetrable by water. Deteriorated and spalled concrete behind the facing required rehabilitation. Contractors removed deteriorated concrete to a sound surface, poured new concrete to match the existing concrete, and bonded the sound concrete with the new concrete layer. Finally, the original limestone facing, in most cases, was reset on metal anchor strips in the mortar courses.

In addition to the fender repairs during this phase, a new pedestrian railing and parapet barrier guard rail were installed. On the bascule span, the east and west decks and sidewalks were rehabilitated, and the center locks were balanced. Almost seven years later the Stage II contract is underway. At the time of this writing, A.G. Lichtenstein and Associates are planning repairs of the center portions of the approach spans.
In May 1990, the Pennsylvania Department of Transportation rated the University Avenue Bridge's overall condition, which is governed by the superstructure rating, as fair. Concerning areas of extensive rusting, inspectors recommended cleaning and painting the superstructure, according this work a high priority. They listed the substructure's condition as satisfactory, making reference to minor masonry spalling and efflorescence.

Inappropriate or inadequate maintenance practices directly affect the life expectancy of bridges. The maintenance history also reveals the detrimental effects of no maintenance, such as with the bronze elements. The bridge deck, concrete, bronze, and pointing cannot be prevented from deteriorating, but timely reconstitution and maintenance extends the life of the bridge, preventing replacement.

Information in the maintenance records reveals the harsh effects of the environment and human use on the bridge. These records clearly indicate that many repairs have been made to the bridge's working machinery, substructure, and superstructure throughout its history, in response to both environmental and human

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18 Inspection Report, University Avenue Bridge, May 10 1990, Pennsylvania Department of Transportation.
conditions. The effect of environmental conditions is seen in the corrosion of the bronze elements and in the pollution stains on much of the bridge. Environmental conditions and the bridge's proximity to water may explain why the electrical system has been replaced several times in its history. Human use also has an effect on the bridge's condition. With the unavoidable use of deicing salts on roadways, corrosion of reinforced concrete is another ongoing problem, and automobile collisions explain why the original railing was replaced. Vandalism is another example of change caused by human use. The effects of the environment and human use will continue as long as the bridge is in service. Understanding these conditions seeks to assist future decisions to insure the bridge is preserved.

This history also reveals that maintaining the bridge as a safe road is a higher priority than maintaining the structure which supports the road. Since emphasis is placed on safety and security, this bridge's design integrity continues to be compromised over time. Only with the selection of A.G. Lichtenstein and Associates, an acknowledged leader in the historic bridge rehabilitation, is there any indication that the University Avenue Bridge is advanced in age or historic.
Future repairs should give greater consideration to this fact.
CHAPTER THREE

Options for Conservation

Chapters One and Two investigated all readily available sources to document the bridge's history, its physical condition, and its prior maintenance record. Historic documentation identified the materials and methods of construction, as well as the cultural context in which the bridge was planned, designed, and built. Non-destructive field investigation largely qualified the condition of this historic resource to determine what factors affected the University Avenue Bridge's evolution in an urban environment. Examination of the maintenance record demonstrated that insensitive repairs and alterations were made to the bridge. This chapter begins to diagnose many of the University Avenue Bridge conditions and considers some of the options for intervening in an effort to preserve the bridge.

Chapter Three is neither a specification for construction nor a maintenance manual, but rather, more correctly, a planning document to prioritize preservation alternatives. It specifies what preservation work is needed on many of the bridge's elements, but also recognizes the limited resources available to achieve such objectives. In addition to providing information about how to "improve" the
bridge, the preservation plan incorporates information which is intended to prevent future adverse effects to the University Avenue Bridge.

To prioritize the steps that need to be taken to preserve the bridge, it is necessary to consider available levels of intervention. The University Avenue Bridge retains much of its integrity, and could conceivably be restored. However, unless an outside funding source enables this type of expensive intervention, alternatives should focus on preservation and stabilization. For many of the bridge's elements, a variety of alternatives for intervention exist. The treatment options discussed emphasize preservation rather than restoration, which implies that an object is returned to its original appearance. In some cases, non-intervention should also be considered.

Planning is the first stage of the preservation process, and can be accomplished within existing mechanisms which afford protection for historic resources. Following a planning recommendation, preservation measures for the bridge are discussed by material. Options for intervention for masonry, mortar, bronze elements, and concrete are considered. Finally, altered elements are discussed to describe how the integrity of the bridge can be revealed better.
Planning

Despite increasing attention to historic bridges by the Federal Highway Administration and departments of transportation, few bureaucracies which own and maintain bridges have the necessary background to consider the effects their work has on historic resources. As a result, protection afforded by nomination to the National Register of Historic Places is essential. Many states prepare inventories of their historic bridges to identify resources eligible for inclusion on the National Register of Historic Places. However, few plans for the preservation of individual bridges exist.

While interest in industrial resources is growing among people in the field of historic preservation, the level of attention given to the preservation of individual bridges is not equal to that for the preservation of individual buildings. Perhaps the issue of ownership the primary reason for this disparity. Buildings are usually rehabilitated or maintained privately, by private investment and non-profit

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1 Published state-wide surveys include: James Cooper, Iron Monuments to Distant Prosperity: Indiana's Metal Bridges, 1870-1930 (Indianapolis: Indiana Department of Natural Resources, 1987); Rhode Island Department of Transportation, Historic Highway Bridges of Rhode Island (Rhode Island Department of Transportation, 1990); Emory Kemp, West Virginia's Historic Bridges (West Virginia Department of Culture and History, 1984); Ohio Department of Transportation, The Ohio Historic Bridge Inventory, Evaluation, and Preservation Plan (Ohio Department of Transportation, 1983); Commonwealth of Pennsylvania, Historic Highway Bridges in Pennsylvania (Commonwealth of Pennsylvania, 1986).
organizations. Bridges, on the other hand, are usually owned by cities and states with financial hardships. With time, more individual bridge preservation projects and literature about methods of bridge preservation will assist those making decisions which affect historic bridge resources.²

Nomination of the bridge to the National Register of Historic Places should be the first step to preserve the University Avenue Bridge. Inclusion on the National Register recognizes those significant properties to be preserved for future generations as part of the nation's heritage. Properties must possess integrity of location, design, setting, material, workmanship, feeling, and association. Under Section 106 of the National Historic Preservation Act of 1966, properties listed on, or deemed eligible for, the National Register of Historic Places are protected from a measure of adverse impact when projects are funded or licensed by the federal government.³ Listing the University Avenue Bridge on the National Register, for example, would invoke a review by the State Historic Preservation Office of any project involving the bridge when federal highway funds are used, to prevent any adverse effect on the bridge.


³ National Register Information Sheet, Maine Historic Preservation Commission. For more detailed information about protection provided by inclusion on the National Register, see the Current Federal Regulation, 36 CFR 800.
Additionally, when federal funds are available, structures listed on the National Register of Historic Places are sometimes eligible for Federal historic preservation grants.

According to the Pennsylvania Historical and Museum Commission, the University Avenue Bridge is eligible for inclusion on the National Register of Historic Places under criterion A and C. Structures nominated under criterion A are associated with events that have made a significant contribution to the broad patterns of our history. Those nominated under criterion C reflect an outstanding manner the distinctive characteristics of a type, period, or method of construction, or represent the work of a master designer.

Because of the University Avenue Bridge's association with Philadelphia's City Beautiful planning, and because of the engineering design, a movable bascule bridge, the bridge is eligible under criterion A. Under criterion C, the University Avenue Bridge is eligible as an example of one of the bridge designs of architect Paul Philippe Cret, whose architecture in Philadelphia and other cities, during the early twentieth century, influenced future generations of

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4 Donna Williams to Avrum Kantor 2 January 1986. File number ER 84-0265-101 (PHMC). A discrepancy exists which may explain why the bridge has not been listed on the National Register. The Pennsylvania survey identified significant bridges which are not owned by the Pennsylvania Department of Transportation. Among those bridges was the University Avenue Bridge, which, according to the survey, is owned by the City of Philadelphia. However, the City, which constructed the bridge, transferred it to the Commonwealth of Pennsylvania in 1961. See Chapter 2, note 1.
architects and left an indelible mark on the built environment where his work is found.

Cleaning

Given the magnitude and variety of staining on the University Avenue Bridge, it is appropriate to consider cleaning options. However, before undertaking a cleaning program or discussion of options, the question must be asked, why clean? Undoubtedly cleaning improves the appearance of a structure by revealing detailing, color, and texture, but an inappropriate cleaning program can permanently damage a structure. Arguments in favor of improving aesthetics are countered by those who believe dirt and natural weathering are part of a structure's "patina." Respecting patina prevents overcleaning, but most evidence suggests most masonry substrates are damaged by excessive surface deposits.\(^5\)

Several reasons explain why masonry decay is accelerated by the formation of surface deposits. First, heavily stained surfaces expose greater, more reactive surfaces to atmospheric pollution. Second, surface deposits can prevent evaporation of water in the substrate and cause freeze/thaw

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and wetting/drying cycles which may cause internal stresses. Associated with water retention is the potential for salt crystallization, which also causes stress in masonry substrate. Third, wet and dirty surfaces can create atmospheric liquids such as carbonic acid, sulfuric acid, and nitric acid which form hardened crusts. These corrosive liquids also dissolve binders in mortars. Finally, wet, dirty surfaces support microvegetation.⁶

Cleaning, then, is implemented to improve aesthetics, expose substrate for evaluation and repair, remove pollutants which damage the masonry, and open the masonry pores to allow proper moisture transpiration.⁷ If a cleaning program is to be implemented to remove staining from areas on the University Avenue Bridge, the chemical and physical nature of the staining should be understood to assure selection of the proper cleaning technique or techniques. A variety of cleaning techniques exist within three main categories: water, chemical, and abrasive.⁸ If the wrong method is chosen, accelerated decay can occur.

Cleaning should be carried out with the "gentlest means possible" and this generally means water before chemical before abrasive. Only an architect or architectural conservator familiar with cleaning techniques and materials should make decisions to develop a cleaning program. A preliminary assessment of the stains and deposits on the University Avenue Bridge suggests which cleaning techniques may be appropriate or inappropriate.

All of the staining on the University Avenue Bridge is located on the masonry, an oolitic limestone (calcium carbonate). This calcareous stone is uniformly textured, buff colored, and grains are visible when the limestone is rubbed. Staining varies in color from green, to red, to black. Intensity also varies. Some stains are surface deposits, but others are integrated into the substrate. Salt deposits and graffiti are also present. In developing a cleaning program for the University Avenue Bridge, there are a number of questions to consider: Is it necessary to clean the entire bridge and how clean should it be? Is it possible to treat all of the staining with one cleaning technique? What are the advantages and disadvantages of each alternative? Economically, how feasible is each alternative? A diagnosis

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of the staining on the bridge suggests the answers to many of these questions.

