THE MODERN ARCH:
AN ANALYSIS OF THE PRESERVATION OF
EARLY REINFORCED CONCRETE ARCH BRIDGES IN THE U.S.

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ABSTRACT

Reinforced concrete arch bridges came into use in the United States at the end of the 19th century, quickly developed in scale and complexity, and became a standard bridge type found across the country. The earliest examples of these bridges are significant because they illustrate the development of reinforced concrete technology and contemporary design trends. However, these structures are underrecognized for their significance and many have been demolished. This thesis aims to illustrate the significance of these bridges and to highlight the preservation challenges they face.

The thesis details the development of early concrete arch bridges, discusses the existing policies governing their preservation, and analyzes the effectiveness of these policies through case studies in Connecticut, New York, and New Jersey. These case study bridges vary in design, condition of preservation, ownership, and significance, yet each bridge provides insights regarding the process of preservation and its challenges. In the analysis of these case studies, it is found that the significance of many early reinforced concrete arch bridges is not properly acknowledged, and they may be destroyed or suffer a loss of integrity as a result.

These earliest reinforced concrete arch bridges are now about 120 years old and worthy of respectful attention. The insights and recommendations developed through the cases studied in this thesis are intended to help both preservation professionals and the general public evaluate other examples of this bridge type.

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ACKNOWLEDGEMENTS

I have learned a lot through this research, and I am very grateful for the support I have received. My initiation to this topic began with a suggestion from my advisor, Tim Michiels, that I consider looking into a Ransome bridge in Shelter Island, N.Y. Norman Weiss quickly advocated for the need for more research in this area. From the beginning, my mentor through the Columbia Preservation Alumni organization, Zach Rice, provided me with steadfast support, grounded in the Socratic Method, as I learned about this topic. Zach's wisdom on the topic was indispensable in organizing the thesis. Tim, Norman, Zach, and Theo Prudon all saw this work grow from a search for information on reinforced concrete and bridges to what it is today, and I am grateful for their patience. Nancy Mandel gave me very thorough feedback that helped me improve my writing. I am also grateful to the many professionals working with historic bridges, archivists, and historians who helped me find information. Finally, thank you to my mom, Rebecca Spencer, for encouraging and supporting me in my studies.

All images are the author's unless otherwise noted.

Introduction: The Smith-Ransome Japanese Bridge (1909-1911)

Within bucolic Shelter Island, N.Y., there is a very unusual bridge that I became acquainted with in the fall of 2020. It is an early 20th century reinforced concrete footbridge, known as the Smith-Ransome Japanese Bridge. Researching the history of this bridge excited and inspired me. It helped me to understand the design and structural possibilities of reinforced concrete, and it was the inspiration for my study. I hope an introduction to this bridge can serve to inspire others.

Figure 1: The Smith-Ransome Japanese Bridge, November, 2020.

The Smith-Ransome Japanese Bridge (Figure 1) was commissioned by Francis Marion Smith and built by Ernest Leslie Ransome between 1909 and 1911. The bridge was part of a large landscaping project at Smith's "Presdeleau" estate, which he assembled beginning in 1892.[1] The project involved the construction of an artificial lagoon with concrete retaining walls and the Japanese garden-style bridge spanning an opening from the lagoon to the Peconic River (Figure 2). The bridge may have been inspired by similar bridges at expositions and the

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[1] George Herbert Hildebrand, *Borax Pioneer: Francis Marion Smith* (San Diego: Howell-North Books, 1982), 119.

Japonisme (or Japan craze) of the time.[2] At the time of the project, Ransome operated a concrete machinery business, which may have been involved with construction of the bridge and sea walls.[3] The bridge and lagoon are the only surviving structures from the Presdeleau estate.[4]

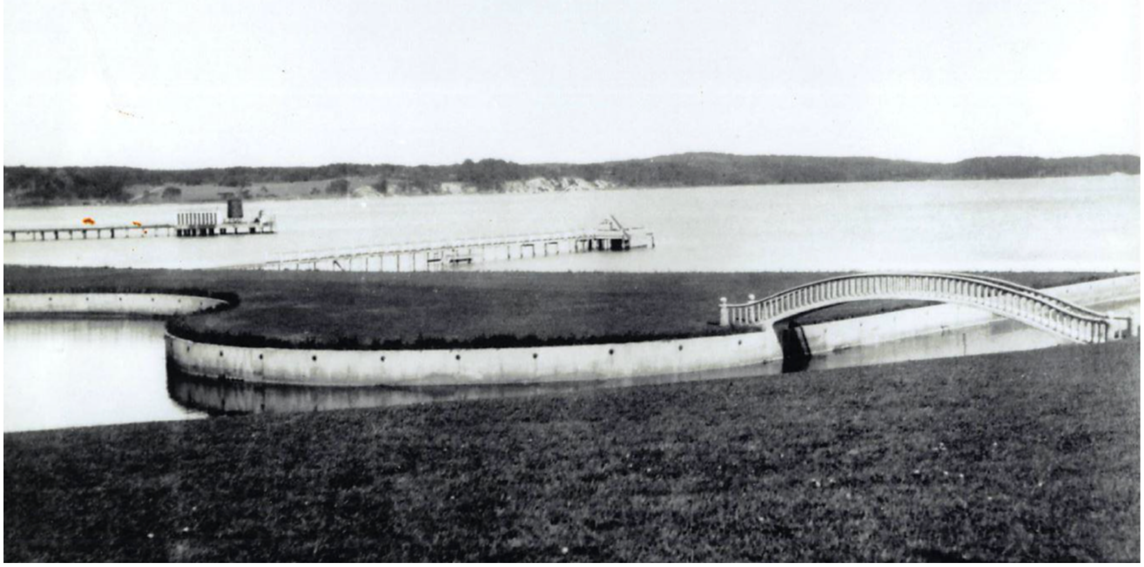

Figure 2: The Smith-Ransome Japanese Bridge and surroundings, undated. Source: South Ferry Hills Association records.

The bridge has distinct technical and aesthetic features that are made possible by its use of reinforced concrete construction. These spans can be thinner and can have a lower slope than spans made with the preceding technology. This bridge has a span of 44 feet and rises six feet and two inches, with a deck that is as thin as eight inches.[5] These slim and graceful proportions are visible in Figure 3. The bridge uses a special type of rebar, known as Ransome Bar, embedded within the concrete deck and railings as its reinforcement. This bridge succinctly

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[2] Zachary N. Studenroth and Jennifer Betsworth, NY SHPO, “National Register of Historic Places Nomination for the Smith-Ransome Japanese Bridge” (November 2017), 9.

[3] Ransome Concrete Machinery Company, *Ransome Concrete Machinery Handbook* (Dunellen, N.J.: Ransome Concrete Machinery Co., 1908) https://archive.org/details/ransomeconcretem00rans/page/n1/mode/2up

[4] Zachary N. Studenroth and Jennifer Betsworth, NY SHPO, “National Register of Historic Places Nomination for the Smith-Ransome Japanese Bridge” (November 2017), 9.

[5] Ron J. Hopper, “South Ferry Hills Association, West Beach-Access Bridge Restoration,” Work Proposal January 5, 1993.

illustrates the structural principles of a reinforced concrete arch, as well as the work of Ernest Ransome, who was a pioneer in reinforced concrete technology.

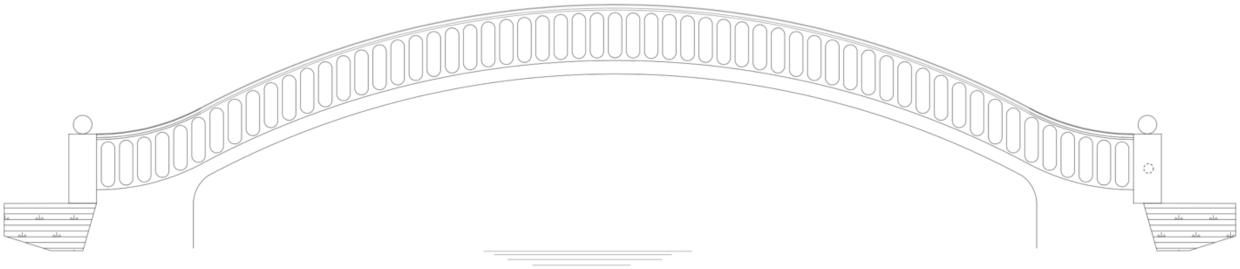

Figure 3: Smith-Ransome Japanese Bridge Elevation. Source: Tim Michiels, Old Structures Engineering, March 24, 2021.

The commissioner of the bridge, Francis Marion Smith, was an entrepreneur who made his fortune through borax mines in the Mojave Desert. He was extraordinarily successful in his field and was known as the "Borax King." Smith's Pacific Coast Borax Company hired Ernest Ransome to construct reinforced concrete borax refineries in Alameda, Calif., and Bayonne, N.J., in the 1890s.[6] Interestingly, Smith's primary residence, Arbor Villa (1895) in Oakland, Calif., also used reinforced concrete.[7] None of these buildings is extant, but they show Ransome and Smith's early use of reinforced concrete for buildings. In his book, *Reinforced Concrete Buildings* (1912), Ransome commends Smith for their working relationship, but does not describe any work on reinforced concrete bridges.[8]

The Smith-Ransome Japanese Bridge was listed on the National Register of Historic Places in 2018, but at that time there was no primary source documentation of Ransome's involvement, and the bridge was dated to circa 1905.[9] Although the bridge has long been

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[6] George Herbert Hildebrand, *Borax Pioneer: Francis Marion Smith*, (San Diego: Howell-North Books, 1982), 38.
[7] George Herbert Hildebrand, *Borax Pioneer: Francis Marion Smith*, (San Diego: Howell-North Books, 1982), 102.
[8] Ernest Ransome and Alexis Saurbrey. *Reinforced Concrete Buildings, A Treatise on the History, Patents, Design and Erection of the Principal Parts Entering into a Modern Reinforced Concrete Building* (New York: McGraw-Hill Book Company, 1912), 6-7.
[9] Zachary N. Studenroth and Jennifer Betsworth, NY SHPO, "National Register of Historic Places Nomination for the Smith-Ransome Japanese Bridge" (November 2017), 1.

attributed to Ernest Ransome, as no original plans have been found, there was no definitive evidence of his role. Recently, Shelter Island resident Ed Shillingburg located a photograph in an album in the Shelter Island Historical Society confirming the bridge's provenance. Within this album, Smith's second wife, Evelyn Ellis Smith, wrote, "Our new cement bridge – Presdeleau – built by Mr. Ransome 1911." The writing is shown in Figure 4, and has been authenticated by Evelyn Smith's grandson, Bob Bayley.[10] In the early history of reinforced concrete bridges, the difference between 1905 and 1909–11 is significant.

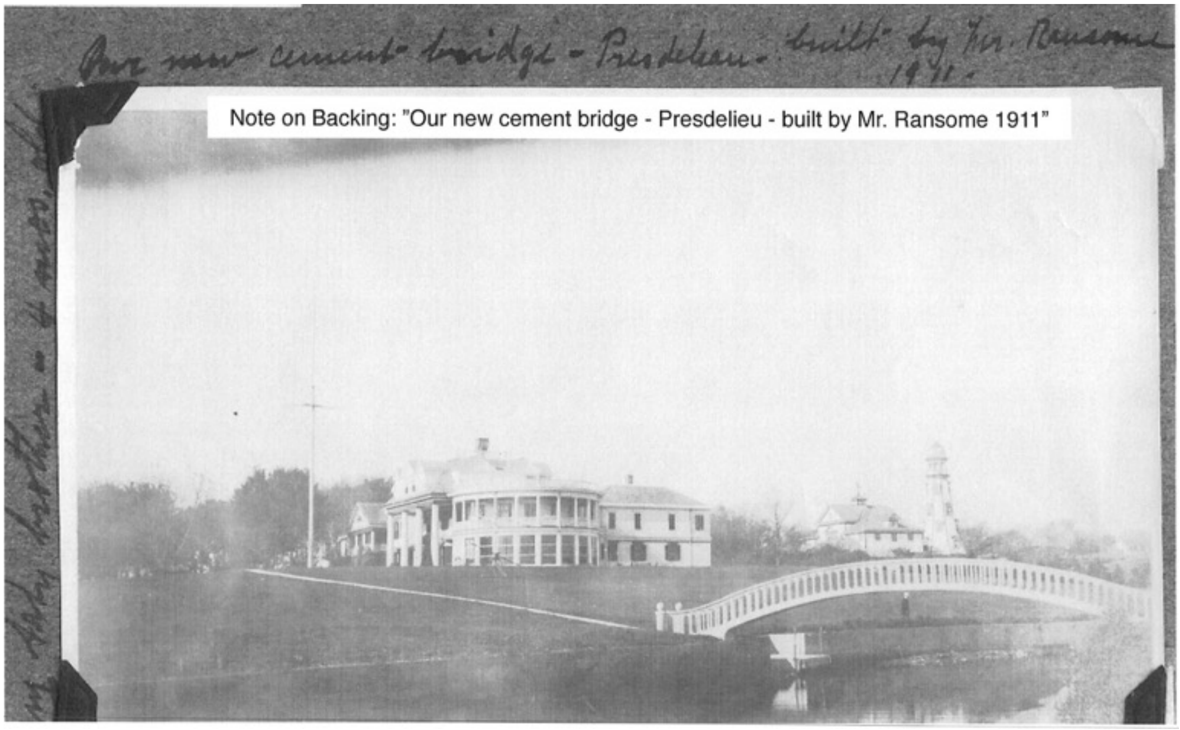

Figure 4: Evelyn Ellis Smith transcription, attributing the bridge to Ransome. Source: Shelter Island Historical Society, F. M. Smith Collection.

In the eleven decades since the bridge's construction, it has gone through a number of changes. The Smith estate was subdivided in 1958, and the bridge and lagoon became the property of South Ferry Hills Association, a group of local homeowners, in 1969.[11] A mid-20th

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[10] Ed Shillingburg, "Citation for the Ransome Photo," March 14, 2021.