By far the most prominent stains on the bridge are those caused by corrosion products that have washed down from bronze elements on the bridge's abutments and piers. Unstable corrosion products which runoff the bronze, consisting of soluble copper salts, penetrate the limestone and chemically bond to the substrate and surface. Unlike black gypsum crusts, a true stain is chemically different from an encrustation. Stains affect the internal grain of the stone. Because of the nature of the stain, water washing will not completely remove a metallic stain, and usually the only technique for removal is a sequestering agent, which reacts with the foreign matter, creates a solution to suspend the matter, and flushes it away.

A poultice is commonly used to remove metallic stains on small areas; this technique employs an inert filler with a solvent or cleaner (forming a paste) to draw the stain out of the masonry substrate. Water rinsing normally follows poulticing to remove any residual cleaner and foreign matter. Care must be taken to select a solvent which will not cause residual staining. This technique can be repeated until the

stain's intensity is reduced to the desired level, or until it proves ineffective.

The intensity of much of the metallic staining on the University Avenue Bridge indicates the probable need for selective poulticing to diminish the copper stains, which can create internal stresses in the limestone. It is unlikely that these stains could be completely removed. Instead, the intensity of the stain might be reduced, improving both the aesthetic appearance and limestone performance.

Iron oxide staining on the piers and abutments is caused by the corrosion of the unpainted, unprotected steel superstructure and reinforcing bars. Iron oxide staining on the bridge masonry is not severe and would best be mitigated by regular maintenance of the steel superstructure. Furthermore, few effective treatments exist for the removal of rust staining from calcareous stone. This type of staining is found on less conspicuous sections of the bridge, an indication that cleaning for such a small surface area is unnecessary. This cleaning would certainly not be warranted until a commitment is made to maintain the superstructure.

Given the minor amount of rust staining, and its low

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12 Norman Weiss, "A Study of Examination and Treatment Techniques for a Limestone Gazebo," Fourth International Congress on the Deterioration and Preservation of Stone Objects (Louisville: The University of Louisville, 1982):140. Of the rust removers that were tested, Ammonium Citrate at a pH of 6.5 was the safest and most effective treatment.
visibility, implementing an expensive cleaning technique which could damage the limestone is not recommended.

Many of the areas on the University Bridge do not require cleaning. Natural water washing from rain cleans the limestone facing where adequate drying occurs. The upstream and downstream elevations of the main piers, in particular, do not require cleaning. These areas are well rinsed naturally and are free from heavy staining or surface deposits. However, protected by the superstructure, the undersides of the piers and abutments are covered with gypsum weathering crusts (calcium sulfate) and salt deposits. Water washing is the safest technique available to remove pollutants and gypsum crust.\textsuperscript{13} The difficulty with removing efflorescence is the potential for moving harmful salts into the substrate. However, if adequate drying is possible, salt deposits can be removed with water.

Because water washing will not adequately clean the metallic staining, more than one cleaning technique seems necessary. Mechanical cleaning would not be appropriate; sub-surface metallic staining would be neither properly nor effectively removed by this technique, and dirt and gypsum crusts can be removed more safely with other means.

\textsuperscript{13} Weiss, \textit{Fourth International Congress}, 141. See also, Lewin, \textit{The Conservation of Stone I}, 350.
Chemical cleaning, which is employed with a water washing format, should also be ruled out because this technique will not sequester the copper ions in the metallic stains. Many common chemical cleaners are acidic, and limestone is acid-soluble, so these chemical must not be used. Moreover, chemical washing increases the risk of residual staining, especially where iron compounds are present. Finally, chemical cleaning is unacceptable because it would release effluents into the Schuylkill River. Unlike chemical water washing, a poultice treatment would be easier to control, and the product being used would not create runoff.

It appears that a "water safe cleaning (WSC)" method in combination with selective poulticing would be the safest for the material and for the environment. A mild water soaking procedure mists water over a surface for intermittent periods of time, loosening dirt and gypsum crusts. Bristle brushes are then used to agitate loose material before a final low-pressure rinsing. Water safe cleaning refers to the following variables that must be properly controlled in a cleaning program: pressure, volume, temperature, nozzle pattern, angle of delivery, and operator skill.14

No cleaning program should be started without analysis of the material to be removed by an architectural conservator

14 Jones, Cleaning Masonry and Stone, 55.
or architect well-versed in cleaning techniques. Additionally, no cleaning should begin before tests are carried out to demonstrate the effectiveness and safety of the proposed technique. Cleaning test panels should be no smaller than four feet square, and they should be placed in unobtrusive locations.\textsuperscript{15}

The degree of cleaning may be determined by the effectiveness of the poulticing in removing copper staining. The degree of cleaning should also be determined by the relative safety of the water washing technique used. A water safe cleaning program seeks to minimize surface loss of the masonry surface, while at the same time removing harmful matter. Selection of a water safe cleaning method is also inexpensive in comparison with chemical and mechanical techniques. Selective poulticing on the bridges abutments and main pier tower to remove metallic stains should diminish the staining's intensity and may improve the performance of the limestone by preventing internal stresses.

\section*{Concrete}

Although the reinforced concrete was not investigated as part of the condition survey, it is the key structural material used in the bridge's construction. The ultimate

\footnote{\textsuperscript{15} Boyer, \textit{Cleaning Masonry and Stone}, 47.}
stability of the bridge depends on this material, and its maintenance and repair require careful technique and knowledge. Unlike many historic reinforced concrete bridges which are reaching maturation, the University Avenue Bridge is faced with masonry, affording a certain amount of protection from the concrete beneath it.

Water penetration deteriorates the concrete under several conditions. If the concrete is carbonated, if deicing salts are present, if reinforcing bars were initially placed too close to the surface, or if inadequate repairs were made, corrosion is likely to occur.\textsuperscript{16} If moisture and contaminants are prevented from penetrating the concrete, it will survive over a long period of time.

A limestone facing and parging layer on top of the reinforced concrete requires destructive testing to confirm corrosion. Techniques such as an impact-echo transducer detects honeycombed areas, cracks, and cold joints. This technique requires a core sample to calibrate the instrument. Core samples are also used to test for compressive strength, paste quality, and chloride content. Finally, active corrosion can be measured by the corrosion half-cell test.\textsuperscript{17}

\textsuperscript{16} Carolyn Searls, "Repair of Historic Concrete," in \textit{Proceedings of the Third Historic Bridge Conference} (Department of Civil Engineering, Ohio State University, 1990), 17.

\textsuperscript{17} Searls, \textit{Third Historic Bridge Conference}, 20. According to Searls, the half-cell test is only effective for detecting active corrosion and not corrosion that has occurred in the past.
While the superstructure's bridge deck has been replaced a number of times, the substructure's reinforced concrete was first repaired in 1983. On the channel elevations, concrete was repaired and masonry reset and replaced. The location of the repairs demonstrates the susceptibility of the bridge's piers to deterioration. Deicing salts used on the roadway in the winter months probably caused much of this decay. Additionally, water penetration contributes to deterioration, where mortar joints are deteriorated and masonry units are loose. Because the University Avenue Bridge's concrete predates air-entrainment, it is likely to be more permeable than air-entrained concrete, and thus deteriorates when unprotected. Survival of the original concrete, and perhaps the bridge, depends on proper maintenance and repair of the concrete and the facing protecting it.

To extend the life of the University Avenue Bridge, the superstructure, composed of the spans and deck, must be continually upgraded and maintained. Techniques which were not available when the bridge was constructed, such as air-entrained concrete, cathodic protection, and epoxy coatings for embedded steel, can increase the longevity of bridge decks.  

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Mortar

Mortar joints of the limestone facing form another important element on the University Avenue Bridge which needs repair. The mortar used to fill these joints contributes to the original appearance of the University Avenue Bridge, and, if allowed to deteriorate, hastens the deterioration of the bridge's structural system. Further, improper repointing alters the original design and can damage the masonry system. Proper maintenance of masonry mortar can greatly prolong the life of historic bridges.

Many of the joints in the University Avenue Bridge's masonry remain intact and do not require attention. However, inappropriate repair techniques and lack of maintenance contribute to the bridge's current condition. Specific areas on the bridge need repointing, but in a manner which is in keeping with the original design. Proper repointing would prevent spalling and improve the appearance of masonry surface, a deliberate design by the architect of the bridge, Paul Cret.¹⁹

¹⁹ No evidence of Cret's intention for the University Avenue Bridge pointing exists, but he clearly considered such details when designing buildings and bridges. Describing the Calvert Street Bridge (Washington, D.C.) design, Cret wrote, "It will be obvious that, in the Calvert Street Bridge, architectural repertory has been sparingly used. There are, in this whole work, two profiles only which required a full size detail. Instead, a careful study of stone jointing and a frank separation of plans by beveled surfaces was sought." [emphasis added] Paul Cret, "The Calvert Street Bridge," Box 18, Cret Collection, Special Collections, University of Pennsylvania.
To determine the component parts of the original mortar, samples were taken for analysis during the condition survey. No evidence suggests that the entire bridge was ever repointed, so the samples which conformed to the original tooling were assumed to be original. Mortar analysis corroborated this conclusion and confirmed the presence of constituents other than Portland Cement.

The original proposal for the "special mortar" to point the facing stone on the University Avenue Bridge specified a combination of sand, hydrated lime, stainless, grey cement, and a pigment or coloring compound. Unfortunately, no ratio of the proportions for this mortar was specified.  

The original proposal called for the same mortar for filling in behind the stone facing, and for parging, omitting the pigment or coloring compound in the parging mortar.

To maintain proper joint widths—a maximum of 1/4 inch—when bedding the face-stone, masons used wooden wedges. Once the stone was set on a particular bed of mortar, the masons removed the wooden pegs and tuck-pointed the remaining joint, which, according to the specification, was to be 3/4 inch in depth from the stone face. Stone joints of the cornices,

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20 "Proposal and Specifications for University Bridge over Schuylkill River," Bridge Division, Department of Streets, City of Philadelphia, 47. A test panel of limestone units and concrete was to be used to determine the special mortar ratio; the specification stated: "various proportions of stainless cement, hydrated lime and sand mixed with varying consistencies shall be tried and the proportion and consistency showing the best bond face-stone to concrete and the least probability of stain on face-stone shall be used on the bridge."
copings, belt courses, and stone gutters were to be caulked with picked oakum and then filled with the "special mortar."21

Because no ratio of the mortar components exists in the original specification, and because mortars evolve over time, the mortar analysis does not attempt to determine the original ratio of the mortar used to construct the University Avenue Bridge. Instead, the mortar analysis, conducted on seven samples, confirmed the type of constituent elements in the original mortar by separating them. Characterization of the binders and aggregate will provide useful information to design an appropriate replacement mortar for the bridge.