[11] Zachary N. Studenroth and Jennifer Betsworth, NY SHPO, "National Register of Historic Places Nomination for the Smith-Ransome Japanese Bridge," (November 2017), 20.

century photograph shows multiple destroyed balusters on the 40-year-old structure (Figure 5). In 1993, a contractor surveyed the bridge and noted the extensive deterioration. There were no available records for the bridge prior to the subdivision of the Smith Estate.[12]

Figure 5: Barbara Bayley on the bridge, 1951. Source: Bob Bayley.

East Area General Contractors, Inc., completed a restoration of the bridge in 1997. The job involved patching of concrete and the use of zinc epoxy coating, and the total cost was quoted as $34,950.[13] The result of this restoration is visible in Figure 6. The bridge was not originally painted with these colors, and they arguably detract from its historic character. The repairs themselves were unrefined, and did not replicate original details such as the cove moldings in the balusters. Some of the repaired balusters are visible in Figure 7, and the rough workmanship can be compared with that of the (deteriorated) finer original detailing shown in Figure 8. It has now been almost 24 years since the repairs were completed, and as evidenced by the exposed Ransome Bar in Figure 8, more repairs are necessary.

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[12] Ron J. Hopper, "South Ferry Hills Association, West Beach-Access Bridge Restoration," January 5, 1993.
[13] Michael Broidy, "East Area General Contractors, Inc. Proposal," January 9, 1997.

Figure 6: The bridge circa 1997. Source: South Ferry Hills Association, Joel Snodgrass.

Figure 7: View of the bridge, November 2020.

Figure 8: Damaged balusters showing exposed twisted rebar, November 2020.

The South Ferry Hills Association has retained the services of Joel Snodgrass of Steward Preservation Services, LLC, to manage a restoration of the bridge. Despite the ongoing issues with the balustrade, the bridge deck is structurally sound.[14] A recent analysis using surface penetrating radar and a pachometer determined that the deck is reinforced with #4 twisted square Ransome Bars, which have a diameter of 0.5 inches. There are 14 longitudinal bars spaced four inches on center, with transverse bars every 16 inches on center.[15] There are two meshes of this design, approximately 1.5 to 2 inches below the surface of the intrados and extrados of the arch.[16] This construction is illustrated in Figure 9. There is far less concrete coverage on the balustrade, which is the reason for all the areas with deterioration and exposed rebar. Old Structures Engineering, a subcontractor for the restoration project, has developed a solution to fix severely damaged balusters using precast concrete with embedded stainless-steel rebar.[17]

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[14] Marie Ennis, "Japanese Bridge Shelter Island New York" (Structural Assessment Report, Shelter Island: Old Structures Engineering, PC, (2017), 3.

[15] Atkinson-Noland & Associates, "Shelter Island Japanese Bridge Investigation Report" (2020), 4.

[16] Atkinson-Noland & Associates, "Shelter Island Japanese Bridge Investigation Report" (2020), 4.

[17] Tim Michiels, "Japanese Bridge Shelter Island, Repair Prototype," Old Structures Engineering, PC, October 28, 2020.

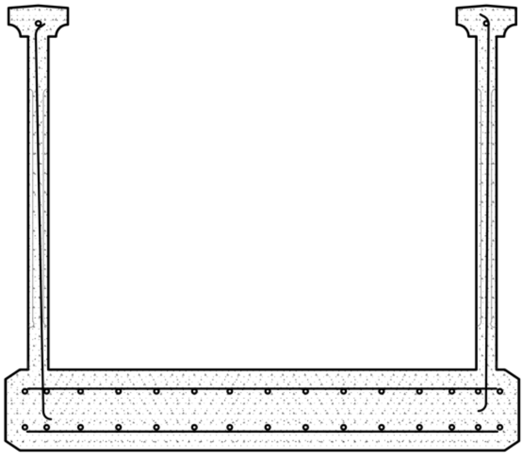

Figure 9: Cross section showing deck reinforcement layout. Source: Tim Michiels, Old Structures Engineering, March 24, 2021.

The story of the Smith-Ransome Japanese Bridge at Shelter Island is intriguing, and it indicates that there is a need for a full analysis of early reinforced concrete arch bridges. Some questions that arise include: How unique is this bridge? How were these bridges built? Who were the key pioneers, and was Ransome one of them? How do we preserve these bridges today?

The Smith-Ransome Japanese Bridge, as a footbridge, is an anomaly, because most early reinforced concrete arch bridges were designed to carry carriages, cars, or trains in addition to pedestrians. These bridges are a key part of the current national discussion on American infrastructure. According to the American Society of Civil Engineers' Infrastructure Report Card, American bridges receive an overall grade of C. 42% of those bridges are more than 50 years old.[18] The case studies featured in this thesis are part of that 42%, and are factored into that "C" grade. The primary function of these bridges is to get us to the other side of a stream or river, valley, or other obstruction. Although they are exciting to some, most people will just drive over these bridges, and never stop to admire them.

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[18] American Society of Civil Engineers, 2021 Report Card for America's Infrastructure, "Overview of Bridges." https://infrastructurereportcard.org/cat-item/bridges/

In answering the questions posed by the Smith-Ransome Japanese Bridge, this thesis makes three major contributions to existing scholarship on early reinforced concrete arch bridges in the U.S. First, it examines both historic and contemporary scholarship with a focus on the preservation of extant examples of these early reinforced concrete arch bridges. Second, this thesis identifies the strengths and weaknesses of the inventories and preservation plans in Connecticut, New York, and New Jersey. Third, through the analysis of five case studies in those three states, this thesis provides real examples of preservation successes and challenges. The thesis makes specific, measurable contributions in documenting the case study bridges, and lays the groundwork for further study. The analysis will be helpful for future practitioners working on the specific case study bridges, and on other similar bridges across the country.

This following three chapters provide background information which will inform the case study analysis. Chapter 1 discusses the history and development of reinforced concrete arch bridges. Chapter 2 discusses bridge inspections and historic bridge preservation in the United States. Chapter 3 outlines several federal reports on historic bridges, and the bridge inventories and preservation plans in the states of Connecticut, New York, and New Jersey.

Chapters 4 through 8 are case studies that analyze some of the earliest reinforced concrete bridges in Connecticut, New York, and New Jersey. The bridges selected as case studies have varied designs and histories, and they illustrate both successes and challenges in managing early reinforced concrete arch bridges. The case study bridges were completed within a seven-year time span, and are ordered chronologically as follows: the White Bridge (1897) and the Coach House Bridge (1897), in Hyde Park, N.Y.; the West Broadway Bridge (1898) in Paterson, N.J.; the North Main Street Bridge (1901) in West Hartford, Conn.; the Seeley Street Bridge (1903) in Brooklyn, N.Y.; and the Route 188 Hop Brook Bridge (1904/1944) in Middlebury, Conn. The case study chapters will detail the preservation status of each bridge, often determining whether prior work was appropriate, and what future preservation efforts should entail. Each case study represents a different situation, and each is informative in illustrating important concepts of early reinforced concrete arch bridge preservation.

In its Conclusion, the thesis makes four detailed recommendations as a result of the findings in the case studies:

1. Prioritize and expand the role of Historic Preservation Officers in state and city DOTs.
2. Improve communication between municipal, regional, state, and federal agencies.
3. Increase the application of the Secretary of the Interior's Standards for the Preservation of Historic Structures specifically for bridges.
4. Increase public awareness through appropriate preservation work, signage, and engagement.

Chapter 1: Historical Background

This chapter begins with a discussion of the literature on reinforced concrete arch bridges. It then briefly outlines the key components of concrete, reinforced concrete, and arches. With this background established, the chapter reviews the history of reinforced concrete arch bridges in the United States.

Literature

There is a substantial amount of literature on early reinforced concrete arch bridges. Much of the information is from the late 19th and early 20th centuries, when the technology was exciting and new. Then there is a gap of about five decades before scholars begin to look back on early concrete buildings from a historical perspective. One early source is *A Treatise on Concrete*, a volume first published by Frederick W. Taylor and Sanford E. Thompson in 1905. Taylor and Thompson were engineers concerned with scientific management and efficiency, and the *Treatise* is an effort to organize industry knowledge on concrete. With the increasing use of concrete in the United States, this volume was reprinted repeatedly and revised with second and third editions. Later editions published in 1909 and 1916 included a chapter on concrete arches by Frank P. McKibben, a professor of Civil Engineering at Massachusetts Institute of Technology, Lehigh University and Union College.[19] Ernest Ransome and Alexis Saurbrey's *Reinforced Concrete Buildings* from 1912 focuses on American patents, theory, and practical information. Carl W. Condit's *American Building Art: The Nineteenth Century* and *American Building Art: The Twentieth Century* were written in the early 1960s, and include discussions of early concrete use in the U.S. David Billington published "History and Esthetics in Concrete

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[19] Frederick W. Taylor and Sanford E. Thompson, *A Treatise on Concrete, Plain and Reinforced; Materials, Construction, and Design of Concrete and Reinforced Concrete* (New York: John Wiley & Sons, 1912), vii: "Prof McKibben Appointed To Lecture For Emergency Fleet Corporation" (*The Brown and White*, January 4, 1918), 1.

Arch Bridges" in 1977, and his 1983 book, *The Tower and the Bridge: The New Art of Structural Engineering,* also examines concrete arch bridges. More recent articles include Dario Gasparini's "Development of Reinforced Concrete Arch Bridges in the U.S.: 1894–1904" and Stephen Mikesell's "Ernest Leslie Ransome; A Vital California Engineer and Builder." The National Cooperative Highway Research Council's 2005 report, "A Context For Common Historic Bridge Types," provides a comprehensive summary of types of reinforced concrete bridges extant in the U.S. In recent years, many individual state departments of transportation have published histories of concrete arch bridges, some of which are cited in this thesis.

Concrete

Taylor and Thompson define concrete as an "artificial stone," made by mixing cement with water and aggregate material such as a sand and gravel mix.[20] Cement, a substance that hardens after being mixed with water, is just one component of concrete, and thus the two words cannot be used interchangeably. Concrete can vary tremendously based on the type of cement and the composition of the aggregate material. Historic concrete construction exemplifies this variation, as there are a number of different types of cements, and mixtures of cements and aggregates were not initially standardized.

The Romans were the first large-scale users of concrete; the technology was lost until the late Middle Ages and came back into widespread usage only during the 19th century.[21] In 1824, English bricklayer Joseph Aspdin invented Portland Cement, a development which ushered in the modern era of concrete.[22] Around the turn of the 20th century, Portland Cement production in

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[20] Frederick W. Taylor and Sanford E. Thompson, *A Treatise on Concrete, Plain and Reinforced; Materials, Construction, and Design of Concrete and Reinforced Concrete* (New York: John Wiley & Sons, 1907), 1.

[21] Carl W. Condit, *American Building Art: The Nineteenth Century* (New York: Oxford University Press, 1960), 223.

[22] Condit, *American Building Art*, 223.

the United States increased dramatically.[23] Throughout the 19th century, the uses for concrete grew tremendously as pioneers in the field continued to experiment with new ideas.

Reinforced Concrete History

One salient improvement in the use of concrete is the development of reinforced concrete. Taylor and Thompson also provide a clear description of reinforced concrete:

> Reinforced concrete is concrete in which steel or other reinforcing metal is imbedded to increase its strength. The reinforcement in general exercises an auxiliary function as it is not self-sustaining but requires the support of the concrete to develop its resistance. Thus, most often reinforcement consists of small bars of little stiffness in themselves but which, when imbedded in concrete to secure lateral support and bond, are capable of developing tensile or compressive resistance equal to that of self-sustaining structural steel.[24]

In other words, plain concrete works well in compression, but has little tensile strength. If steel is added, and well bonded to the concrete, the combination increases the tensile strength of concrete. The steel reinforcing bar or "rebar" must have sufficient surface area to create a strong bond with concrete, while the concrete surrounding the rebar must be sufficiently thick to protect the steel from deterioration.

The history of reinforced concrete also traces to the Romans' use of wood and metal rods within concrete roofs, and to several French pioneers in the mid- to late 19th century.[25] The first known modern use is Josef Lambot's concrete and iron rowboat, built in 1848 and shown at the Paris International Exhibition in 1855.[26] Also in 1855, François Coignet received a French patent for "a two-way grid of iron rods imbedded in concrete floor slabs."[27] Arguably the most

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[23] Edwin Thacher, "Concrete and Concrete-Steel in the United States" (*Transactions, American Society of Civil Engineers*, Vol. 54, Issue 7, Paper No. 70, 1905), 426.

[24] Frederick W. Taylor and Sanford E. Thompson, *A Treatise on Concrete, Plain and Reinforced; Materials, Construction, and Design of Concrete and Reinforced Concrete* (New York: John Wiley & Sons, 1916), 349.

[25] Carl W. Condit, *American Building Art: The Nineteenth Century*, 231.

[26] Taylor and Thompson, *A Treatise on Concrete* (1916), 570: Carl W. Condit, "The First Reinforced-Concrete Skyscraper: The Ingalls Building in Cincinnati and Its Place in Structural History" (*Technology and Culture* 9, no. 1, 1968), 1.

[27] Condit, "The First Reinforced-Concrete Skyscraper," 2.

influential pioneer was Parisian gardener Joseph Monier.[28] Monier initially applied concrete over a wire mesh to create stronger flower pots for his garden, and received a patent in France for his technology in 1867, and one for larger concrete structures in 1877.[29] Condit writes that while Lambot, Coignet, and Monier pioneered the use of iron reinforcing, they were likely more concerned with concrete adhesion and unaware of the increases in tensile strength from reinforcement.[30] Another Frenchman, François Hennebique, experimented with reinforced concrete without publicizing his work in the 1870s and 1880s, and received French patents for his reinforcing system in 1892. Condit describes how Hennebique's system, compared to the others, was the most "scientific," because its rebar design best accounted for concrete's weakness in tension.[31] The Coignet, Monier, and Hennebique patents would end up having a broader influence outside of France.

German builder Gustav A. Wayss purchased the rights to Monier's patents in 1879, and used them in construction in beginning in the 1880s.[32] In 1887, Wayss and J. Bauschinger published test results showing the strength of the Monier System.[33] Soon, engineers in Austria were also building in reinforced concrete, testing and devising new systems of reinforcement.[34] The Monier System became widely known as a result of these developments.[35]

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[28] Condit, *American Building Art*, 232: F. E. Turneaure and E. R. Maurer, *Principles of Reinforced Concrete Construction* (Third Edition) (New York: John Wiley & Sons, 1919), 1.

[29] Dario Gasparini, "Development of Reinforced Concrete Arch Bridges in the U.S.: 1894–1904," *American Civil Engineering History* (Washington D.C., 2002), 323: Frederick W. Taylor and Sanford E. Thompson, *A Treatise on Concrete, Plain and Reinforced; Materials, Construction, and Design of Concrete and Reinforced Concrete* (New York: John Wiley & Sons, 1912), 537.

[30] Condit, "The First Reinforced-Concrete Skyscraper," 2.

[31] Condit, "The First Reinforced-Concrete Skyscraper," 6.

[32] Gasparini, Development of Reinforced Concrete Arch Bridges," 323: Condit, "The First Reinforced-Concrete Skyscraper," 4: David Billington, *The Tower and the Bridge: The New Art of Structural Engineering* (Princeton, N.J.: Princeton University Press, 1983), 149.

[33] F. E. Turneaure and E. R. Maurer, *Principles of Reinforced Concrete Construction*, 3rd Ed. (New York: John Wiley & Sons, 1919), 2.

[34] Turneaure and Maurer, *Principles of Reinforced Concrete Construction*, 2.

[35] Gasparini, "Development of Reinforced Concrete Arch Bridges in the U.S.: 1894-1904," 323.

There were also mid- to late 19th century American developments, some following the French pioneers and others achieved independently. S. T. Fowler patented a concrete wall reinforced with timbers in 1860, and by 1870, other Americans were using metal in their reinforcement patents.[36] From 1871 to 1876, William E. Ward built a reinforced concrete house in Port Chester, New York.[37] This house uses reinforcement techniques from both Coignet's and Monier's French patents.[38] It also uses concrete beams reinforced with I-beams to support the floors, a method that Austrian Josef Melan would later use in reinforced concrete bridge construction.[39] American Thaddeus Hyatt also conducted experiments testing reinforced concrete with David Kirkaldy in London, and published *Experiments with Portland Cement Concrete* in 1877. Condit writes that Hyatt's developments were a "theoretical counterpart" to Ward's "practical demonstration."[40]

In the United States, the most important pioneer in reinforced concrete building construction was Ernest Leslie Ransome.[41] Ernest Ransome was born in England, and worked as an apprentice for his father, who developed artificial stone blocks for masonry construction beginning in 1844.[42] The younger Ransome immigrated to San Francisco in 1870 to continue to work in the same industry.[43] In 1884, he received a U.S. patent for a design for twisted square rebar, which could be made of iron or steel, now known as Ransome Bar (Figure 1.1). Mikesell

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[36] Condit, *American Building Art: The Nineteenth Century*, 232.
[37] Condit, "The First Reinforced-Concrete Skyscraper," 2: Taylor and Thompson, *A Treatise on Concrete* (1916), 570.
[38] Condit, *American Building Art: The Nineteenth Century*, 233.
[39] Condit, "The First Reinforced-Concrete Skyscraper," 4.
[40] Condit, *American Building Art: The Nineteenth Century*, 233.
[41] Condit, *American Building Art: The Twentieth Century*, 154: Stephen Mikesell, "Ernest Leslie Ransome: A Vital California Engineer and Builder," *California History* 96, no. 3 (August 1, 2019), 77: Edwin Thacher, "Concrete and Concrete-Steel in the United States," 428.
[42] Theodore H. M. Prudon, "Simulating Stone, 1860–1940: Artificial Marble, Artificial Stone, and Cast Stone" (*APT Bulletin: The Journal of Preservation Technology* 21, no. 3/4, 1989), 82: Condit, *American Building Art: The Nineteenth Century*, 235.
[43] Prudon, "Simulating Stone," 82: Mikesell, "Ernest Leslie Ransome: A Vital California Engineer and Builder," 80.

notes that Ransome may not be the original inventor of rebar, but that his twisted design greatly improved the cohesion of the rebar and the concrete.[44] Ransome would use this rebar in several important commissions.

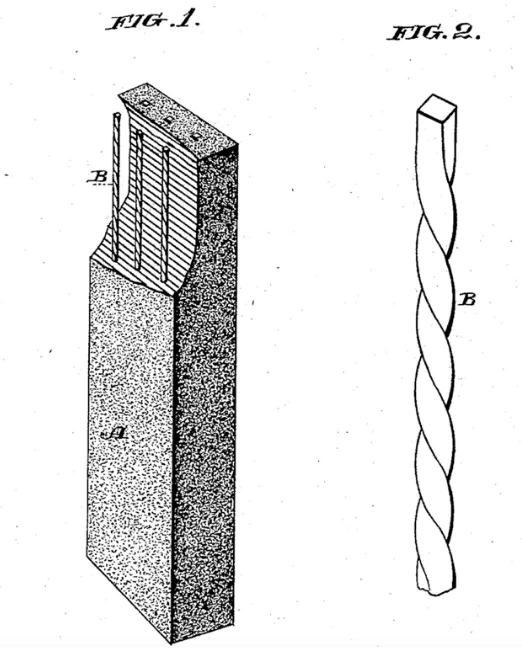

Figure 1.1: Ransome, Ernest. Building Construction. US Patent 305,226, filed May 1, 1884, and issued September 9, 1884.

In 1888, Ransome formed a business partnership with borax mining magnate Francis Marion Smith. Mikesell notes that this partnership involved Ransome using Smith's capital to expand the use of reinforced concrete technology.[45] Ransome built Smith's Pacific Coast Borax Works in Alameda, Calif., in 1893, likely the world's first reinforced concrete factory building.[46] Ransome also built Smith's larger Pacific Coast Borax Company building in Bayonne, N. J., in 1897. This building made innovative use of reinforced concrete, and survived a large fire in 1906.[47] Ransome moved to the East Coast around 1897, first to Brooklyn, and then to New

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[44] Mikesell, "Ernest Leslie Ransome: A Vital California Engineer and Builder," 93.

[45] Mikesell, "Ernest Leslie Ransome: A Vital California Engineer and Builder," 82.

[46] Mikesell, "Ernest Leslie Ransome: A Vital California Engineer and Builder," 91.

[47] Reyner Banham, "Ransome at Bayonne," *Journal of the Society of Architectural Historians* 42, no. 4 (December 1, 1983), 385.

Jersey, where he lived until his death in 1917.[48] Other important projects include the United Shoe Machinery Company in Beverly, Mass., in 1902, Ransome's largest reinforced concrete building, and the Ingalls Building in Cincinnati, Ohio, the first reinforced concrete skyscraper, in 1903.[49] Ransome died in 1917, and the bridge at Shelter Island was one of his later projects.

Arches

An arch is defined as "A curved symmetrical structure spanning an opening and typically supporting the weight of a bridge, roof, or wall above it."[50] The impressive structural feature of an arch is that it transmits load out from the center to the sides of the form. Arches constructed of stone have prehistoric origins, but they were most prolifically used in Roman bridges and aqueducts.[51] These arches depended on careful placement of voussoirs and a keystone to create a structure which was stable and load-bearing. After the Romans, stone arch bridges were used continuously in Europe, and later in the United States.[52] Reinforced concrete arches are monolithic as opposed to polylithic stone arches, but they still feature the same properties, which allow them to carry great loads.

Arches are measured by their span, rise, and crown thickness, which are illustrated in Figure 1.2. The span of an arch is the measure of the distance between its two supports or abutments. The rise is the vertical distance between the beginning of the arch, the springing, and the crown. The crown is the highest point on an arch. Although the diagram does not show it, an arch is a three-dimensional form, and its width is another characteristic to be measured.

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[48] Mikesell, "Ernest Leslie Ransome: A Vital California Engineer and Builder," 80-82.
[49] Banham, "Ransome at Bayonne," 383: Carl W. Condit, "The First Reinforced-Concrete Skyscraper," 1.
[50] Lexico.com. "Arch," n.d. https://www.lexico.com/en/definition/arch.
[51] Condit, *American Building Art: The Nineteenth Century,* 240.
[52] Condit, *American Building Art: The Nineteenth Century*, 241.

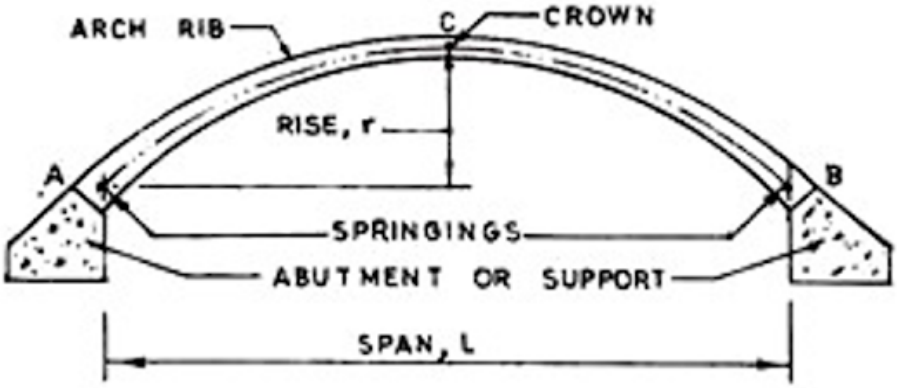

Figure 1.2: Diagram showing three components of arch measurement. Source: N. Balasubramanya, "Components of the Arch," *Civil Engineering* [Blog], April 25, 2020. https://1civilengineering.blogspot.com/2020/04/components-of-arch.html

There is a vocabulary for reinforced concrete arch bridges, illustrated in Figure 1.3. The spandrel is the area between the arch or arch ring and the deck or road surface of a bridge. A reinforced concrete arch bridge can either be "closed spandrel," meaning that this area is entirely filled in, or "open spandrel," meaning that the connection between the arch surface and the deck is made with columns or smaller arches. Early reinforced concrete arches, including all of the case studies in this thesis, are of closed spandrel design, which is shown in Figure 1.3. While the arch ring is always constructed with concrete, the fill may be earthen or concrete, and the spandrel walls, the sides of the bridge, can be either concrete or of masonry construction. While some sources may describe bridge "facades," this thesis will use the term "spandrel walls" to refer to the sides of reinforced concrete arch bridges. The arch ring has an intrados or soffit, which is its underside, and an extrados, which is the overside of the arch. There are two different structural forms which can support an arch: Abutments are supports at the ends of a bridge, while piers are supports in the middle of a bridge, used with multi-arch spans. A parapet is a railing on the bridge, while wing walls are sometimes employed as retaining walls extending out from the abutment.

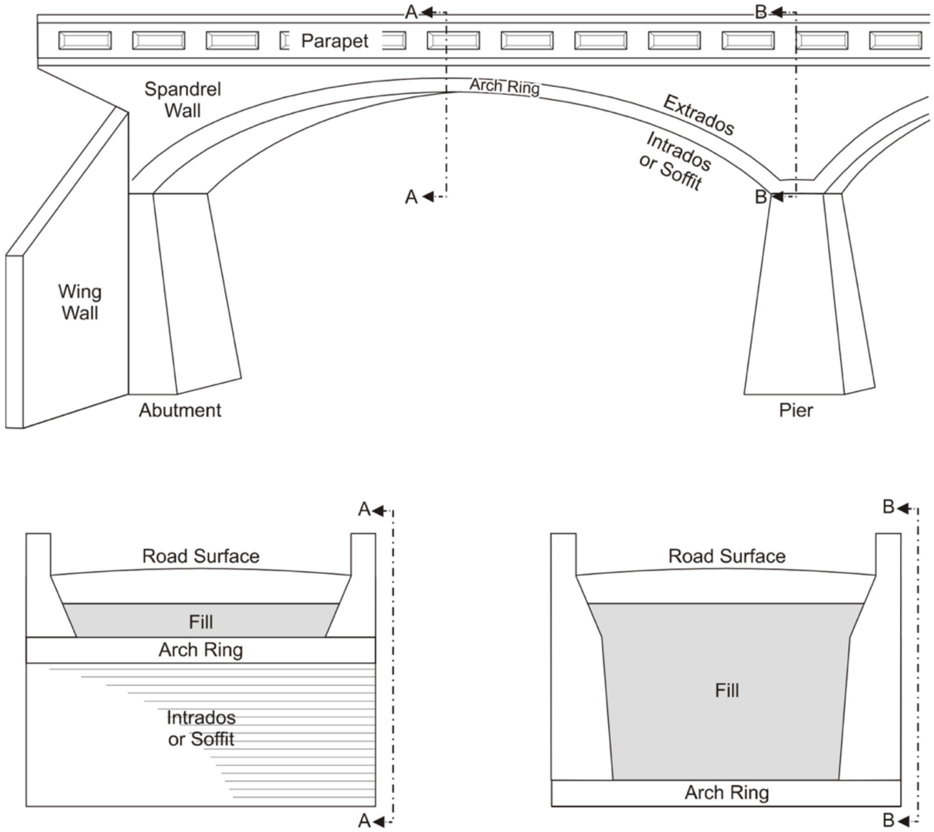

Figure 1.3: "Illustrations with Arched Bridge Terminology." Source: Miller, Clark, & Grimes, "Survey of Masonry and Concrete Arch Bridges in Virginia," 8.