The University Avenue Bridge should be selectively repointed in areas where the existing mortar is deteriorated or missing. To prevent damaging the limestone facing during repointing, chiselling out of the deteriorated mortar, or raking, should be performed by a skilled mason. Moreover, mechanical band saws should not be used. The preferred depth of raking usually equals 2 1/2 to 3 times the width of the joint. On the University Avenue Bridge, the raking depth should be 3/4 inch, which equals 3 times the joints width.

Designing a replacement mortar that will be compatible with the historic appearance of bridge and its materials is not an easy task. However, certain considerations assure the new mortar's compatibility. First, to prevent stress on the

21 "Proposal and Specifications for University Bridge," 47.
surrounding masonry, the replacement mortar for the University Avenue Bridge should be softer in compressive strength than the surrounding masonry units and softer than the original mortar.\textsuperscript{22} Additionally, softer mortars (usually made with a lime component), are self healing, preventing moisture from becoming trapped in the structural system.

An appropriate replacement mortar matches, to the best degree possible, the original mortar's color, texture, and physical characteristics. This match is best achieved through the selection of sand which matches the original aggregate. The original sand used to make the mortar for the University Avenue Bridge is fine grained and contains some quartz. If necessary, mixtures of more than one kind of sand can be used to match the original aggregate.\textsuperscript{23}

Matching the color of the University Avenue Bridge's original mortar can be achieved by curing a mixture which matches the interior portion of the original mortar. Because the original mortar's coloring compound is not described, pigment might be used to design a replacement mortar.\textsuperscript{24} The existing, weathered color of the mortar should not be

\textsuperscript{23} Mack, \textit{Masonry Cleaning}, 169.
matched, as this mortar has aged and the replacement mortar will also weather over time.

**Bronze**

Among the most distinguishing features of the University Avenue Bridge are the bronze elements. These include the approach and pier lanterns, the main piers' doors, and the bull's eye windows. To assure their preservation, intervention is necessary to arrest deterioration. A variety of treatments are available to treat bronze, and the proper intervention should be developed by an architectural or art conservator. This section describes the factors which influence the condition of the bridge's bronze elements, and suggests several levels of intervention which a conservator might consider to develop a metal conservation program for the University Avenue Bridge.

Outdoor bronze sculpture and architectural ornament are subjected to harsh environmental conditions which deteriorate and disfigure this copper alloy. After an induction period, the bronze forms a layer of copper sulfate, followed by runoff, streaking, and scab formation. Once pitting begins, all of the bronze becomes covered with a sulfate layer.25

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primary corrosion is caused by interactions of moisture, particulate matter, and harmful acids such as sulfuric acid, nitric acid, and carbonic acid.\textsuperscript{26}

Removing the bronze elements from the outdoor environment and treating them is one option for conservation, but not desirable. These elements are an integral part of the bridge's design, and placing them in a museum would destroy the historical context. Another option is to not intervene. However, left untreated, the bronze would continue to deteriorate. Furthermore, runoff of corrosion products would continue to disfigure the limestone below the lanterns, doors, and windows.

Although the foundry of the bridge's bronze elements has been documented, there is still no indication of the foundry-applied patina. Questions arise about how to properly preserve the metal object, an artistic work. Even though the bridge's bronze elements are not the work of a sculptor, they should be respected for their design value. Paul Cret, the bridge architect, may have called for a specific bronze patination or patinations.\textsuperscript{27} An appropriate conservation

\textsuperscript{26} Ashurst, \textit{Practical Building Conservation}, 81.

\textsuperscript{27} During the late nineteenth and early twentieth centuries, it was common for sculptors and architects to manipulate color and experiment with textural differentiation. Cret's training and vast number of commissions indicate that he may have been aware of such techniques and specifying them in his designs. Phoebe Dent Weil,
program addresses both issues, balancing the need to conserve the metal and the aesthetic history. Even if the original appearance is not revealed through documentation, the bronze on the University Avenue Bridge should be preserved.

Two basic techniques are utilized for most treatments of outdoor bronze. Both institute a barrier coating but one technique removes the corrosion layer and requires repatination of the bare metal surface, and the second leaves all or most of the corrosion layer intact, usually requiring little or no repatination. Stripping all of the corrosion layer from the bronze is controversial because it removes metal from the surface, sculpture detail is lost, and texture is altered. Stripped bronze is also subject to rapid corrosion if left unprotected.

One of the most successful current techniques for bronze conservation utilizes pulverized walnut shells to air blast a bronze object. This technique removes dirt, surface


corrosion, and grime, producing a clean surface, onto which a barrier coating is applied.\(^{31}\) Employing this technique improves the aesthetic appearance of an object and reduces the potential for further corrosion damage. Much of the remaining, hardened patina (formed by chemical patination at the foundry but more so by chemical interaction with the environment) is left intact, protecting the original fabric of the object.\(^{32}\)

Since each bronze object is subjected to unique environmental conditions, treatments vary for different bronzes. In the case of the University Avenue Bridge's bronze, conservation of the material is most important when designing a treatment in the absence of a documented patination color. A conservator should investigate the bridge's bronze to ascertain if any of the original patination survives. However, the patination for the bronze doors and the approach lanterns may have varied.

No documentary or physical evidence of any past treatment exists for the University Avenue Bridge's bronze elements. Exposed to bird droppings, acidic industrial pollution and automobile emissions coupled with continual wet/dry cycles for over sixty years, the bronze on the bridge exhibits streaking and pitting. A green oxide layer covers

\(^{31}\) Montagna, *Conserving Outdoor Bronze Sculpture*, 2.
\(^{32}\) Ibid.
most of the bronze elements and contributes to some of these elements' deterioration. The deterioration of the lanterns and doors is accelerated by the exposure of the interior surfaces to water, dirt, and other harmful pollutants, where the glass panes and door handles are missing.

At the very least, the lanterns on the approaches should be stabilized. If glass is not reinstalled in the lanterns, the interior globes should be unobtrusively capped to prevent water from infiltrating the lower portions of the lantern bases, masonry, and reinforced concrete system the bronze rests on. This least expensive stabilization measure could be followed by surface cleaning and protection with a barrier coating, most commonly a wax or acrylic lacquer. A protective coating requires a regular maintenance program to assure a proper wax or lacquer covering on areas where weathering is greatest.

The second, more desirable intervention option is a program to remove the accretions and loose friable corrosion products with a pulverized walnut shell blasting technique to clean the bronze surfaces. Prior to shell blasting,

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34 Montagna, Conserving Outdoor Bronze Sculpture, 5
cleaning of the bronze normally takes place with high temperature pressure washing using a non-ionic detergent. Unlike the techniques which remove the entire corrosion layer (patina) to bare metal, the walnut shell technique only partially divests the surface, to retain the original fabric of the object.

In the second stage of this procedure, the bridge's bronze elements would be coated with either a corrosion inhibitor (Benzotriazole is the most widely used) and wax, or combination of waxes, or a lacquer in which the corrosion inhibitor can be suspended. Like the first intervention option, a maintenance program is essential to maintain the protective coating.

Examination of historic photographs of the bronze elements by a trained conservator would perhaps provide valuable information toward the development of an appropriate conservation plan. The bronzes' luster, for instance, might be discerned, enabling more accurate repatination if this technique is selected. Even without this information, the bronze should still be treated with the assistance of a skilled conservator. Leaving these elements untreated and

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35 Conserving Outdoor Bronze Sculpture, 2.
36 Rika Smith and Arthur Beale, Open-Air Exposure, 105.
unmaintained slowly erodes one of the most distinguishing features of this City Beautiful bridge.

**Alterations, Missing Elements, Deferred Maintenance, and Priorities**

While the majority of the University Avenue Bridge's original fabric remains intact, measures should be taken to prevent any further loss of the bridge's distinctive features. Insensitive alterations, missing fabric and deferred maintenance compromise the integrity of the University Avenue Bridge. Under ideal circumstances, the design integrity would be improved by returning some of the key features to their original appearance. However, at the very least, addressing these issues will increase the life of the bridge. A description of many of the alterations, missing elements, and areas which have not been maintained follows, with suggestions for improving both the bridge's appearance and its condition.

As with most buildings, one of the primary design goals is the control of water and how it is shed away from a structure. On the University Avenue Bridge, the north operator's tower, plagued by water infiltration throughout its history, continues to deteriorate. Without even investigating the structure's roof, several points are evident. Visible voids in the tower's upper level masonry joints demonstrates inadequate maintenance of the bridge's
pointing, contributing to the potential for water penetration. Another deterioration mechanism is an abandoned scaffolding, used to repair pointing, which should be removed. This scaffolding stains the masonry and provides an avenue for water into the building. Finally, the replacement of the submarine cable connecting the two towers with an overhead cable necessitated installation of a frame support on each tower. Inappropriately attached to the tower roofs, each frame support probably contributes to the leaky roof condition.

Fencing used to secure the lower halves of the window frames forms another insensitive alteration on the towers. While, this fencing may be necessary, but it obscures the original spiral pattern of the bronze window frames and the widows. They should be removed to improve the integrity of the operator's towers and to prevent ongoing rust staining of the masonry below the window frames.

Opposite the operator's towers are the downstream plazas of the main piers. The integrity of these elements, too, are compromised by the transformers which are located there. Protected by chain-link fencing, the transformers are inappropriately placed on the main piers, and would be better located out of public view for both safety and aesthetic reasons.
Maintaining safety requirements is one of the most challenging and difficult tasks when attempting to preserve historic bridges. Such is the case with the University Avenue Bridge's railing, which deteriorated after numerous automobile collisions into it. As a result, the original steel and cast iron railing was replaced across the bridge spans. However, two sections of the original railing remain intact on the south approach to the bridge. These sections should be preserved as examples of the original bridge design. In good structural condition, preservation of these railing sections is possible by simply maintaining a paint coating on the steel and cast iron.

Original fabric from the University Avenue Bridge which has been lost is another factor to consider when preserving the bridge. The amount of missing fabric is minimal, and the lost fabric either exists on other parts of the bridge, or can be documented. Of the missing fabric, most is bronze. Replication of bronze detailing is one preservation option to be considered. Several lanterns are missing swags, part of the lantern design. Because the swags are not structural, and because many of the swags are intact, it is unnecessary to replace this fabric. Replication, however, could be conducted by removing an existing swag to cast a mould for the replacement parts.
The lanterns' glass formed one of the most distinguishing features of the approach and pier lanterns and has been missing for some time. According to the original specification, Colonial Opalescent glass made by Westinghouse Electric Company was to be used for the lanterns. Field investigation revealed fragments of the original glass, which could be used for matching replacement glass. The importance of replacing the glass in the lanterns cannot be overstated. If the lanterns continue to be left unmaintained, they become more a ruin than an integral part of the operating bridge. Without glass, the lanterns and the masonry below deteriorate more quickly. If vandalism is an issue, capping the lanterns to prevent moisture penetration may be the best alternative. Exploring the possibility of a fiberglass which matches the original glass in appearance and texture might also be considered. Of course, the most desirable alternative would be rewiring and reilluminating the bridge's lanterns.

Historic photographs reveal the type of door handle originally on the bronze doors of the main piers. Removed for some time, the doors no longer have handles, and bolts now pierce the area where the original hardware was located. Again, if replication is not considered, the hardware on the doors should be repaired to prevent further deterioration caused by water infiltration.

38 "Proposal and Specifications for University Bridge," 52.
Another area where missing fabric is evident is on the limestone facing. During the 1982 rehabilitation, limestone facing was reset and selectively replaced on the channel elevations of the main piers. Today, very little of the limestone is in poor condition. Along the main and intermediate piers are small areas where the protruding limestone has been severed or cracked off. In no case is there evidence of structural deterioration, so no repairs of these elements seem needed. However, on the southwest approach railing wall, cracked and missing limestone should be repaired to match the existing stone.

Priorities for Conservation

While there are many measures that might be taken to improve the appearance of the University Avenue Bridge, this plan attempts to define priorities to extend the life of the bridge. Some of the options discussed address preserving the bridge's integrity, while, at the same time, seeking to improve the performance of the bridge's materials. With limited resources available for expensive restoration work, it is necessary to take basic steps to preserve the bridge. By establishing priorities, the preservation work can be staged.
Stage I priorities would include stabilizing the bronze elements, selective repointing of the masonry, and nomination of the bridge to the National Register of Historic Places.

**Bronze Stabilization:**

Runoff of corrosion products from the bronze continues to discolor the limestone masonry. Stabilizing the bronzes will prevent further staining and will protect the metal from many of the elements which cause its deterioration. A conservation plan should be developed by a trained art or architectural conservator. The cost of such a program is estimated at $5,000 per bronze. This cost would include materials, labor, and rental of an hydraulic lift. The bronzes would be detergent cleaned and coated with a wax, or cleaned, walnut shell blasted, and waxed, depending on the condition. With nine major lanterns, four bronze doors and three bronze plaques, the latter two of which would not require the hydraulic lift, a total of at least $60,000 would be needed to complete a conservation program.\(^{39}\) Cyclical maintenance for detergent cleaning, inspection, and renewel of the wax coating is estimated at $5,000. Reinstalling glass

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\(^{39}\) Estimates are based on my discussions with Dennis Montagna. Five sculpture groups in Washington, D.C., were cleaned with this treatment for $28,000 in 1987. See Montagna, *Conserving Outdoor Bronze Sculpture*, 8.
in the lanterns would prevent further deterioration and obviate the need to maintain the lantern interiors.

Once they are properly conserved, the bridge's bronze elements will require maintenance and commitment. Since the Pennsylvania Department of Transportation only plans major rehabilitations of the bridge, it is not likely to allocate the entire amount of money for the conservation plan. The Department of Transportation might be eligible, however, for funding from the National Endowment for the Arts, or from the Pew Foundation, which both support conservation projects.  

Repointing:

Reconstituting the deteriorated and missing mortar on the bridge should be an important priority. While stone facing affords protection to the concrete beneath its, water infiltration through mortar joints hastens deterioration of the reinforced concrete. An expenditure by the Commonwealth of Pennsylvania to selectively repoint the bridge will prevent major repairs in the future. An appropriate replacement mortar should be developed by an architectural

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40 Sculptural Monuments, 55. Penny Balkin Bach, "Choreography and Caution: The Organization of a Conservation Program," in Sculptural Monuments, 55. Pew recognized the need for planning among those agencies responsible for preserving Philadelphia's sculpture. In her presentation, Bach advocated development of a survey and maintenance program for the city's inheritance, which should include such architectural bronze's as those on the University Avenue Bridge.
conservator. The cost to develop a mortar replication is estimated at $1,000. In addition to preserving the integrity of the materials, repointing will effect material conservation of the bridge's structure and extend the bridge's life. This work would be coordinated by the Pennsylvania Department of Transportation during a rehabilitation.

Nomination to the National Register of Historic Places:

The University Avenue Bridge should be nominated to the National Register of Historic Places. It has already been determined to be eligible, and with the documentation in this thesis, the nomination could easily be prepared. This planning measure is an important part of the Stage I proposal because it formally recognizes the bridge as historic, increasing awareness among agencies responsible for this bridge.

Once the bronze is stabilized, and repointing completed, the Stage II work would address the issues of maintenance, cleaning, painting, and removal of insensitive alterations.
Maintenance:

A maintenance plan should be developed to care for the University Avenue Bridge. This plan would address maintaining the conserved bronze, cleaning the scuppers of the piers, and monitoring bridge elements for decay, and potential repair work. Forms such as those used in the condition assessment for this thesis might assist inspectors making a periodic inspections. The maintenance plan could be coordinated by the Bridge Maintenance Unit of the City's Department of Streets.

Masonry Cleaning:

Developing a cleaning program will require an architectural conservator or architect familiar with cleaning techniques. The cost of a water-misting procedure for the sections of the bridge covered with black staining, dirt, grime and bird droppings is estimated at $25,000.\(^4\)\(^1\) This would include water mist/low pressure cleaning of the abutments, the lower elevations of the main piers, and the intermediate piers. A poultice treatment might be employed to diminish the most intense copper staining on the approach

\(^{41}\)Water mist cleaning costs approximately one dollar per square foot, and I have estimated the bridge's square footage to be between 22,000 and 25,000.
railing walls, but this technique would not be used for all of copper staining due to expense. Stabilizing the bronze would prevent further staining, and in many locations the staining is not intense. This work could be coordinated through the Pennsylvania Department of Transportation during a rehabilitation.

**Painting, Graffiti, Alterations:**

The last Stage II work to be completed would be painting the remaining original section of the steel and iron railing on the south approach, removing graffiti, and removing insensitive alterations. Perhaps the easiest of these objectives to address is the railing. Stripping and painting the railing would be handled by the City's Bridge Maintenance Unit at a minimal cost. In developing a plan to remove graffiti and additions made to secure the operator's houses, an assessment of the potential for preventing new acts of vandalism must be made. Would a cleaned bridge prevent further vandalism, or would vandalism continue? It may not be feasible to keep graffiti off the bridge's accessible elements. A more realistic possibility is the removal of fencing from the operator's houses' windows and replacement of glass to panes where it is broken or missing. The Bridge
Maintenance Unit or Pennsylvania Department of Transportation could plan these repairs.

Many of these preservation objectives could be planned as part of ongoing and future rehabilitations. Repairs which preserve the integrity of the bridge's design also conserve material, which, in the long run, will prevent more expensive rehabilitation work. As a whole these measures will insure that the University Avenue Bridge remains sound for continued use as a highway bridge for many years to come.
CONCLUSION

The dearth of published material about the preservation of historic industrial resources, especially bridges, suggests the need for further research and publications in this field. As a vital link in our understanding of transportation and engineering history, bridges warrant increased attention by the historic preservation community. Only within the last decade have statewide surveys begun to inventory historic bridges. In addition to inventories and planning, more information is needed about techniques for preserving this largely ignored resource group, which continues to serve as part of the nation's highway system.

Many of the nation's 275,000 federally aided bridges are historic and will require repair and rehabilitation in the future. Fully 28% are estimated to be deficient on some level.1 To remedy the situation, state and local agencies are developing bridge management systems to create procedures for rehabilitation and replacement.2 These systems determine the economic viability of various replacement and rehabilitation techniques. Since the life-span of bridges is estimated to be sixty years, most historic bridges face replacement if

1G.W. Maupin, Jr., Bernard Brown, and Abba Lichtenstein, editors, Extending the Life of Bridges (Philadelphia: ASTM, 1990), 1.
2Ibid.
they become obsolete or deficient. An important criteria which might be added to the attribute categories of such systems would be historic significance. An important criteria which might be added to the attribute categories of such systems would be historic significance. Integration of this attribute might be utilized to encourage rehabilitation instead of replacement.

The University Avenue Bridge is now sixty-one years old. While not immediately threatened, the fate of early modern concrete bridges remains uncertain. In fact, Philadelphia's Walnut Lane Bridge (1947-50), the first pre-stressed concrete bridge, was recently demolished. The importance of sensitive maintenance, repair and rehabilitation cannot be overstated. Fortunately, major rehabilitations on the University Avenue Bridge are being handled by A.G. Lichtenstein and Associates, one of the leading authorities on historic bridge rehabilitation.

While we have reason to be optimistic about the future of the University Avenue Bridge, many other deficient historic bridges are likely to be destroyed in the coming years as Congress authorizes money for bridge rehabilitation and replacement. Balancing the need for safe highways with the preservation of our industrial heritage is a difficult task for those involved with historic bridges. Successful planning and technological solutions will require the

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3 Ibid., 16. The authors of this article advocate enhancing such data base systems because local engineers and planners are knowledgeable about the physical structures which they manage.
expertise and cooperation of bridge administrators, historians, engineers, and planners. New techniques for bridge rehabilitation should benefit those interested in preserving historic bridges, and ultimately those involved in historic preservation must recognize that not all bridges can be saved or retained in their original form.