Reinforced Concrete Arches

The first use of reinforced concrete arches is credited to French and Swiss inventors and engineers in the last quarter of the 19th century.[53] Concrete had been used in unreinforced monolithic arches and in block form for projects in France and in the United States (such as John C. Goodridge's 1871 Cleft Ridge Span in Prospect Park, Brooklyn). McKibben credits Monier with being the inventor of the reinforced concrete arch.[54] Monier built a reinforced concrete bridge near Chazelet, France, perhaps the first in the world, in 1875, although this bridge is more of a girder bridge than an arch.[55] Condit writes that there were Monier-type arches in France by

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[53] Condit, *American Building Art: The Nineteenth Century*, 247.

[54] Taylor and Thompson, *A Treatise on Concrete* (1912), 536.

[55] Zlatko Šavor and Jelena Bleiziffer, "From Melan Patent to Arch Bridges of 400 M Spans," Chinese-Croatian Joint Colloquium: Long Arch Bridges (Brijuni Islands, 2008), 350.

1885, reaching lengths of greater than 120 feet in Switzerland by 1890.[56] Most American reinforced concrete bridge developments followed European patents.[57]

The National Highway Research Council's 2005 report, "A Context For Common Historic Bridge Types," examines the various types of bridges built in the United States prior to the passage of the Federal Highway Act in 1956.[58] This report is "intended to provide assistance to practitioners with assessing the historic significance of bridge types within the context of the United States."[59] The report divides reinforced concrete arches into multiple categories, listed below:

1. Reinforced Concrete Melan/von Emperger/Thacher Arches
2. Reinforced Concrete Luten Arches
3. Reinforced Concrete Marsh or Rainbow (Through) Arches
4. Reinforced Concrete Closed Spandrel Arches
5. Reinforced Concrete Open Spandrel Arches
6. Reinforced Concrete Tied Arches
7. Reinforced Concrete Hinged Arches[60]

The case study bridges used this thesis are Melan/von Emperger/Thacher arches and earliest closed spandrel arches (Categories 1 and 4). These types of arches are all uncommon, and are noted as significant for representing the development of the technology.[61] Luten arches (Category 2) were frequently built in the United States, and are also significant, although most date to the 1910s and 20s.[62] Marsh or Rainbow arches (Category 3) place the arch partly above the deck, and were developed in the 1910s, after the earliest reinforced concrete types.[63] Open

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[56] Condit, *American Building Art: The Nineteenth Century*, 247-248.
[57] Condit, *American Building Art: The Nineteenth Century*, 247.
[58] Parsons Brinckerhoff and Engineering and Industrial Heritage, "A Context For Common Historic Bridge Types," (NCHRP Project 25-25, Task 15, The National Cooperative Highway Research Program Transportation Research Council National Research Council, October 2005), iv.
[59] Parsons Brinckerhoff et al., "A Context For Common Historic Bridge Types," iv.
[60] Parsons Brinckerhoff et al., "A Context For Common Historic Bridge Types," vi.
[61] Parsons Brinckerhoff et al., "A Context For Common Historic Bridge Types," 3-65.
[62] Parsons Brinckerhoff et al., "A Context For Common Historic Bridge Types," 3-59.
[63] Parsons Brinckerhoff et al., "A Context For Common Historic Bridge Types," 3-61.

spandrel arches (Category 5) can be traced as far back as 1906, but were most broadly used in the 1920s and 30s.[64] The final two categories represent other possible structures of reinforced concrete arches, as they can be broken down into those that are fixed, hinged, or tied. Hinged arches were uncommon in the United States, where engineers preferred heavier reinforcement.[65] Tied arches were a development of the 1920s and 30s, and thus are also not a factor in the case studies.[66] The following paragraphs will describe the details of the systems used in early reinforced concrete arch bridges in the United States.

Ransome

Ernest Ransome built the first reinforced concrete arch bridge in the U.S., the Alvord Lake Bridge in Golden Gate Park in San Francisco (Figure 1.4).[67] The bridge is listed as a Historic Civil Engineering Landmark by the American Society of Civil Engineers, and is often considered to be "the defining aspect of [Ransome's] life history."[68] The closed spandrel arch carries a road over a pedestrian walkway, with an span of 20 feet and a rise of four feet and three inches, and a width of more than 60 feet, reinforced with Ransome's signature twisted rebar.[69]

Mikesell writes that there are inaccuracies in the accepted history of the Alvord Lake Bridge, as scholars have cited past scholars rather than primary sources. The bridge is generally recorded as having been built in 1889, but Mikesell argues that it was actually built in 1890–91. Another, very similar, bridge near the Conservatory of Flowers was built in Golden Gate Park at that time, designed by the architecture firm Percy & Hamilton.[70] Mikesell concludes that both bridges were likely designed by Percy & Hamilton with Ransome and business partner Sidney

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[64] Parsons Brinckerhoff et al., "A Context For Common Historic Bridge Types," 3-67.
[65] Parsons Brinckerhoff et al., "A Context For Common Historic Bridge Types," 3-77.
[66] Parsons Brinckerhoff et al., "A Context For Common Historic Bridge Types," 3-71.
[67] Mikesell, "Ernest Leslie Ransome: A Vital California Engineer and Builder," 77.
[68] Mikesell, "Ernest Leslie Ransome: A Vital California Engineer and Builder," 85.
[69] Condit, *American Building Art: The Nineteenth Century*, 132.
[70] Mikesell, "Ernest Leslie Ransome: A Vital California Engineer and Builder," 86.

Cushing acting as contractors.[71] Ransome likely designed the reinforcing systems for both bridges, but he was not the sole designer for either bridge. According to Mikesell, “Any recognition of the significance of the Alvord Lake Bridge in the history of reinforced concrete bridge construction should be extended to the conservatory bridge as well.”[72] Both bridges predate the next earliest reinforced concrete arch bridges in the United States by several years. They also do not have any direct successors in design, as there is no evidence that Ransome worked on any reinforced concrete bridges until the Smith-Ransome Japanese Bridge almost two decades later. In the intervening years, many systems for reinforced concrete arches were introduced in the U.S. Some of these systems were minor refinements on existing systems, and for some, there are no extant American examples today.

Figure 1.4: The Alvord Lake Bridge, January 2021. Source: Emily Fitts.

The development of reinforced concrete arch bridges in the United States after Ransome’s Golden Gate Park bridge(s) involved many different patents and technologies, mainly deriving from the Monier and Melan patents. The earliest reinforced concrete bridges in the U.S.

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[71] Mikesell, “Ernest Leslie Ransome: A Vital California Engineer and Builder,” 86.
[72] Ibid., 86.

(1894–1904) were primarily of the Melan type, of which the von Emperger and Thacher arches are considered a subtype.[73] There are at least nine surviving Melan-type bridges from before 1900 in the U.S. identified as part of this thesis, five of which are in New York or New Jersey. After some debate over the steel usage in Melan-type arches, the Monier-type arch became the most common in the U.S. within the first decade of the 20th century.[74] The following sections will discuss the Monier System, the Melan System, and additional contributions by von Emperger, Thacher, and Daniel Luten.

The Monier System

Joseph Monier received patents in the United States for the use of his wire mesh system for railroad ties in 1884 and for "Construction of reservoirs, tanks, silos, vats, cisterns, and other containers, pipes, and conduits" in 1892.[75] Figure 1.5 shows a section of typical Monier wire mesh, which early on could have been either iron or steel. The system developed from using a thin gauge of wire (.28 to .39 inches) for reinforcement to using sets of rigid bars on the longitudinal part of the arch with smaller perpendicular transverse connections.[76] These lattices were eventually applied in two layers one near the intrados and the other near the extrados of the arch.[77] The timing of rebar use in the Golden Gate Park bridges coincides with the evolution of the Monier system away from wire and to rebar.[78] While Monier was the pioneer, he is not known to have built any bridges in the United States. Ransome is known to have built only three reinforced concrete bridges: the two in San Francisco and the one in Shelter Island. It would be

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[73] Dario Gasparini, "Development of Reinforced Concrete Arch Bridges in the U.S.: 1894–1904," 328.

[74] Condit, *American Building Art: The Twentieth Century*, 196: Taylor and Thompson, *A Treatise on Concrete* (1912), 537.

[75] Monier, Joseph. Construction of Railway Sleepers & c. US Patent 302,664, filed December 22, 1883, and issued July 29, 1884: Monier, P. A. J. Construction of Tanks, Reservoirs, Silos, &c. US Patent 486,535, filed October 31, 1891 and issued November 22, 1892.

[76] Gasparini, "Development of Reinforced Concrete Arch Bridges in the U.S.: 1894–1904," 323.

[77] Taylor and Thompson, *A Treatise on Concrete* (1912), 537.

[78] Gasparini, "Development of Reinforced Concrete Arch Bridges in the U.S.: 1894–1904," 323.

other engineers who would end up using the principles that Monier and Ransome developed in American bridges.

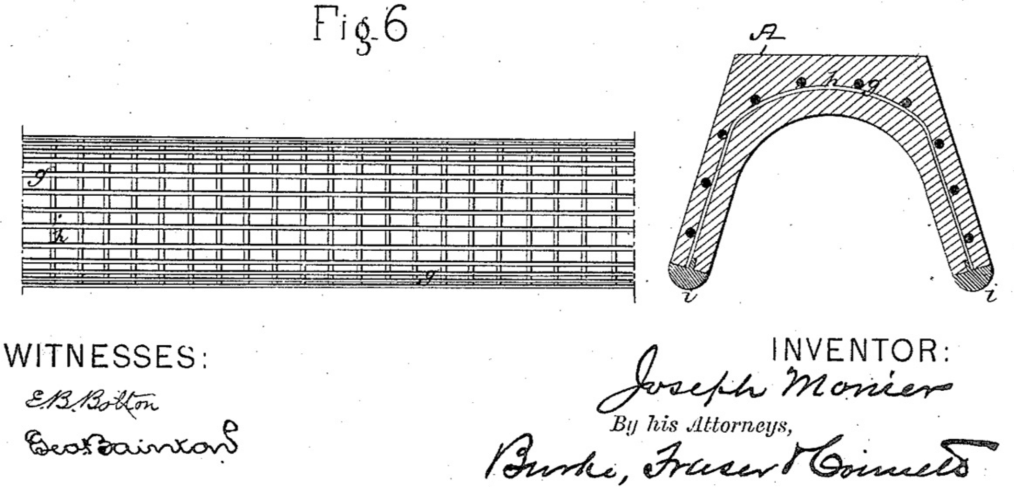

Figure 1.5: Monier, Joseph. Construction of Railway Sleepers & c. US Patent 302,664, filed December 22, 1883 and issued July 29, 1884.

The Melan System

The Melan System was invented by Josef Melan of Austria, who received a U.S. patent for his design in 1893. Melan arches use steel beams imbedded in concrete as opposed to wire mesh or rebar. The beams are curved, and can be joined at angles to form the curve of a bridge (Figure 1.8). An arch bridge is composed of multiple sets of beams or ribs, as seen in Figure 1.7. Gasparini notes that the Melan system "does not rely on steel-concrete bond and composite behavior."[79] This distinction is important, because if the concrete and the steel are not working in cohesion, then it is unclear if the structure is in fact to be considered reinforced concrete. Taylor and Thompson clarify that a Melan-type arch is considered a reinforced concrete structure if "the metal ribs, even if otherwise strong enough to carry all the load, are not connected by lateral bracing and therefore have insufficient stability without assistance of concrete."[80] That is, if the steel superstructure of the bridge is completely stable without any concrete, it is not a reinforced

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[79] Dario Gasparini, "Development of Reinforced Concrete Arch Bridges in the U.S.: 1894–1904," 326.

[80] Taylor and Thompson, *A Treatise on Concrete* (1916), 349.

concrete bridge. In the case of a Melan-type bridge, the individual beams are separate, and would not be stable without the concrete surrounding them.

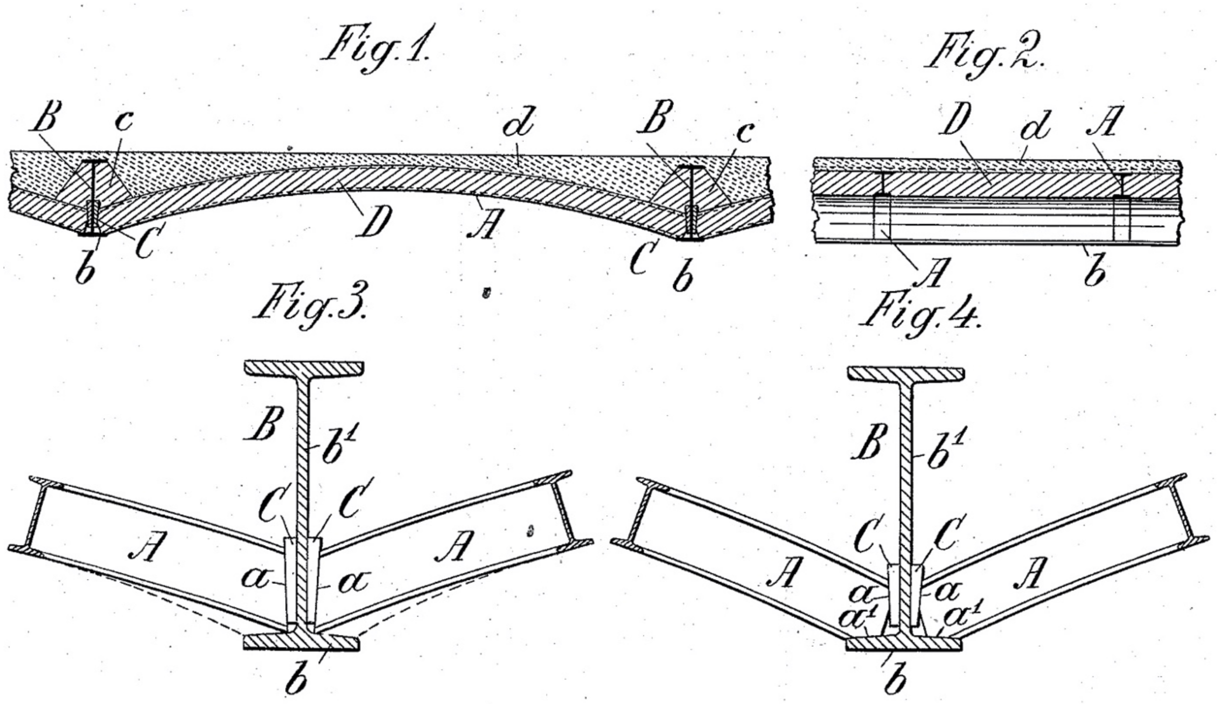

Figure 1.6: Melan, J. Vault for Ceilings and Bridges, &c. US Patent 505,054, filed May 17, 1893 and issued September 12, 1893.