Bridges like the University Avenue Bridge represent an important facet of our industrial and cultural heritage, and are worthy of investigation and preservation. Hopefully other studies on individual bridges will contribute to the work of historians and engineers dedicated to the study of bridges.
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Materials Conservation


Appendix A

Illustrations
UNIVERSITY AVENUE BRIDGE: Illustrations

ILLUSTRATION 1

NAME OF PHOTOGRAPH
PROPOSED UNIVERSITY BRIDGE

DATE
5/27/1927

PHOTOGRAPH COLLECTION: Philadelphia Evening Bulletin
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PHOTOGRAPH COLLECTION: Bridge Maintenance Unit  
City of Philadelphia
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<td>5</td>
<td>STUDY FOR MAIN PIER</td>
<td>1927</td>
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PHOTOGRAPH COLLECTION: Architectural Archives
University of Pennsylvania
UNIVERSITY AVENUE BRIDGE: Illustrations

ILLUSTRATION 6

NAME OF PHOTOGRAPH
RENDERING OF MAIN PIER

DATE 1927

PHOTOGRAPH COLLECTION: Architectural Archives University of Pennsylvania
ILLUSTRATION 7

NAME OF PHOTOGRAPH
STUDY OF MAIN PIER

DATE 1927

PHOTOGRAPH COLLECTION: Architectural Archives
University of Pennsylvania
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City of Philadelphia
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<td>11</td>
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PHOTOGRAPH COLLECTION: Bridge Division
City of Philadelphia
ILLUSTRATION 12

NAME OF PHOTOGRAPH
MAIN PIER REFUGE BAY & LANTERNS

DATE 6/26/1929

PHOTOGRAPH COLLECTION: Bridge Division
City of Philadelphia
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City of Philadelphia
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PHOTOGRAPH COLLECTION: Bridge Maintenance Unit
City of Philadelphia
UNIVERSITY AVENUE BRIDGE: Illustrations

ILLUSTRATION | NAME OF PHOTOGRAPH | DATE
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17 | N. MAIN CAISSON WORKING CHAMBER | 11/23/1927

PHOTOGRAPH COLLECTION: Bridge Maintenance Unit
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PHOTOGRAPH COLLECTION: Bridge Maintenance Unit
City of Philadelphia
### UNIVERSITY AVENUE BRIDGE: Illustrations

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City of Philadelphia
**UNIVERSITY AVENUE BRIDGE: Illustrations**

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PHOTOGRAPH COLLECTION: Bridge Division  
City of Philadelphia
UNIVERSITY AVENUE BRIDGE: Illustrations

ILLUSTRATION | NAME OF PHOTOGRAPH | DATE
--- | --- | ---
30 | Extruded Bronze Lamp | 1930

*Left:* Extruded Bronze Lamp, University Bridge, Philadelphia. Paul Cret, Architect

*Courtesy: Newman Manufacturing Co.*

*Right:* The Circle Figure, Old Midway Gardens, Chicago, Illinois. A. Iannelli, Sculptor. Frank Lloyd Wright, Architect

THE WESTERN ARCHITECT
OCTOBER :: :: 1930

PHOTOGRAPH COLLECTION: The Western Architect
October 1930
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PHOTOGRAPH COLLECTION:  Bridge Maintenance Unit
                        City of Philadelphia
UNIVERSITY AVENUE BRIDGE: Illustrations

ILLUSTRATION 35

NAME OF PHOTOGRAPH
Approach Plan

DATE
4/26/1931

PHOTOGRAPH COLLECTION:
Philadelphia Inquirer
April 26, 1931
UNIVERSITY AVENUE BRIDGE: Illustrations

ILLUSTRATION 37

NAME OF PHOTOGRAPH
#32503-A

DATE 1/7/1932

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**PHOTOGRAPH COLLECTION:** Philadelphia Evening Bulletin

May 11, 1933
Appendix B

Condition Assessment Data
Condition Assessment

Location Diagrams
Conflict Assessment

Resolution Mechanism
## Key to Condition Survey Forms

<table>
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<tr>
<th>Condition</th>
<th>Pattern</th>
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<td>Black Staining</td>
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<tr>
<td>Rust Staining</td>
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<tr>
<td>Biological Growth</td>
<td><img src="image4.png" alt="Pattern" /></td>
</tr>
<tr>
<td>Graffiti</td>
<td><img src="image5.png" alt="Pattern" /></td>
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<td>Efflorescence</td>
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<td>Erosion</td>
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<td>Spalling</td>
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<td>Missing Fabric</td>
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<td>Deteriorated Pointing</td>
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UNIVERSITY AVENUE BRIDGE: Condition Survey

PHOTO
5, 10

NAME OF ELEMENT
NORTH ABUTMENT

DRAWING
1
UNIVERSITY AVENUE BRIDGE: Condition Survey

NAME OF ELEMENT
NORTH APPROACH LANTERNS (EAST)

PHOTO
2

DRAWING
2
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<td>NORTH OPERATOR'S HOUSE (WEST)</td>
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Diagram of the structure with labeled elements.
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UNIVERSITY AVENUE BRIDGE: Condition Survey
UNIVERSITY AVENUE BRIDGE: Condition Survey

PHOTO
-

NAME OF ELEMENT
NORTH OPERATOR'S HOUSE (NORTH)

DRAWING
6
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<td>NORTH OPERATOR'S HOUSE PLAZA</td>
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UNIVERSITY AVENUE BRIDGE: Condition Survey

PHOTO
4, 8

NAME OF ELEMENT
NORTH MAIN PIER (SOUTH)

DRAWING
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UNIVERSITY AVENUE BRIDGE: Condition Survey

PHOTO 11

NAME OF ELEMENT
SOUTH OPERATOR'S HOUSE (WEST)

DRAWING 12
UNIVERSITY AVENUE BRIDGE: Condition Survey

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UNIVERSITY AVENUE BRIDGE: Condition Survey

NAME OF ELEMENT
SOUTH OPERATOR'S HOUSE (NORTH)

DRAWING 14
UNIVERSITY AVENUE BRIDGE: Condition Survey

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<td>12</td>
<td>SOUTH OPERATOR'S HOUSE PLAZA</td>
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![Drawing of South Operator's House Plaza](image-url)
UNIVERSITY AVENUE BRIDGE: Condition Survey

PHOTO
14,16

NAME OF ELEMENT
SOUTH MAIN PIER (WEST)

DRAWING
19
UNIVERSITY AVENUE BRIDGE: Condition Survey

PHOTO
24, 25, 26, 27

NAME OF ELEMENT
SOUTH ABUTMENT

DRAWING
20
UNIVERSITY AVENUE BRIDGE: Condition Survey

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<td>21, 22</td>
<td>SOUTH APPROACH LANTERNS (EAST)</td>
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UNIVERSITY AVENUE BRIDGE: Condition Survey

PHOTO

NAME OF ELEMENT
SOUTH APPROACH LANTERNS (WEST)

DRAWING

23

22
Condition Assessment
Details and Photographs
Constitution Assessment

Decision and Photography
UNIVERSITY AVENUE BRIDGE: Condition Survey

PHOTO  
1

NAME OF ELEMENT  
NORTH OPERATOR'S HOUSE

DRAWING  
4

DESCRIPTION OF ELEMENT:

One of two main pier operator's houses, the north main pier building is octagonal in shape, with windows between cylindrical limestone columns. The entrance is reached via stairs flanking the door. Above the carved limestone cornice is a cylindrical tower, which is decorated with a limestone panel.

CONDITION:

Pointing on the operator's house is in poor condition. On the upper sections the pointing is missing or deteriorated, while on the lower section replacement mortar is too hard and cracking the surrounding masonry.

Insensitive fencing covers the bronze window frames, to which the fencing is bolted. Another insensitive element is an abandoned scaffolding on the upper section. The roof is also covered with biological growth.

The condition of the masonry cornice is excellent; however, the limestone stairs are eroding and have shifted. Graffiti also covers much of the lower sections of this elevation.

The bronze lantern exhibits an even green patina and is missing its glass; the bronze plaque is covered with graffiti, and the metal railing is bent and deteriorating.

DATE OF SURVEY:  11/27/1990

NAME OF SURVEYOR:  JESTER
UNIVERSITY AVENUE BRIDGE: Condition Survey

PHOTO 2
NAME OF ELEMENT NORTH APPROACH LANTERNS (EAST)
DRAWING 2

DESCRIPTION OF ELEMENT:

One of four lantern groups, the northeast group features a low railing wall and a lantern base surmounted by a bronze lantern.

CONDITION:

Of all the elements on the bridge which exhibit green staining from the bronze, this lantern group has the most intense staining of this type. An intense strip under the lantern covers the entire length of the lantern base.

Graffiti covers much of the lantern base as well, and the limestone shows signs of erosion. The railing wall and recessed panel are covered by biological growth, and pointing on this element is in poor condition.

DATE OF SURVEY: 11/20/1990
NAME OF SURVEYOR: JESTER
UNIVERSITY AVENUE BRIDGE: Condition Survey

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<tr>
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<td>3</td>
<td>NORTH APPROACH LANTERNS (WEST)</td>
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</table>

DESCRIPTION OF ELEMENT:

One of four approach lantern groups, the northwest group has a low railing wall, a lantern base, on which the lantern is located.

CONDITION:

Of the four approach lantern groups, the northwest one is in the poorest condition. Biological growth covers most of the limestone, graffiti covers a large percentage of the lantern base, and green staining on the same element is relatively intense. Pointing is also missing from some of the joints on this element.

DATE OF SURVEY: 11/20/1990
NAME OF SURVEYOR: JESTER
# UNIVERSITY AVENUE BRIDGE: Condition Survey

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</table>

**DESCRIPTION OF ELEMENT:**

The west end of the north main pier's south elevation supports a bascule span, where the bull's eye window are located, and forms the refuge bay's lantern shaft.

**CONDITION:**

Evidence of reconstruction is evident on this elevation east of the bull's eye windows. In this area patches of efflorescence are present, and the masonry joints' width is larger than the original stonework's. Pointing on the cornice is in poor condition; otherwise, this elevation is in good condition.

**DATE OF SURVEY:** 11/20/1990

**NAME OF SURVEYOR:** JESTER
UNIVERSITY AVENUE BRIDGE: Condition Survey

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<tr>
<th>PHOTO</th>
<th>NAME OF ELEMENT</th>
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<tbody>
<tr>
<td>5</td>
<td>EAST END OF NORTH ABUTMENT</td>
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</table>

**DESCRIPTION OF ELEMENT:**

Projecting stonework and battered walls form the east end of the north abutment. The steel span meets the abutment above a narrow abutment cornice.

**CONDITION:**

Varying intensities of green staining cover the east end of the north abutment below the bronze lantern. At the top of the wall, staining is as heavy as any place on the bridge.

The lower sections of this abutment are covered with graffiti, and much of this wall is covered by efflorescence, especially under the railing on the projecting part of the wall.