Von Emperger

The Melan System's early predominance in the U.S. is likely due to the influence of Fredrich (Fritz) von Emperger of Austria.[81] Fritz von Emperger promoted the Melan system in an 1894 article in the *Transactions of the American Society of Civil Engineers* and founded the Melan Arch Construction Company with William Mueser. He built the first two Melan-type bridges still extant in the United States, in Rock Rapids, Iowa (1894), and Cincinnati, Ohio (1895). Figure 1.7 shows the individual ribs of the Eden Park (Cincinnati) Melan Arch span under construction. Fritz von Emperger received a patent for his refinements to the Melan system

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[81] Gasparini, "Development of Reinforced Concrete Arch Bridges in the U.S.: 1894-1904," 328.

in 1897, and they involved using a lattice of steel between solid intrados and extrados sections, as opposed to a solid I-beam.[82]

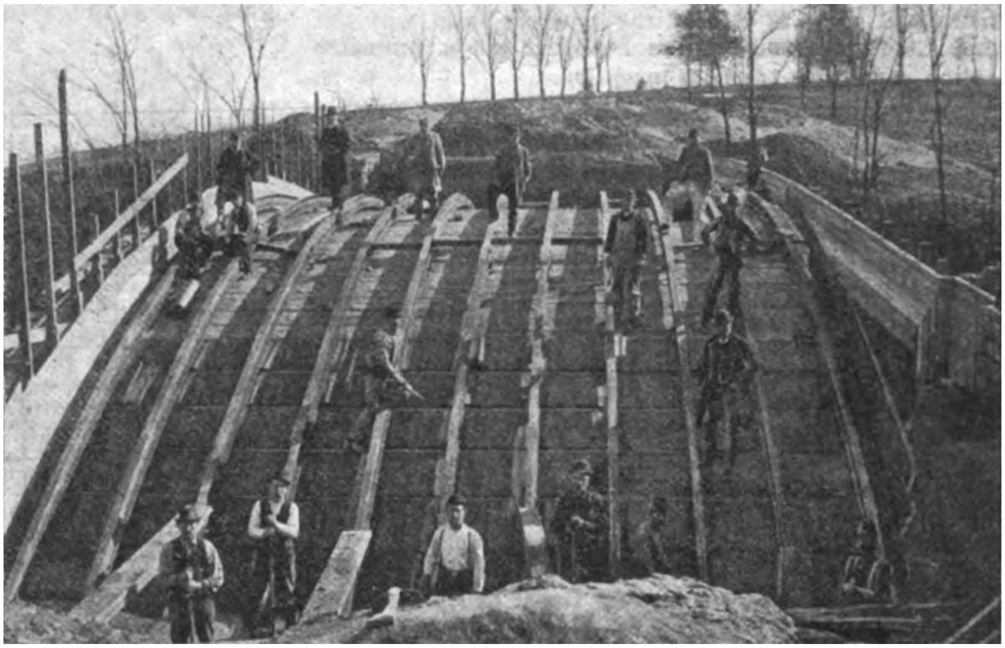

Figure 1.7: Construction of the Eden Park Melan Arch, Cincinnati, OH, 1895. Source: *Engineering News*, October 3, 1895, page 214.

Thacher

Edwin Thacher designed approximately 200 concrete bridges between 1895 and 1912, and was one of the most important American designers of the type.[83] His Kansas River Bridge (demolished) was considered the first major Melan type bridge in the United States.[84] Thacher determined that there was no need for a connection between the intrados and extrados reinforcement, and he received a patent in 1899 for a design using separate reinforcing bars at the intrados and extrados.[85] Gasparini describes Thacher's reinforcement as "flat steel bars," and observes that "the new reinforcing systems that evolved essentially approached that of Jean

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[82] Taylor and Thompson, *A Treatise on Concrete, Plain and Reinforced* (1912), 537: Gasparini, "Development of Reinforced Concrete Arch Bridges in the U.S.: 1894–1904," 329.

[83] David P. Billington, "History and Esthetics in Concrete Arch Bridges" (*Journal of the Structural Division* 103, no. 11, 1977), 2133.

[84] Billington, "History and Esthetics in Concrete Arch Bridges," 2134.

[85] Gasparini, "Development of Reinforced Concrete Arch Bridges in the U.S.: 1894–1904," 329.

Monier, who used individual rods, wired together to form grids, in the 1860s."[86] Later, Thacher and William Mueser formed a partnership in the Concrete-Steel Engineering Company, which came to control the Melan, Emperger, and Thacher patents.[87] Melan-type bridges continued to be built well into the 20th century, although their numbers were surpassed by bridges in other technologies. The first two case studies involve Melan-type bridges, and one was designed by Thacher. All use I-beams as illustrated in the original Melan patent, rather than the von Emperger or Thacher refinements.

Luten

Daniel B. Luten was also an important figure in the development of American reinforced concrete arches. Gasparini highlights Luten's National Bridge Company, founded in 1902, as one of the preeminent early firms in the design of reinforced concrete arch bridges.[88] Instead of following or improving on the Melan patents, Luten developed his own reinforcement system.[89] In the Luten System, the bars are "bent to follow the regions of potential stresses."[90] "A Context For Common Historic Bridge Types" describes Luten's contributions to reinforced concrete arches as follows:

> Luten diverged from the relatively conservative Melan/von Emperger/Thacher line of development that placed the importance of steel (or iron) as a load-bearing element in bridge arches above that of concrete, and aggressively promoted a system that stemmed more from the Monier methodology that gave primacy to concrete in load bearing, with metal as a strengthening element.[91]

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[86] Gasparini, "Development of Reinforced Concrete Arch Bridges in the U.S.: 1894-1904," 332.

[87] Ibid., 328.

[88] Ibid., 328.

[89] Ibid., 330.

[90] Ibid., 330.

[91] Parsons Brinckerhoff and Engineering and Industrial Heritage, "A Context For Common Historic Bridge Types," (NCHRP Project 25-25, Task 15, The National Cooperative Highway Research Program Transportation Research Council National Research Council, October 2005), 3–59.

Luten's divergence from the Melan system and connection to the Monier system connects him with the work of Thacher and of Ransome, who both patented and used rebar in their bridges. Luten's rise as a bridge designer coincides with the decline in the use of Melan-type reinforcing in bridges built in the 1910s and 20s. Figure 1.8 is very useful in contextualizing these difference and it is described in the following paragraph.

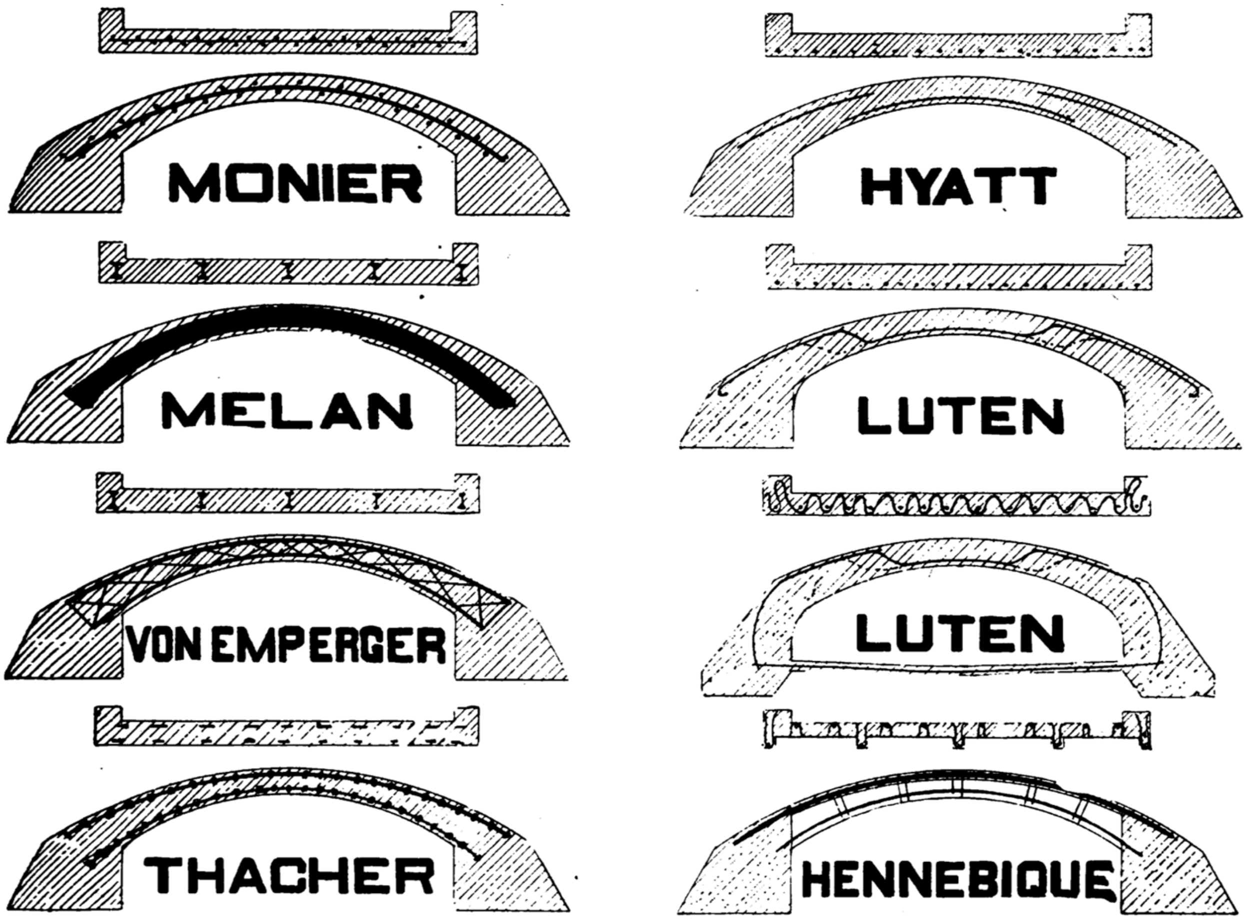

Figure 1.8: Examples of early arch reinforcement systems. Source: Daniel Luten, "Concrete-Steel Arch Bridges," page 113.

In 1903, Daniel Luten read a paper, "Concrete-Steel Arch Bridges," which was subsequently published by the Indiana Engineering Society. In the published version, Luten provides a diagram (Figure 1.8) and description of some but not all types of early reinforced concrete arches.[92] In the left column of Figure 1.8, Luten shows sections of Monier, Melan, von Emperger, and Thacher arches. In the right column he shows an arch using the reinforcing techniques of Thaddeus Hyatt and Francois Hennebique, and two Luten arches. The Monier arch section shows one layer of mesh, as the earlier Monier-type bridges used only one layer of mesh at the center. The Melan section shows the solidity of the solid steel beams running the length of the arch. The von Emperger section illustrates the steel lattices. The Thacher section shows the disconnected intrados and extrados bars, which resemble later Monier-type reinforcement. Hyatt's design separates the longitudinal bars so that they might not weaken the concrete in their compression. Luten's own sections illustrate the use of his bent rebar in two different arrangements. Finally, the Hennebique system uses bars at the intrados and extrados, with U-shaped connections between them.[93]

` There are several key takeaways from Luten's diagram, in which he places his own work among some of the early pioneers in reinforced concrete. At the time of his writing in 1903, Luten had yet to hit the peak of his own career. Luten's section of the Monier System only shows one layer of wire mesh, although the system developed to use two layers, similar to the Thacher section. Luten also explains that Ransome twisted bars could be used in the systems that he shows (although presumably not in Melan-derived arches).[94] Luten's diagram clearly shows the distinction between Monier- and Melan-type arches, both of which were common in the U.S. His inclusion of Hyatt and Hennebique should not be misconstrued; Hyatt is not known to have designed any bridges, and while Hennebique designed bridges in Europe, there is no evidence that he worked in the United States. Luten's diagram also omits the Robert Wünsch System,

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[92] Daniel B. Luten, "Concrete-Steel Arch Bridges" (*Proceedings of the Twenty-Third Annual Meeting of the Indiana Engineering Society*, Indiana Engineering Society, 1903), 112.
[93] Luten, "Concrete-Steel Arch Bridges," 113–114.
[94] Luten, "Concrete-Steel Arch Bridges," 114.

developed in Budapest in 1884. The Wünsch-type arch has a curved intrados and a straight horizontal extrados, with steel ribs for reinforcement.[95] McKibben notes that few Wünsch-type bridges were built, and an *Engineering Record* article from 1910 writes, “With respect to reinforcement, the Monier and Melan are practically the only types used in America, although the Wünsch type has been used in a few cases.”[96] Overall, Luten’s diagram illustrates the complex history of early reinforced concrete arch reinforcing systems in the United States.

Reinforced concrete bridges grew in popularity because of their advantages over other methods of bridge construction. Reinforced concrete arches were cheaper to construct than stone arches, and McKibben gives four reasons for their use in bridges over steel trusses or girders:

1. Greater durability
2. Less cost of maintenance
3. Less vibration and less noise
4. More aesthetic effects[97]

Reinforced concrete bridges would not immediately show rust and would not require frequent painting. Luten explained that concrete was as good or better than paint for protecting steel from the harmful gases produced by locomotives.[98] The nature of concrete construction also makes for less shifting under loads, and also allows for ornamentation on the surface. McKibben was quite optimistic, writing “When properly designed and built, no repairs whatever should be required, and no limit can be placed on the life of the bridge.”[99]

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[95] Taylor and Thompson, *A Treatise on Concrete* (1916), 711–712.
[96] *The Engineering Record*, “The Present Status of Reinforced Concrete Bridges” (Volume 62, No. 7, August 13, 1910), 169.
[97] Taylor and Thompson, *A Treatise on Concrete* (1916), 708.
[98] Luten, “Concrete-Steel Arch Bridges,” 126.
[99] Taylor and Thompson, *A Treatise on Concrete* (1916), 708.

Chapter 2: Bridge Inspections and the Preservation of Historic Bridges

In the United States, considerations of safety are the most important factor in the preservation of historic bridges. Old bridges can be more likely to fail, and potential liabilities are a large concern. This chapter briefly describes the process of bridge inspections in the United States. It then examines the laws, regulations, rules, and the processes in place for the preservation of historic bridges. The chapter then reviews the character and defining features of a historic reinforced concrete arch bridge.

Bridge Inspections

Bridge inspection standards in the United States are defined by the National Bridge Inspection Standards (NBIS), which are administered by the U.S. Department of Transportation through its agency, the Federal Highway Administration.[100] These standards were established in 1971 following the passage of the Federal Highway Act of 1968.[101] They apply to all road bridges that are publicly owned, but they do not apply to railroad or pedestrian bridges, which are often inspected by other authorities.[102] The National Highway Bridge Inspection Standards also only apply to structures with a total span greater than 20 feet, the minimum required length in the Federal Highway Administration's definition of a bridge.[103] All case study bridges except the Smith-Ransome Japanese Bridge (a privately owned pedestrian bridge) are subject to the National Bridge Inspection Standards. Each state has its own bridge management system, and each contributes data for the National Bridge Inventory (NBI).[104]

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[100] Ryan, Thomas W., J. Eric Mann, Zachary M. Chill, and Bryan T. Ott, "Bridge Inspector's Reference Manual (BIRM)" (Federal Highway Administration, Revised 2006, 2012, 2002), 1.1.1.

[101] Ryan et al., "Bridge Inspector's Reference Manual (BIRM)," 1.1.3.

[102] U.S. Department of Transportation, Federal Highway Administration, "Questions and Answers on the National Bridge Inspection Standards 23 CFR 650 Subpart C," n.d. https://www.fhwa.dot.gov/bridge/nbis/

[103] Ibid.

[104] Ryan et al. "Bridge Inspector's Reference Manual (BIRM)," 1.1.1.

The Federal Bridge Inspector's Reference Manual (BIRM) provides details on the specifics of bridge inspections. It stresses the importance of thoroughness in inspections, and notes that inspectors can very well end up in legal proceedings after an incident.[105] The manual does not address the value of historic bridges; it notes that preservation should "extend the performance life of as many bridges as possible and minimize the need for costly repairs or replacement."[106] There is no discussion of aesthetics or historic technology, as the objective is to have safe bridges while keeping costs down.

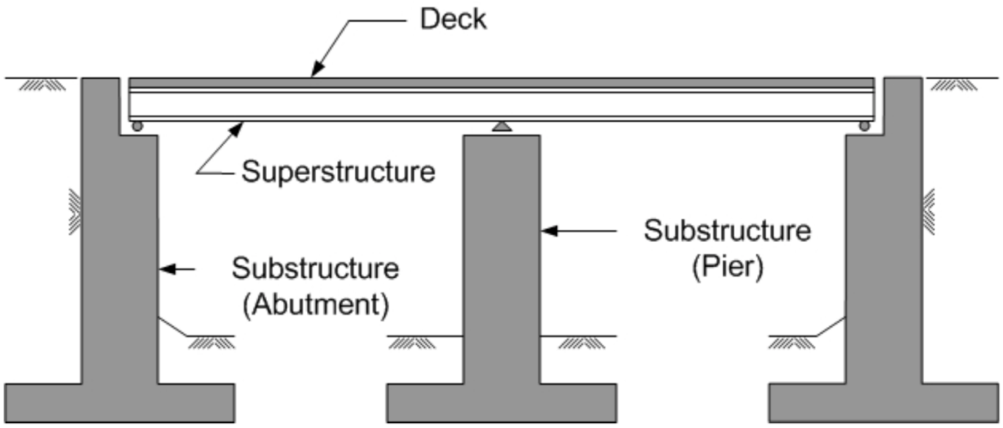

Figure 2.1: Diagram of Major Bridge Components. Source: Ryan et al., "Bridge Inspector's Reference Manual," 3.1.3.

The manual highlights separate inspection of the major bridge components—the deck, the superstructure, and the substructure (Figure 2.1)—and the manner in which they are graded, from zero to nine. A grade of nine signifies excellent condition, while a grade of one indicates "imminent" failure condition, and a grade of zero indicates failed condition.[107] Individual elements of bridges may be in worse or better condition, and inspectors determine how the condition of the elements affects the overall grade. If there is a "critical finding," it is to be immediately reported to officials in the state agency, although definitions and procedures vary

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[105] Ryan et al. "Bridge Inspector's Reference Manual (BIRM)," 1.2.6.
[106] Ibid., 1.2.2
[107] Ibid., 4.2.1-4.2.3.

from state to state.[108] Engineers will use flowcharts to process findings, and determine for example whether a bridge should be immediately closed or not.[109]

After inspectors determine the condition of a bridge, a "sufficiency rating" is used to decide whether it should be rehabilitated or replaced. This rating is a number between zero and 100. The number is composed of four components weighted according to their importance. The first and most important is structural adequacy and safety, followed by serviceability and functional obsolescence, essentiality for public use, and finally, special reductions for other conditions such as "detour length, traffic safety features, and structure type."[110] If the sufficiency rating is greater than or equal to 80, then the bridge may be eligible for funding for rehabilitation. If it is less than 50, then it is eligible for funding for replacement.

Topic 9.5 of the Bridge Inspector's Reference Manual (BIRM) pertains to concrete arches, with a section on closed spandrel arches. Concrete arches should be inspected for cracks, scaling, delamination, and spalling like other concrete structures.[111] These conditions are generally visible on the surface of the concrete, although an inspection for a closed spandrel arch will not be able to visually examine the extrados or top part of the arch, because it is filled in.[112] Sounding by hammer may be used, and sometimes other non-destructive testing methods may be applied.[113]

Federal Laws Governing Historic Bridge Preservation

There were two foundational federal laws signed on October 15, 1966: The National Historic Preservation Act (NHPA) and the Department of Transportation Act (USDOT Act).

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[108] Ryan et al. "Bridge Inspector's Reference Manual (BIRM)," 4.5.2-4.5.4.
[109] Ibid., 4.5.11.
[110] Ryan et al. "Bridge Inspector's Reference Manual (BIRM)," 4.2.12.
[111] Ibid., 9.5.9.
[112] Ibid., 9.5.8.
[113] Ibid., 9.5.4.

Both laws have been updated and supplemented since their original passage. The NHPA established the National Register of Historic Places, the individual State Historic Preservation Offices, and the Advisory Council on Historic Preservation, while the USDOT Act established the Department of Transportation. Federal agencies and departments, such as the National Park Service and the Department of Transportation, establish regulations, which include rules to enforce the laws and guidance to explain the rules. Section 106 of the NHPA and Section 4(f) of the USDOT Act are two sections of the two laws that are used by practitioners working with historic bridges as well as other historic resources.[114]

Section 106 of the National Historic Preservation Act (NHPA) requires that any project that involves the Federal Government must review its effects on historic sites or resources.[115] Many, if not most, projects involving bridges must be reviewed, because they receive federal funding, or some other license, review, or permission from a federal agency. The review process is illustrated in Figure 2.2. Federal agencies involved with the project must allow the Advisory Council on Historic Preservation, established in the NHPA, to comment, and they must consult with the appropriate State Historic Preservation Office (SHPO) and Tribal Historic Preservation Office (THPO).[116] These reviews by the SHPOs and THPOs will examine historic sites or resources, evaluate their significance, and determine the effects of the proposed project on the historic sites or resources. In consultation with all parties involved including the public, the reviews are expected either to end in an agreement or require mediation with the Advisory Council on Historic Preservation.

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[114] Section 4(f) Overview, U.S. Department of Transportation, Federal Highway Administration. https://www.environment.fhwa.dot.gov/env_topics/4f_tutorial/overview.aspx?j=e#j

[115] National Historic Preservation Act, Section 106: A Quick Guide for Preserving Native American Cultural Resources. https://www.nps.gov/history/tribes/Documents/106.pdf

[116] Ibid.

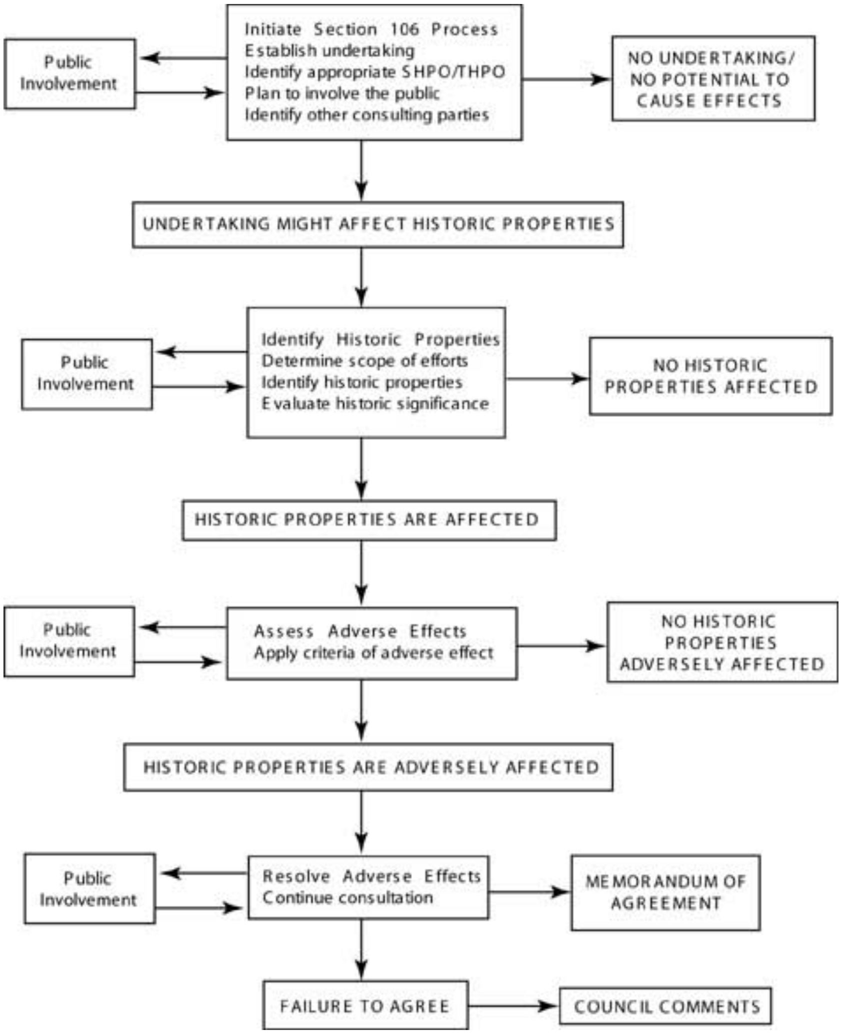

Figure 2.2: A flowchart showing the Section 106 Evaluation Process. Source: U.S. Forest Service, https://www.fs.fed.us/eng/pubs/htmlpubs/htm00712854/page03.htm

Section 4(f) in the Transportation Act requires projects involving the USDOT be evaluated for their potential impact on historic sites, parks, and refuges.[117] The USDOT Federal Highway Administration writes,

> Before approving a project that uses Section 4(f) property, FHWA must determine that there is no feasible and prudent alternative that avoids the Section 4(f) properties and that the project includes all possible planning to minimize harm to the Section 4(f) properties; or, FHWA makes a finding that the project has a de minimis impact on the Section 4(f) property.[118]

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[117] Section 4(f) Overview, U.S. Department of Transportation, Federal Highway Administration, https://www.environment.fhwa.dot.gov/env_topics/4f_tutorial/overview.aspx?j=e#j

[118] Ibid.

There are several important terms within this statement, and they are defined in the U.S. Code. Essentially, within reason, Section 4(f) will favor keeping a historic site intact rather than interfering with it. If the site must be interfered with, it is to be done with "least overall harm."[119] As with Section 106, the SHPO and the Advisory Council on Historic Preservation are involved with the Section 4(f) process, determining a site's significance and how it will be affected by a project.

For both Section 106 and Section 4(f), a historic site is a property which has been determined eligible for or has already been listed on the National Register of Historic Places.[120] A bridge that is presently on the National Register or that has been determined eligible for listing will trigger these sections. A bridge whose eligibility has not been determined must be evaluated by the appropriate SHPO or THPO as part of the Section 106 and Section 4(f) process.[121]

The Secretary of the Interior's Standards

The National Historic Preservation Act also directed the Secretary of the Interior to establish a set of professional standards, and these are now known as the Secretary of the Interior's Standards for the Treatment of Historic Properties.[122] These standards were first published in 1978, revised in 1992, published with guidelines in 1995, and revised and published again in 2017.[123] They are structured as four different standards corresponding to the four treatments appropriate for a historic site, defined as follows:

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[119] Ibid.

[120] "Section 4(f) of the Transportation Act," *Code of Federal Regulations*, Title 23, Part 774. https://www.ecfr.gov/cgi-bin/text-idx?c=ecfr&SID=6f9fc7f0f6a10bd453ddd0245586d278&rgn=div8&view=text&node=23:1.0.1.8.46.0.1.9&idno=23

[121] National Historic Preservation Act, Section 106: A Quick Guide for Preserving Native American Cultural Resources. https://www.nps.gov/history/tribes/Documents/106.pdf

[122] National Park Service: Technical Preservation Services, "The Secretary of the Interior's Standards for the Treatment of Historic Properties." https://www.nps.gov/tps/standards.htm.