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**NAME OF SURVEYOR:** JESTER
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PHOTO 6

NAME OF ELEMENT
WEST ELEVATION OF N.W. LANTERN WALL

DRAWING -

DESCRIPTION OF ELEMENT:

Recessed panels of carved limestone form the north end of the north abutment's west elevation.

CONDITION:

This area of the west elevation exhibits biological growth, as demonstrated by both the ivy attached to the stone and by the green patches. Pointing on this elevation is in good condition. Industrial yellow paint covers a small section of this elevation.

DATE OF SURVEY: 11/27/1990
NAME OF SURVEYOR: JESTER
UNIVERSITY AVENUE BRIDGE: Condition Survey

PHOTO 7

NAME OF ELEMENT
WEST ELEVATION OF NORTH ABUTMENT

DRAWING -

DESCRIPTION OF ELEMENT:

Battered walls form the shaft of the approach lantern on the west elevation of the north abutment. This abutment is reinforced concrete and faced with limestone.

CONDITION:

Green staining covers the area beneath the lantern and extends to the base of this elevation. Its intensity is greatest on the upper sections, dissipating on the lower sections. Aside from the extensive graffiti on the lower level, the condition of this wall is good; pointing is in good condition, as is the concrete foundation.

DATE OF SURVEY: 11/27/1990

NAME OF SURVEYOR: JESTER
UNIVERSITY AVENUE BRIDGE: Condition Survey

PHOTO  
8

NAME OF ELEMENT  
EAST END OF NORTH MAIN PIER (SOUTH)

DRAWING  
8

DESCRIPTION OF ELEMENT:

The north main pier supports the bascule span on the south elevation. Side walls, where the bull's eye windows are located, and a central pier carry the load of the steel structure. Like most of the other bridge elements, this pier is constructed of reinforced concrete and faced with limestone.

CONDITION:

The sidewalls and central pier on this elevation appear to have been reconstructed: the stone facing in these locations does not match the original limestone, and the joints between the new masonry units is wider than the original joint width.

In the areas which were reconstructed, efflorescence is evident, as is minor spalling of the original masonry. Black staining covers a small percentage of this elevation. The east end of the beltcourse is cracked, but less severely than on other elevations.

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<tr>
<td>9</td>
<td>NORTH INTERMEDIATE PIER (NORTH)</td>
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DESCRIPTION OF ELEMENT:

The north intermediate pier supports the spans between the north abutment and this abutment. Steel rests on the pier on four points. It is built of reinforced concrete and faced with limestone. Simple battered walls are decorated only by a dressed stone course at the fender level.

CONDITION:

Stonework on the north intermediate pier is in good condition. Rust staining covers a small percentage of this pier. Black staining and dirt cover the central section of this elevation.

DATE OF SURVEY: 11/20/1990
NAME OF SURVEYOR: JESTER
UNIVERSITY AVENUE BRIDGE: Condition Survey

PHOTO
10

NAME OF ELEMENT
EAST END OF NORTH ABUTMENT

DRAWING
1

DESCRIPTION OF ELEMENT:

Like the south abutment, the north abutment is constructed of reinforced concrete and faced with limestone. Above the stringer-line, no limestone facing is used.

CONDITION:

Above the stringer-line, concrete is extensively spalled, especially near the bridge deck. Much of the limestone facing is stained from rust and dirt, and efflorescence is also prevalent. Graffiti is also found on the lower areas of this abutment.

DATE OF SURVEY: 11/20/1990

NAME OF SURVEYOR: JESTER
UNIVERSITY AVENUE BRIDGE: Condition Survey

PHOTO 11
NAME OF ELEMENT SOUTH OPERATOR'S HOUSE
DRAWING 12

DESCRIPTION OF ELEMENT:

Opposite the refuge bays on the main piers are the operator's houses. Octagonal in shape, the south operator's house is constructed of reinforced concrete and faced in carved limestone. Windows fall between cylindrical columns, above which is a carved stone cornice. Finally, a cylindrical tower surmounts the house.

Facing the roadway is the entrance to the operator's house, which is reached via stairs flanking the doorway. Hanging above the stairs is a bronze lantern.

CONDITION:

Overall, the condition of the south operator's house is poor. This element of the bridge is covered with a variety of colors of graffiti, and has been altered. Protective fencing has been bolted to the bronze window frames, destroying the integrity of the original design.

Masonry on the operator's house is also in poor condition. Cementicious mortar has been used for repointing, causing stress fractures in the limestone; The stairs have shifted and exhibit signs of erosion. On the upper part of the tower, pointing is non-existent in some joints, and biological growth is evident on the roof.

Like the other bronze on the bridge, the south operator's house lantern and plaque are in poor condition. Graffiti covers the plaque, and the lantern is missing its glass. The bronze railing is in better condition and is painted.

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UNIVERSITY AVENUE BRIDGE: Condition Survey

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<tr>
<td>12</td>
<td>SOUTH OPERATOR'S HOUSE PLAZA</td>
<td>15</td>
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</table>

DESCRIPTION OF ELEMENT:

The south refuge bay (plaza) is characterized by the low parapet wall, lantern shafts and bronze lanterns. Each of the two refuge bays now holds a transformer and is protected by fencing.

CONDITION:

The integrity of the refuge bay is diminished by the addition of the transformer and fencing. In addition to altering the original appearance of the bay, the fencing contributes to the deterioration of the masonry which is stained by the fencing.

Graffiti covers much of the lantern shafts, which are also stained green. Each lantern is uniformly weathered green, and neither of the lanterns has any glass in the panes.

The foreground illustrates the protective barrier on the side of the roadway.

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<tr>
<td>13</td>
<td>SOUTH MAIN PIER (WEST)</td>
<td>16</td>
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</table>

DESCRIPTION OF ELEMENT:

The west end of the south main pier is comprised of the refuge bay towers, the balustrade, and the bull's eye windows on the south elevation. At the fender level is a bronze door.

CONDITION:

Green staining on the lantern shafts is the main condition of these elevations. In some places the staining covers the entire lantern shaft. Near the steel spans on the south elevation, efflorescence is evident.

Biological growth covers much of the fender area at the base of the pier.

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<tr>
<td>14</td>
<td>SOUTH MAIN PIER (WEST)</td>
<td>19</td>
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**DESCRIPTION OF ELEMENT:**

Each of the main piers features a carved limestone panel under the balustrade of the refuge bay tower (the west elevation). Under the cornice of this element are carved limestone swags and a carved panel with a ship.

**CONDITION:**

Where natural water washing is minimal, the limestone is covered with black encrustations, shown in this photo under the limestone swags. Otherwise, the condition of the carved stone is very good. This photograph also illustrates the need for pointing in the masonry of the cornice.

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<tr>
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<td>SOUTH OPERATOR'S HOUSE PLAZA</td>
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</table>

#### DESCRIPTION OF ELEMENT:

Each of the two main piers has a refuge bay with two lanterns, one of which is shown in photo 15. Each bronze lantern is hexagonal in shape and rests on a masonry shaft with recessed decoration.

#### CONDITION:

The south operator's refuge lantern (north) exhibits an even patina of light green color. None of these lanterns on either pier retain their glass, causing water penetration. The lantern shaft is covered by heavy green staining, and black graffiti. Pointing is in good condition.

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<tr>
<td>16</td>
<td>BRONZE DOOR S. MAIN PIER (WEST)</td>
<td>19</td>
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</tbody>
</table>

**DESCRIPTION OF ELEMENT:**

Each of the main piers has an upstream and downstream elevation with bronze doors at the fender level. Like the other doors, the south main pier’s east door has a central, geometrical pattern over heavy glass and is embraced by circular medallions.

**CONDITION:**

Like the east elevation door on this pier, the west bronze door is missing the circular medallions and the original hardware. The patina on this door is more even. Some pitting is evident.

**DATE OF SURVEY:** 11/15/1990  
**NAME OF SURVEYOR:** JESTER
UNIVERSITY AVENUE BRIDGE: Condition Survey

PHOTO
17

NAME OF ELEMENT
BRONZE DOOR S. MAIN PIER (EAST)

DRAWING
18

DESCRIPTION OF ELEMENT:

Each of the main piers has an upstream and downstream elevation with bronze doors at the fender level. Like the other doors, the south main pier's east door has a central, geometrical pattern over heavy glass and is embraced by circular medallions.

CONDITION:

The south main pier's east bronze door is in poor condition. All of the bronze medallions have been removed. The original hardware has also been removed, and the bolt holding the door closed has rusted the metal frame. No even patina exists on this door. Patches of green layers are evident in addition to protected areas. Black encrustations also cover much of the bronze door's central panel.

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NAME OF SURVEYOR: JESTER
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PHOTO 18
NAME OF ELEMENT SOUTH MAIN PIER (SOUTH) DRAWING 16

DESCRIPTION OF ELEMENT:

The south main pier's south elevation supports the span between this pier and the south intermediate pier. It is constructed of reinforced concrete and faced with limestone. Two arches flank the central pier which supports the stringers. Below the arches is the stone beltcourse.

CONDITION:

Black staining covers much of this elevation. This elevation also exhibits a large percentage of efflorescence on the outside ends of the elevation. The dressed stone is in good condition, as is the pointing on most of the elevation.

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NAME OF SURVEYOR: JESTER
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<tr>
<td>19</td>
<td>SOUTH MAIN PIER (NORTH)</td>
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</table>

**DESCRIPTION OF ELEMENT:**

The north elevation of the south main pier is faced in limestone and features a narrow beltcourse above the fender level.

**CONDITION:**

This elevation's beltcourse is damaged, presumably by ships passing between the piers. Shown in this photo is the east end of the stone beltcourse, where the cracking is most severe. Also evident is rust staining, efflorescence and dirt deposits.

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<tr>
<td>20</td>
<td>S.E. CORNER OF SOUTH MAIN PIER</td>
<td>18</td>
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</table>

**DESCRIPTION OF ELEMENT:**

The southeast corner of the south main pier is faced with limestone and rests on a concrete foundation. This corner is near the fender level.

**CONDITION:**

Masonry on this corner exhibits cracking, erosion and biological growth. Pointing in this location is also in poor condition, or missing.

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<tr>
<td>21</td>
<td>SOUTH APPROACH LANTERNS (EAST)</td>
<td>21</td>
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</table>

DESCRIPTION OF ELEMENT:

The southeast approach lantern is comprised of the railing wall, which has a recessed panel at the end, the lantern base, and the bronze lantern.

CONDITION:

Green staining, graffiti, and missing pointing are the primary conditions on the southeast approach lantern. Minor erosion of the limestone is evident along the base of the railing wall. Finally, the lantern base's masonry is cracked at the corner near the sidewalk.

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<tr>
<td>22</td>
<td>SOUTH APPROACH LANTERN (EAST)</td>
<td>21</td>
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</table>

**DESCRIPTION OF ELEMENT:**

Each of the approaches has two bronze lanterns, which rests on a limestone base. The lanterns are octagonal and cylindrical in shape, with peeling leaves and decoration in the lights. Originally, one of the lights opened on a hinge.

**CONDITION:**

Like the other lanterns, the southeast approach lantern is covered by a relatively even green oxide layer. This corrosion layer contributes to the decay of all of the bronze lanterns. Black staining covers part of this lantern, which may be prone to pitting. Runoff from all of the bronze lanterns stains the masonry bases.

None of the lanterns retains any glass, original or replacement in the lights. This condition results in unnecessary water infiltration, deteriorating the railing wall.

**DATE OF SURVEY:** 11/20/1990

**NAME OF SURVEYOR:** JESTER
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<tr>
<td>23</td>
<td>SOUTH APPROACH RAILING WALL (WEST)</td>
<td>22</td>
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</table>

**DESCRIPTION OF ELEMENT:**

Constructed on reinforced concrete, concrete parging and limestone facing, the southwest railing wall is the formal entrance to the bridge. Each railing wall leads to the approach lanterns.

**CONDITION:**

The southwest railing wall is one of the places on the bridge where attention is needed immediately. Cracked and missing stone, coupled with shifting facing, opened a void, into which water and debris are collecting. The interior of the railing wall is exposed, revealing the parging. Pointing in this location is also in poor condition.

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**NAME OF SURVEYOR:** JESTER
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<tr>
<td>24</td>
<td>SOUTH ABUTMENT</td>
<td>20</td>
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</table>

**DESCRIPTION OF ELEMENT:**

The south abutment supports the steel span between the approach and the first intermediate pier. This large wall is faced in limestone below the stringer-line. Outside ends of this abutment form the shafts of the approach lanterns.

**CONDITION:**

Black staining covers a large percentage of the south abutment. Below many of the steel stringers, rust staining covers the masonry. On the outside ends of the abutment, green staining covers the masonry, especially on the east end of the elevation.

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<tr>
<td>25</td>
<td>EAST END OF SOUTH ABUTMENT</td>
<td>20</td>
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</table>

DESCRIPTION OF ELEMENT:

The east end of the south abutment forms the approach lantern shaft above the steel span which the abutment supports. The foundation is constructed of rough concrete below the stone-faced concrete.

CONDITION:

In addition to extensive green staining from the approach lantern, which covers the entire height of the abutment wall, efflorescence is also present. At the right side of the photograph is one of the abandoned downspouts on this elevation.

DATE OF SURVEY: 11/20/1990
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PHOTO 26  NAME OF ELEMENT SOUTH ABUTMENT  DRAWING 20

DESCRIPTION OF ELEMENT:

The main wall of the south abutment is constructed of reinforced concrete and faced with large masonry units. Above the narrow cornice there is no stone facing on the concrete.

CONDITION:

Efflorescence covers much of the south abutment. Other conditions found on this elevation are biological growth and rust staining. Patches of spalled concrete are also present on the concrete above the stringer-line cornice.

Finally, abandoned down-spouts remain attached to the abutment wall in several locations.

DATE OF SURVEY: 11/20/1990
NAME OF SURVEYOR: JESTER
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PHOTO  
27  

NAME OF ELEMENT  
WEST END OF SOUTH ABUTMENT  

DRAWING  
20  

DESCRIPTION OF ELEMENT:

The upper west end of the south abutment is constructed of a combination of concrete and stone faced concrete. Lantern shafts form the outside ends of this abutment. Stringer beams meet the abutment above the stringer-line cornice.

CONDITION:

Above the stringer-line, extensive spalling is present on both sides of the stringer beams. Pointing in this location is poor, and masonry units below the stringer-line are cracked.

Residual green staining and black graffiti can also be seen on this side of the south abutment.

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NAME OF SURVEYOR:  JESTER
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#### PHOTO

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<tr>
<td>28</td>
<td>SOUTH INTERMEDIATE PIER (NORTH)</td>
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#### DESCRIPTION OF ELEMENT:

The north elevation of the south intermediate is identical to that of the south elevation.

#### CONDITION:

This elevation of the south intermediate pier exhibits less rust staining, efflorescence and dirt staining. A small piece of the fender level beltcourse is missing on the east end of this elevation, but otherwise the condition of this elevation is good.

### Date of Survey:

11/20/1990

### Name of Surveyor:

JESTER
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<tr>
<td>29</td>
<td>SOUTH INTERMEDIATE PIER (SOUTH)</td>
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**DESCRIPTION OF ELEMENT:**

The intermediate south intermediate pier supports the spans between the south abutment and the south main pier. Steel rests on top of the pier on four points. It is built of reinforced concrete and faced with limestone. Simple battered walls are decorated only by a dressed stone course at the fender level.

**CONDITION:**

Overall the condition of the south intermediate pier is satisfactory. The most prevalent conditions are rust staining and efflorescence. At the west end of this pier, biological growth is stressing the stone on the rounded end. A large percentage of this elevation is also covered with heavy pollution and dirt.

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**NAME OF SURVEYOR:** JESTER
UNIVERSITY AVENUE BRIDGE: Condition Survey

NAME OF ELEMENT: NORTH OPERATOR'S HOUSE

DATE OF SURVEY: 11/27/1950

NAME OF SURVEYOR: JESTER
UNIVERSITY AVENUE BRIDGE: Condition Survey

PHOTO 2

NAME OF ELEMENT:
NORTH APPROACH LANTERNS (EAST)

DRAWING 2

DATE OF SURVEY: 11/20/1990
NAME OF SURVEYOR: JESTER
UNIVERSITY AVENUE BRIDGE: Condition Survey

NAME OF ELEMENT: NORTH APPROACH LANTERNS (WEST)

DATE OF SURVEY: 11/20/1990
NAME OF SURVEYOR: JESTER
UNIVERSITY AVENUE BRIDGE: Condition Survey

NAME OF ELEMENT:
WEST END OF NORTH MAIN PIER

DATE OF SURVEY: 11/20/1990
NAME OF SURVEYOR: JESTER
UNIVERSITY AVENUE BRIDGE: Condition Survey

PHOTO
5

NAME OF ELEMENT:
EAST END OF NORTH ABUTMENT

DRAWING
1

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NAME OF SURVEYOR: JESTER
# UNIVERSITY AVENUE BRIDGE: Condition Survey

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<td>6</td>
<td>WEST ELEVATION OF N.W LANTERN WALL</td>
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**NAME OF SURVEYOR:** JESTER
UNIVERSITY AVENUE BRIDGE: Condition Survey

PHOTO
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NAME OF ELEMENT:
WEST ELEVATION OF NORTH ABUTMENT

DRAWING
-

DATE OF SURVEY:  11/27/1990
NAME OF SURVEYOR:  JESTER
UNIVERSITY AVENUE BRIDGE: Condition Survey

NAME OF ELEMENT: EAST END OF NORTH MAIN PIER (SOUTH)

DATE OF SURVEY: 11/20/1990
NAME OF SURVEYOR: JESTER
UNIVERSITY AVENUE BRIDGE: Condition Survey

NAME OF ELEMENT:
NORTH INTERMEDIATE PIER (NORTH)

DATE OF SURVEY: 11/20/1990
NAME OF SURVEYOR: JESTER
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PHOTO 10

NAME OF ELEMENT: EAST END OF NORTH ABUTMENT

DRAWING 1

DATE OF SURVEY: 11/20/1990
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<th>NAME OF SURVEYOR: JESTER</th>
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<td>SOUTH OPERATOR'S HOUSE</td>
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PHOTO 12

NAME OF ELEMENT: SOUTH OPERATOR'S HOUSE PLAZA

DRAWING 15

DATE OF SURVEY: 11/26/1990

NAME OF SURVEYOR: JESTER
UNIVERSITY AVENUE BRIDGE: Condition Survey

PHOTO 13

NAME OF ELEMENT: SOUTH MAIN PIER (WEST)

DRAWING 16

DATE OF SURVEY: 11/15/1990

NAME OF SURVEYOR: JESTER
UNIVERSITY AVENUE BRIDGE: Condition Survey

NAME OF ELEMENT: SOUTH MAIN PIER (WEST)

DATE OF SURVEY: 11/15/1990
NAME OF SURVEYOR: JESTER
UNIVERSITY AVENUE BRIDGE: Condition Survey

PHOTO 15

NAME OF ELEMENT:
SOUTH OPERATOR'S HOUSE PLAZA

DRAWING -

DATE OF SURVEY: 11/15/1990
NAME OF SURVEYOR: JESTER
UNIVERSITY AVENUE BRIDGE: Condition Survey

PHOTO
16

NAME OF ELEMENT:
BRONZE DOOR S. MAIN PIER (WEST)

DRAWING
19

DATE OF SURVEY: 11/15/1990

NAME OF SURVEYOR: JESTER
**UNIVERSITY AVENUE BRIDGE: Condition Survey**

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<tr>
<td>17</td>
<td>BRONZE DOOR S. MAIN PIER (EAST)</td>
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**NAME OF SURVEYOR:** JESTER
UNIVERSITY AVENUE BRIDGE: Condition Survey

PHOTO
18

NAME OF ELEMENT:
SOUTH MAIN PIER (SOUTH)

DRAWING
16

DATE OF SURVEY: 11/15/1990

NAME OF SURVEYOR: JESTER
UNIVERSITY AVENUE BRIDGE: Condition Survey

<table>
<thead>
<tr>
<th>PHOTO</th>
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<td>SOUTH MAIN PIER (NORTH)</td>
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DATE OF SURVEY: 11/15/1990
NAME OF SURVEYOR: JESTER
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DATE OF SURVEY: 11/15/1990
NAME OF SURVEYOR: JESTER
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<td>SOUTH APPROACH LANTERNS (EAST)</td>
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DATE OF SURVEY: 11/20/1990
NAME OF SURVEYOR: JESTER
UNIVERSITY AVENUE BRIDGE: Condition Survey

NAME OF ELEMENT: SOUTH APPROACH LANTERN (EAST)