[123] Anne E. Grimmer, "The Secretary of the Interior's Standards for the Treatment of Historic Properties with Guidelines for Preserving, Rehabilitation, Restoring & Reconstruction Historic Buildings" (Washington, D.C.: U.S. Department of the Interior National Park Service Technical Preservation Services, 2017), vii.

> **Preservation** focuses on the maintenance and repair of existing historic materials and retention of a property's form as it has evolved over time.
> **Rehabilitation** acknowledges the need to alter or add to a historic property to meet continuing or changing uses while retaining the property's historic character.
> **Restoration** depicts a property at a particular period of time in its history, while removing evidence of other periods.
> **Reconstruction** re-creates vanished or non-surviving portions of a property for interpretive purposes.[124]

In terms of historic preservation, these standards each have a clear definition, and they all seek to maintain original material wherever possible. However, these definitions are those used in the historic preservation world; engineers have different definitions, which can present challenges in bridge preservation projects.

The California Department of Transportation's publication "Differences in Technical Vocabulary when Referring to Design Treatments for Historic Bridges" outlines the differences in definitions for the four standards between a preservation professional and a bridge engineer. The word *preservation* for a preservation professional involves "long-term retention of historic materials," while for an engineer it means "maintaining functionality and meeting safety and capacity requirements."[125] In order to "preserve" a structure, a bridge engineer might drastically modify its historic elements. *Rehabilitation* for a preservation professional involves "a combination of retention and repair of historic materials to maintain the overall historic character of the bridge," while for an engineer, rehabilitation means "completely restoring bridge elements or components to improve structural integrity and correct major safety defects."[126] Rehabilitation is considered to be less drastic than restoration for a preservation professional, while for an

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[124] National Park Service: Technical Preservation Services, "The Secretary of the Interior's Standards for the Treatment of Historic Properties." https://www.nps.gov/tps/standards.htm.

[125] California DOT, "Differences in Technical Vocabulary When Referring to Design Treatments for Historic Bridges" (2014), 1. https://dot.ca.gov/-/media/dot-media/programs/environmental-analysis/documents/env/f0003965-bridge-vocabulary-a11y.pdf

[126] "Differences in Technical Vocabulary When Referring to Design Treatments for Historic Bridges," 2.

engineer, rehabilitation can involve anything short of demolition. *Restoration* for a preservationist involves "retention of materials from a specific time in a property's history and permits removal of materials outside that historic period," in order to accurately depict the property in that period.[127] There is no comparable bridge engineer's definition, and the document notes that this treatment is rare because bridges change to meet present needs. The same is true for r*econstruction*, which involves new construction accurately depicting a historic site or in this case, a bridge, that is no longer extant. "From an engineering perspective, a new bridge must be designed to meet standards for safety and capacity and accurately depicting the appearance may be of secondary importance."[128] These different priorities show how there may be difficulties in maintaining a historic bridge, because engineers and preservationists have completely different perspectives.

A draft report, "Secretary of Interior's Standards for Bridges in Pennsylvania" from the Pennsylvania Department of Transportation (PennDOT) (issued as a draft in 2018 but apparently never finalized) discusses the application of the Secretary of the Interior's Standards for bridges. It notes that work on historic bridges will usually use either the preservation or rehabilitation standard. It also mentions two goals of the standards: preservation of historic materials and preservation of historic character.[129] Historic materials contribute to historic character, but especially in the case of bridges, they may not be adequate for present safety standards. Modern standards may require the significant use of new materials; however, historic character can be maintained through sympathetic replacement of historic materials.

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[127] Ibid., 2.

[128] Ibid., 3.

[129] "DRAFT Secretary of Interior's Standards for Bridges in Pennsylvania" (Pennsylvania Department of Transportation, April 2018), 1.

The PennDOT document includes a discussion of the eligibility requirements for the National Register of Historic Places. Almost all bridges that are determined eligible for the National Register are categorized under either Criterion A or C. Criterion A is used for "association with events that have made a significant contribution to the broad patterns of our history."[130] Criterion C is written as "Embodiment of the distinctive characteristics of a type, period, or method of construction or that represent the work of a master, that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction."[131] While many historic bridges may be eligible for Criterion A, the early reinforced concrete arches that are the subject of this thesis will be most easily recognized for their significance under Criterion C, as they are examples of the technological development discussed in Chapter 1.

Integrity, or "the ability of a property to convey its significance," is always a determining factor for National Register eligibility.[132] The National Register Bulletin lists seven components of integrity: Setting, Materials, Design, Location, Workmanship, Feeling, and Association. Requirements for integrity are different depending on the type of resource being evaluated. "DRAFT Secretary of Interior's Standards for Bridges in Pennsylvania" discusses the meanings of the seven components specifically for historic bridges:

> **Setting** is the physical environment of a historic resource. This includes the character of the location and how the bridge is situated in relationship to other features, such as the roadway and landforms.
> **Materials** are the elements that were originally combined to construct the structure and are an important aspect for historic bridges.

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[130] "DRAFT Secretary of Interior's Standards for Bridges in Pennsylvania," 2.

[131] Ibid., 2.

[132] "National Register Bulletin; How to Apply the National Register Criteria for Evaluation" (U.S. Department of the Interior, National Park Service, 1997), 44. https://www.nps.gov/subjects/nationalregister/upload/NRB-15_web508.pdf

> **Design** is the combination of elements that create the form, plan, space, structure, and style of a resource. Historic bridges are often significant as reflections of the technology of bridge design.
> **Location** is the place where the bridge was originally constructed or where a historic event occurred.
> **Workmanship** is evidence of the builder's craft skills and technology.
> **Feeling** is the appearance of the bridge in terms of its expression of the aesthetic or historic sense of a particular time period.
> **Association** is the direct link between an important historic event or person and the bridge.[133]

The PennDOT document notes that materials, design, and workmanship are most important for Criterion C, and there is a specific section on concrete bridges which discusses these elements. For materials, it notes "When determining whether rehabilitation of a historic concrete bridge if possible, it is necessary to consider the condition of the concrete and reinforcing steel alongside the size and scale of the bridge and significance."[134] For workmanship, the document continues "Repairs should be carried out in a manner that reproduces original detailing like scoring or cornices/string courses or open parapets."[135] Improper repairs can compromise the integrity of a bridge. Materials that are used are to match with the historic materials as closely as possible. For design modifications, the article mentions lessening the fill in an arch to decrease its dead load, and potentially widening an arch with cantilevered decks.[136]

Character defining features are most important for preservation. For early reinforced concrete arch bridges, the main feature is the arch reinforcement system, but it may also be the decorative details, and sometimes even the wing walls, abutments, and piers.[137] Setting, association, and feeling are also important components for reinforced concrete arch bridges, as

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[133] "DRAFT Secretary of Interior's Standards for Bridges in Pennsylvania," 3.
[134] Ibid., 20.
[135] Ibid., 20.
[136] Ibid., 19.
[137] Ibid., 19.

some were constructed as purely utilitarian structures, while others may fit into the city beautiful movement, and still others were part of designed landscapes. Within the case studies there are examples of each of these types. In each of the case studies I have used the PennDOT guidelines to evaluate the project (Some of the bridges have already undergone restoration; others have not yet been determined eligible).

Chapter 3: Federal Reports, State Inventories, and Preservation Plans

In addition to the National Historic Preservation Act and the USDOT Act, another formative piece of legislation is the Surface Transportation and Uniform Relocation Assistance Act of 1987, specifically Title I, The Federal-Aid Highway Act of 1987. This law required the Transportation Research Board to conduct a study on historic bridge rehabilitation, and for the states to take inventories of historic bridges.[138] This chapter will outline key details of the resulting federal reports and the state reports of Connecticut, New York, and New Jersey, which will be key to evaluating the six case studies.

Federal Historic Bridge Preservation Reports

The American Association of State Highway and Transportation Officials (AASHTO) has sponsored multiple reports on historic bridges. The first was the Contextual Study discussed in Chapter 1. The Standing Committee on the Environment's "Guidelines for Historic Bridge Rehabilitation and Replacement" reiterates the idea that the earliest reinforced concrete bridges can be important for both their technology and their aesthetics:

> For an early reinforced concrete arch bridge that is technologically significant, for instance, it is the arch ring that is important, not the standard-design railings or the roadway width. For another arch bridge that was designed to reflect the aesthetic tenets of the City Beautiful movement, it may be that all of the features, including the railings, are important and thus worthy of preservation in order to maintain historical significance.[139]

AASHTO also sponsored a report entitled "Best Practices and Lessons Learned on the Preservation and Rehabilitation of Historic Bridges" that chronicles the efforts of many states. It does not include Connecticut, New York or New Jersey in its case studies. While this report does

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[138] Congress.gov, Summary: H.R.2 — 100th Congress (1987-1988) https://www.congress.gov/bill/100th-congress/house-bill/2

[139] J. Patrick Harshbarger, Mary E. McCahon, Joseph J. Pullaro, Steven A. Shaup, Lichtenstein Consulting Engineers, Inc., In association with Parsons Brinckerhoff Quade & Douglas, Inc., "Guidelines for Historic Bridge Rehabilitation and Replacement" (NCHRP Project 25-25/ Task 19, National Cooperative Highway Research Program, Transportation Research Board. American Association of State Highway and Transportation Officials (AASHTO) Standing Committee on the Environment, 2007), A-10

not discuss the states, it does note that New York City does not have a resource management plan for historic bridges, a fact confirmed by Zephreny Parmenter, Historic Resources Coordinator at the New York City Department of Transportation.[140] The Seeley Street Bridge case study is located in Brooklyn, New York, and will be discussed in detail in a later chapter. Overall, the Federal Reports indicate that the process of historic bridge preservation is complex. Some parts are such as federal laws and inspection standards are centralized, while management and inspections themselves are decentralized.

Parts of Connecticut, New York, and New Jersey are often grouped together for studies of the New York City metropolitan area, but these states can also be compared against one another to elucidate their differences in state DOT bridge preservation policies. This three-state comparison shows that there can be variation among the states.

Connecticut Historic Bridge Preservation:

Connecticut's Historic Bridge Survey and Preservation Plan were originally published in 1990–91. Both are in the process of being updated, but will not be republished in the immediate future.[141] According to the Historic Bridge Survey, concrete arches in Connecticut were "experimental" until approximately 1920. The survey divides concrete arches into categories of those built in 1920 and earlier and those from 1921 and later, when the technology became more common.[142] If a concrete arch bridge dates to 1920 or earlier, it is "generally eligible" for the National Register, unless there are significant problems with its integrity, as is the case

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[140] Parsons Brinckerhoff, Inc., TranSystems, Inc., and Brelend C. Gowan, JD, "Best Practices and Lessons Learned on the Preservation and Rehabilitation of Historic Bridges," (NCHRP Project 25-25, Task 66, National Cooperative Highway Research Program, American Association of State Highway and Transportation Officials (AASHTO) Standing Committee on the Environment, July 2012), 36: Zephreny Parmenter, NYC DOT Historic Bridges, Telephone, March 26, 2021.

[141] Mark McMillan, Questions about Historic Bridges in Connecticut, Telephone, March 8, 2021.

[142] Connecticut DOT, "Connecticut Historic Bridge Survey: Inventory-Phase Final Report: Project Narrative, Inventory and Recommendations" (1990), 62–63.

elsewhere.[143] On the list, there are seventeen pre-1920 bridges that are eligible, and three that are not eligible, generally because they were built close to 1920 and are minor, plain, or have lost structural integrity. Some concrete arches are classified as "Simple Highway Concrete Arches," while others are "Decorative Concrete Arches."[144] Connecticut's Preservation Plan notes that the early arches themselves are what gives a bridge integrity as opposed to the later Merritt Parkway bridges, for which the significance is largely visual.[145] The Preservation Plan discusses the 1901 North Main Street Bridge in West Hartford, the oldest concrete arch in the state, and the third case study.[146] Neither the 1904 Hop Brook Bridge, considered in this essay, nor the recently demolished Liberty Street Bridge (1907) in Waterbury is included in the plan.

New Jersey Historic Bridge Preservation:

New Jersey's Historic Bridge Survey and Historic Bridge Database date to 1994, with database modifications from 2001. The Bridge Survey discusses definitions for the National Register of Historic Places and reviews a history of transportation and bridge building in New Jersey.[147] The database includes all structures longer than twenty feet constructed in 1946 and earlier.[148] This year is not significant in terms of reinforced concrete bridges; it was likely chosen

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[143] "Connecticut Historic Bridge Survey: Inventory-Phase Final Report: Project Narrative, Inventory and Recommendations," 62: Mead & Hunt et al, "Evaluation of National Register Eligibility: Task C3 of the Historic Bridge Inventory and Management Plan" NYS Dept. of Transportation (2012), 4–6. https://www.dot.ny.gov/divisions/engineering/environmental-analysis/manuals-and-guidance/epm/repository/HBI_Evaluation_of_Natl_Register_Eligibility.pdf

[144] "Connecticut Historic Bridge Inventory: Final Report: Preservation Plan," 26.

[145] "Connecticut Historic Bridge Inventory: Final Report: Preservation Plan," 174–175.

[146] "Connecticut Historic Bridge Survey: Inventory-Phase Final Report: Project Narrative, Inventory and Recommendations," 30.

[147] A. G. Lichtenstein & Associates, Inc. "The New Jersey Historic Bridge Survey" (New Jersey Department of Transportation Bureau of Environmental Services and The Federal Highway Administration New Jersey Division, September 1994, modifications-2001), 24.