DATE OF SURVEY: 11/20/1990
NAME OF SURVEYOR: JESTER
UNIVERSITY AVENUE BRIDGE: Condition Survey

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DATE OF SURVEY: 11/20/1990

NAME OF SURVEYOR: JESTER
UNIVERSITY AVENUE BRIDGE: Condition Survey

NAME OF ELEMENT: SOUTH ABUTMENT

DATE OF SURVEY: 11/20/1990
NAME OF SURVEYOR: JESTER
UNIVERSITY AVENUE BRIDGE: Condition Survey

PHOTO
26

NAME OF ELEMENT:
SOUTH ABUTMENT

DRAWING
20

DATE OF SURVEY: 11/20/1990

NAME OF SURVEYOR: JESTER
UNIVERSITY AVENUE BRIDGE: Condition Survey

NAME OF ELEMENT:
WEST END OF SOUTH ABUTMENT

DATE OF SURVEY: 11/20/1990
NAME OF SURVEYOR: JESTER
**UNIVERSITY AVENUE BRIDGE: Condition Survey**

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<td>28</td>
<td>SOUTH INTERMEDIATE PIER (NORTH)</td>
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**DATE OF SURVEY:** 11/20/1990

**NAME OF SURVEYOR:** JESTER
UNIVERSITY AVENUE BRIDGE: Condition Survey

PHOTO  
29

NAME OF ELEMENT:  
SOUTH INTERMEDIATE PIER (SOUTH)

DRAWING  
-

DATE OF SURVEY: 11/20/1990
NAME OF SURVEYOR: JESTER
Mortar Analysis Data
Worser Wynfrey Data
Mortar Analysis

Identification
Project/Site: University Avenue Bridge Date Sampled: 11/20/90
Location: Philadelphia Date Analyzed: 1/29/91
Analysis performed by: Jester Sample Number: M1

Description of Sample
Type/Location of Sample: North Main Pier-South Elevation (east end)
Surface Appearance: Dirt layer, fine surface with some aggregate protruding
Cross Section Appearance: Sand colors--yellow, red, white/grey binder
Color: Munsell 9/5Y/1 Texture: Tighly packed
Micro Structure:
Hardness: hard Gross Weight: 13.69g

Separation of Components
Acid Soluble Fraction -- Weight: 7.35g Weight %: 54%
  Description of reaction: Mild/strong yellow/green color
Fines -- Color: Grey Weight: 2.26g Weight %: 17%
  Analysis: Portland Cement
Aggregate -- Density: Weight: 4.08g Weight %: 29%
  Color(s): Red, yellow Quartz

Grain Shape(s): round
Sieve Analysis:

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<tr>
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Mineralogical Analysis:

Assessment:
Mortar Type: Hydrated Lime/Portland Cement
Binder to aggregate ratio (parts by volume): not calculated
Aggregate Match: Champion Sand Company, New York
Recommended Formulation Type: High Lime Content/Fine Sand
Mortar Analysis

Identification
Project/Site: University Avenue Bridge Date Sampled: 11/26/90
Location: Philadelphia Date Analyzed: 1/29/91
Analysis performed by: Jester Sample Number: M2

Description of Sample
Type/Location of Sample: North Main Pier-South Elevation (under Bull's eye)
Surface Appearance: Dirt layer, fine surface
Cross Section Appearance: Sand colors--yellow, red white/grey binder
Color: Munsell 9/5Y/1 Texture: Tightly packed
Micro Structure:
Hardness: hard Gross Weight: 8.54g

Separation of Components
Acid Soluble Fraction -- Weight: 4.38g Weight %: 51%
Description of reaction: Mild light olive green
Fines -- Color: grey Weight: 2.34g Weight %: 27%
Analysis: Portland Cement
Aggregate -- Density: Weight: 1.82g Weight %: 21%
Color (s): Red, Yellow Quartz

Grain Shape (s): round
Sieve Analysis:

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Mineralogical Analysis:

Assessment:
Mortar Type: Hydrated Lime/Portland Cement
Binder to aggregate ratio (parts by volume): not calculated
Aggregate Match: Champion Sand Company, New York
Recommended Formulation Type: High Lime Content/Fine Sand
Mortar Analysis

Identification
Project/Site: University Avenue Bridge  Date Sampled: 11/15/90
Location: Philadelphia  Date Analyzed: 1/29/91
Analysis performed by: Jester  Sample Number: M3

Description of Sample
Type/Location of Sample: South Main Pier-East Elevation (south end)
Surface Appearance: Dirt Layer, fine surface
Cross Section Appearance: Sand colors--yellow, red white/grey binder
Color: Munsell 9/5Y/1  Texture: Tightly packed
Micro Structure: _____________________________
Hardness: hard  Gross Weight: 10.56g

Separation of Components
Acid Soluble Fraction -- Weight: 5.78g  Weight %: 54.7%
   Description of reaction: Mild light green
Fines -- Color: grey  Weight: 1.93g  Weight %: 18.3%
   Analysis: Portland Cement
Aggregate -- Density:  -  Weight: 2.85g  Weight %: 27%
   Color (s): Yellow Quartz
   Grain Shape (s): round

Sieve Analysis:

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Mineralogical Analysis: __________________________

Assessment:
Mortar Type: Hydrated Lime/Portland Cement
Binder to aggregate ratio (parts by volume): not calculated
Aggregate Match: Champion Sand Company, New York
Recommended Formulation Type: High Lime Content/Fine Sand
Mortar Analysis

Identification
Project/Site: University Avenue Bridge  Date Sampled: 11/15/90
Location: Philadelphia  Date Analyzed: 1/29/91
Analysis performed by: Jester  Sample Number: M4

Description of Sample
Type/Location of Sample: South Main Pier-West Elevation (above doorway)
Surface Appearance: Dirt Layer, some protruding aggregate
Cross Section Appearance: Sand colors--yellow, red white/grey binder
Color: Munsell 9/5Y/1  Texture: Tightly packed
Micro Structure: 
Hardness: hard  Gross Weight: 10.72g

Separation of Components
Acid Soluble Fraction -- Weight: 6.2g  Weight %: 58%
Description of reaction: Mild/Strong
Fines -- Color: grey  Weight: 2.37g  Weight %: 22%
Analysis: Portland Cement
Aggregate -- Density:  Weight: 2.15g  Weight %: 20%
Color(s): Yellow, Red Quartz

Grain Shape(s): round, some jagged
Sieve Analysis:

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Mineralogical Analysis:

Assessment:
Mortar Type: Hydrated Lime/Portland Cement
Binder to aggregate ratio (parts by volume): not calculated
Aggregate Match: Champion Sand Company
Recommended Formulation Type: High Lime Content/Fine Sand
Mortar Analysis

Identification

Project/Site: University Avenue Bridge  Date Sampled: 11/15/90
Location: Philadelphia  Date Analyzed: 1/29/91
Analysis performed by: Jester  Sample Number: M5

Description of Sample

Type/Location of Sample: South Main Pier-North Elevation (west end)
Surface Appearance: Dirt Layer
Cross Section Appearance: Sand Colors--yellow, red white/grey binder
Color: Munsell 9/5Y/1  Texture: Tightly Packed
Micro Structure:
Hardness: hard  Gross Weight: 5.84g

Separation of Components

Acid Soluble Fraction -- Weight: 3.91g  Weight %: 66%
Description of reaction: small light green
Fines -- Color: grey  Weight: .98g  Weight %: 17%
Analysis: Portland Cement
Aggregate -- Density: .95g  Weight %: 16%
Color (s): Yellow Quartz
Grain Shape (s): round
Sieve Analysis:

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Mineralogical Analysis:

Assessment:

Mortar Type: Hydrated Lime/Portland Cement
Binder to aggregate ratio (parts by volume): not calculated
Aggregate Match: Champion Sand Company, New York
Recommended Formulation Type: High Lime Content/ Fine Sand
## Mortar Analysis

### Identification

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<thead>
<tr>
<th>Project/Site:</th>
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### Description of Sample

<table>
<thead>
<tr>
<th>Type/Location of Sample</th>
<th>South Main Pier-South Elevation (west end)</th>
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<tbody>
<tr>
<td>Surface Appearance</td>
<td>Dirt Layer, some protruding aggregate</td>
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<tr>
<td>Cross Section Appearance</td>
<td>Sand colors--yellow white/grey binder</td>
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<tr>
<td>Color</td>
<td>Munsell 9/5Y/1</td>
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<tr>
<td>Texture</td>
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<td>Micro Structure</td>
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<td>Hardness</td>
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<td>Gross Weight</td>
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### Separation of Components

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<th>Acid Soluble Fraction</th>
<th>Weight: 2.84g</th>
<th>Weight %: 65%</th>
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<tr>
<td>Description of reaction</td>
<td>Mild olive green</td>
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<tr>
<td>Fines Color: grey</td>
<td>Weight: .66g</td>
<td>Weight %: 15%</td>
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<td>Analysis: Portland Cement</td>
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<tr>
<td>Aggregate Density:</td>
<td>Weight: .90g</td>
<td>Weight %: 20%</td>
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<td>Color(s): Yellow, red Quartz</td>
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<p>| Grain Shape(s): | round |</p>
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### Assessment

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<td>Binder to aggregate ratio (parts by volume):</td>
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<tr>
<td>Aggregate Match:</td>
<td>Champion Sand Company, New York</td>
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<td>Recommended Formulation Type:</td>
<td>High Lime Content/ Fine Sand</td>
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Mortar Analysis

Identification
Project/Site: University Avenue Bridge
Location: Philadelphia
Analysis performed by: Jester
Sample Number: M7

Date Sampled: 11/26/90
Date Analyzed: 1/29/91

Description of Sample
Type/Location of Sample: North end of South Operator's House
Surface Appearance: white under dirt layer, spotty aggregate
Cross Section Appearance: Sand colors--yellow, red
Color: Munsell 9/5Y/1
Texture: tightly packed
Micro Structure: 
Hardness: hard
Gross Weight: 13.69g

Separation of Components
Acid Soluble Fraction --
Weight: 7.35g
Weight %: 54%
Description of reaction: Mild/Strong yellow/green color

Fines -- Color: grey
Weight: 2.26g
Weight %: 17%
Analysis: Portland Cement

Aggregate -- Density: 4.08g
Weight %: 29%
Color (s): reds, yellows (quartz)

Grain Shape (s): round
Sieve Analysis:

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Mineralogical Analysis:

Assessment:
Mortar Type: Hydrated Lime/Portland Cement
Binder to aggregate ratio (parts by volume): not calculated
Aggregate Match: Champion Sand Company, New York
Recommended Formulation Type: High Lime Content/Fine Sand