[148] A. G. Lichtenstein & Associates, Inc. "The New Jersey Historic Bridge Database" (New Jersey Department of Transportation Bureau of Environmental Services and The Federal Highway Administration New Jersey Division With Modifications based on Consultation between The New Jersey Department of Environmental Protection Historic Preservation Office, The New Jersey Department of Transportation, and Others, Survey-Database Modifications-2001 1994), 2.

in the mid 1990s because the state took 50 years old as a minimum for historic structures. The bridges in the database are divided by counties, which are often the owners of the bridges. This stands in contrast to Connecticut, where public bridges are usually either municipal or state-owned. The survey discusses several early Melan-type arches, some of which are major spans such as the West Broadway Bridge, and others are smaller spans.[149] There are also some Monier-type bridges from the early 1900s. In 1906, the evolved Monier/Ransome type began to proliferate, with the technology becoming "commonplace" in New Jersey.[150] This date is earlier than Connecticut's and is indicative of a larger number of early concrete bridges in New Jersey. The database document is supposed to be updated regularly, but the version that is still available shows no update concerning the 2008 rehabilitation of the West Broadway Bridge in Paterson, which is a case study.[151]

New York Historic Bridge Preservation

New York State's Contextual Study of Historic Bridges, and Inventory and Management Plans date to 1999–2002.[152] The Contextual Study has one mention of Monier, and makes a brief reference to Ransome's Alvord Lake Bridge, but does not allude to specific bridges in New York which use their methodologies.[153] The study does discuss Melan, Thacher, and the Melan Arch Company, but does not discuss any early Melan arches in New York State.[154] New York's Historic Bridge Inventory and Management Plan identified both state and local bridges eligible

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[149] A. G. Lichtenstein & Associates, Inc. "The New Jersey Historic Bridge Survey," 65.
[150] Ibid., 65.
[151] Ibid., 2, 1397.
[152] Mead & Hunt, "Contextual Study of New York State's Pre-1961 Bridges" (New York State Department of Transportation, November 1999), https://www.dot.ny.gov/divisions/engineering/environmental-analysis/repository/bridgescontextuastudy-99.pdf: Mead & Hunt and Allee King Rosen & Fleming, Inc, "Evaluation of National Register Eligibility: Task C3 of the Historic Bridge Inventory and Management Plan," (Albany, New York: New York State Department of Transportation, Federal Highway Administration, January 2002), https://www.dot.ny.gov/divisions/engineering/environmental-analysis/repository/historicbridgemanagementplan.pdf.
[153] Mead & Hunt, "Contextual Study of New York State's Pre-1961 Bridges," 38.
[154] Ibid., 38.

for listing on the National Register.[155] The report identified a period of standardization of closed spandrel reinforced concrete bridges in New York as occurring between 1911 and 1926. There were twenty-nine filled-spandrel concrete arch bridges from before standardization, fifteen of which were recommended as eligible for the National Register.[156] It also recognized that filled-spandrel arches from before 1926 are part of the early period of standardization, before 1911, and are eligible "unless they have a significant integrity problem."[157] Bridges are not described individually; they are identified by an identification number, a region, county, eligibility criteria, and a simple explanation, most often "Dates to early period of standardization."[158] The eligible list does not include any of the case study bridges in New York. In the process of building the New York State Management Plan, Allee King Rosen & Fleming interviewed officials in several other states, including both Connecticut and New Jersey, to analyze their successes and failures in historic bridge preservation.[159] The report, prepared by the NYS DOT, considers only bridges managed by that department, or local governments, but not Federal facilities. The White Bridge and the Coach House Bridge are not mentioned in any NYS DOT documents because they are under federal jurisdiction, which is described in the following chapter. The Seeley Street Bridge is also not mentioned, but this is an error, which will be described in Chapter 7.

Summary

Each state has both a survey and a preservation plan. Connecticut's report is the oldest and is in the process of being updated. New Jersey's preservation plan provides the most information about each bridge, such as a bibliography of sources for bridges that have been

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[155] Mead & Hunt and Allee King Rosen & Fleming, Inc. "Evaluation of National Register Eligibility: Task C3 of the Historic Bridge Inventory and Management Plan," 2-1.

[156] Mead & Hunt et al. "Evaluation of National Register Eligibility," 4-7.

[157] Ibid., 4-6.

[158] Ibid., 4-8.

[159] Amy Squitieri and Mary Ebeling, "Historic Bridge Management: A Comprehensive Approach," (*CRM: The Journal of Heritage Stewardship* 1, no. 1, 2003).

researched. New York State's plan, while it does document a large number of bridges across the state, is lacking in its coverage of the earliest reinforced concrete arch bridges. It may not have taken full advantage of the earlier reports from the neighboring states. Both the Connecticut and New York historic bridge databases are missing bridges for different reasons that will be discussed as case studies. The three states have different dates by which they categorize their earliest reinforced concrete bridges: before 1905 for New Jersey, before 1911 for New York, and before 1921 for Connecticut. Additionally, Bergen County, New Jersey, and West Hartford, Connecticut, are both recognized for having embraced reinforced concrete bridge technology early on.[160] All three states have programs to provide funding to local governments for bridge repairs and rehabilitation. Most importantly, the examination of these state preservation policies and their effects on the case studies has led to the recommendations which are discussed in the Conclusion.

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[160] A. G. Lichtenstein & Associates, Inc. "The New Jersey Historic Bridge Survey," 105: "Connecticut Historic Bridge Survey: Inventory-Phase Final Report: Project Narrative, Inventory and Recommendations," 62.

Chapter 4: The White Bridge (1897) and the Coach House Bridge (1897)

There are two 1897 Melan-type reinforced concrete arch bridges located within the Vanderbilt Mansion National Historic Site in Hyde Park, New York, the White Bridge and the Coach House Bridge (also called the Rustic Bridge). Frederick William Vanderbilt commissioned both bridges, and they both span the Crum Elbow Creek at different sites, approximately 600 yards apart.[161] The estate has been in the care of the National Park Service (NPS) since 1940, and the two bridges are maintained by the NPS, with all bridge work managed by the Federal Highway Administration.[162] They are also both documented in the Historic American Engineering Record and both have been rehabilitated since 1998. Both the White Bridge and the Coach House Bridge are contributing structures listed on the State Register and the National Register. They are listed as historic structures in the 1979 Nomination for the Vanderbilt Mansion National Historic Site. In the report, the White Bridge is identified as an early Melan arch span, while the Coach House Bridge was simply described as a reinforced concrete bridge.[163] The White Bridge is listed as an example in the National Highway Research Council's "A Context for Common Historic Bridge Types" report, but the Coach House Bridge is not.[164] The White Bridge is a single arch with a concrete spandrel wall and balustrade, while the Coach House Bridge consists of two arches of different spans, and a stone spandrel wall and balustrade. These stylistic differences and the lack of recognition of the Coach House Bridge are fundamental considerations for this case study.

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[161] "Two Recent Melan Arch Bridges," *Engineering News*, November 10, 1898, 290.

[162] David J. Hayes, "Re: White Bridge Inquiry," Message to Thomas Rice, March 3, 2021, Email.

[163] Bronwyn Krog, "Vanderbilt Mansion National Historic Site," National Register of Historic Places Nomination, 1979, 5–6. http://npshistory.com/publications/vama/nr-vanderbilt-mansion-nhs.pdf

[164] Parsons Brinckerhoff et al., "A Context for Common Historic Bridge Types," 3–56.

Figure 4.1: The White Bridge, Hyde Park, N.Y. (1897). Source: *Engineering News*, November 10, 1898, 290.

Figure 4.2: The Coach House Bridge, Hyde Park, N.Y. (1897). Source: *Engineering News*, November 10, 1898, 290.

History and Significance

Although the bridges have been documented in a National Register Nomination and in two Cultural Landscape Reports (Vol. 1 prepared for the NPS in 1992, Vol 2. in 2009), these sources do not fully document their significance. Both the 1979 National Register Nomination and the 1992 Cultural Landscape Report note W. T. Hiscox and Co. of New York as the designer and builder of the White Bridge, and Norcross Brothers as the designer and builder of the Rustic Bridge or Coach House Bridge.[165] A second volume of the Cultural Landscape Report from 2009 writes that W. T. Hiscox designed and built the White Bridge while Norcross Brothers "apparently" designed and built the Coach House Bridge, as they had built most of the structures at the estate.[166] In contrast to these sources, an *Engineering News* article from 1899 describes both bridges as being "designed and superintended" by the Melan Arch Construction Co. of 35 Nassau Street in New York.[167] Additionally, an article in the *Engineering Record* from 1901 writes that the Rustic Bridge (the Coach House Bridge) was designed by the Melan Arch Construction Company and built by W. T. Hiscox & Company.[168] The National Register nomination and Cultural Landscape Reports make clear that Hiscox was involved in many landscaping projects on the estate, but they make no mention of the Melan Arch Construction Company. Although the Melan Arch Construction Company was associated with Fritz von Emperger and William Mueser, plans for both bridges show solid I-beams, rather than the von Emperger patent lattice beams (Figures 4.5, 4.6). Later, both bridges would be used in

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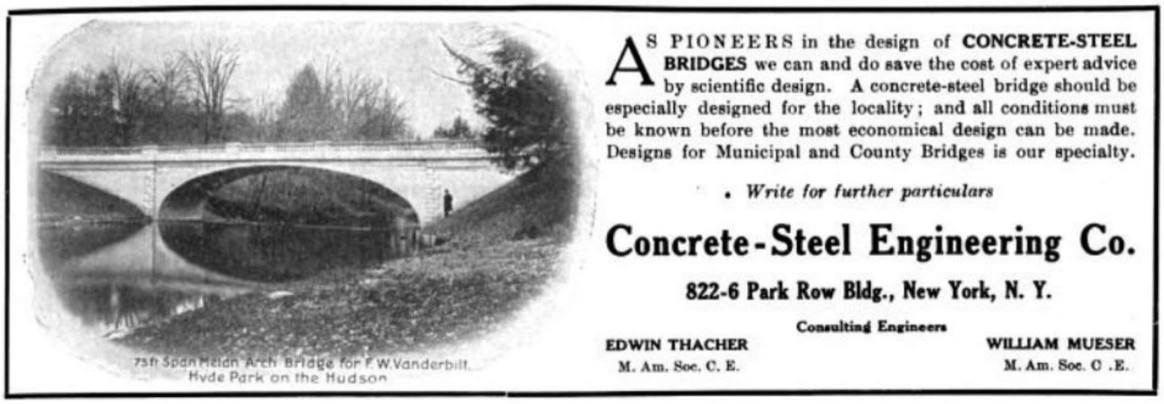
[165] Patricia M. O'Donnell, Charles A. Birnbaum, Landscapes, Inc. Landscape Architecture, Planning, Historic Preservation, and Cynthia Zaitzevsky, Ph.D., Zaitzevzky and Associates, Inc. "Cultural Landscape Report for Vanderbilt Mansion National Historic Site: Volume 1: Site History, Existing Conditions, and Analysis" (National Park Service, 1992), 114: Bronwyn Krog, "Vanderbilt Mansion National Historic Site," National Register of Historic Places Nomination, 1979, 5–6.

[166] John W. Hammond, "Cultural Landscape Report for Vanderbilt Mansion National Historic Site; Volume II: Treatment" (Boston, MA: Olmsted Center for Landscape Preservation, National Park Service, 2009), 30.

[167] "Two Recent Melan Arch Bridges" (*Engineering News*, November 10, 1898), 290.

[168] "A Private Park Arch Bridge" (*The Engineering Record*, January 14, 1899), 144.

advertisements for the Concrete-Steel Engineering Company, the successor firm of the Melan Arch Construction Company, which came to hold the Melan patents, as shown in Figure 4.3.[169]


75ft Span Melan Arch Bridge for F.W.Vanderbilt.
Hyde Park on the Hudson

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M. Am. Soc. C .E.

Figure 4.3: Advertisement featuring the White Bridge. Source: *Good Roads Magazine*, June 1909, 77.

Frederick William Vanderbilt was heavily involved in his family's railroad business, and many railroads built reinforced concrete bridges in the early 20th century. There is one known Melan-type railroad bridge that predates the Hyde Park spans, a Thacher design for the Michigan Central Railroad in Detroit in 1895.[170] It is unknown whether Vanderbilt was aware of this bridge, or if the use of Melan arches at Hyde Park is connected with their use for railroad bridges. It is quite possible that Vanderbilt was simply embracing the latest technology to build attractive bridges irrespective of its use for railroads.

These two Vanderbilt bridges are among the earliest reinforced concrete arch bridges in the United States, and it is notable that these early examples were privately built as part of an estate. The White Bridge carries the one-way Entrance Drive, after it passes through the monumental gates en route to the Mansion. The arch springs from close to the water level, with a span of 75 feet and a rise of 14 feet, 8 inches, as illustrated in Figure 4.5. One of the three dams

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[169] *Concrete-Steel Engineering Company, Successors to Melan Arch Construction Company, Consulting Engineers*. (New York: Concrete-Steel Engineering Company, 1904), 7, 22.
[170] Gasparini, "Development of Reinforced Concrete Arch Bridges in the U.S.: 1894-1904," 329.

W.T. Hiscox designed for the property[171] is directly under the White Bridge; the dams created ponds which "complement the architecture of the bridge."[172] The White Bridge features an urn-type balustrade (Figure 4.4), classical acanthus leaf ornamentation in concrete pots (Figure 4.8), and quoins framing the arch spandrel (Figure 4.11). The Coach House Bridge is off to the south side of the estate, and is in a more wooded and secluded location. It is uses fieldstone for its spandrel walls and cut stones on the arch rings. The pier of the bridge is constructed with a larger and rougher pointed stone than the spandrel walls (Figure 4.10). The Coach House Bridge is asymmetrical, with one span of 53 feet and one of 26 feet. Both have a rise of 7.5 feet, yet one springs from an abutment to the pier, the other from an outcrop to the pier, as illustrated in Figure 4.6. The *Engineering News* writes,

> The scenery at the two locations required very different artistic treatment to harmonize the structures with their surroundings. Mr. Vanderbilt, after extended investigation, finally selected the Melan system of concrete-steel arch construction, not only on account of its lower cost with equal permanence as compared with voussoir stone arches, but also because of the ready adaptation of this style of construction to the varying architectural treatment required in different locations.[173]

This difference in appearance is important in terms of the preservation of these bridges, as they are significant technologically as early Melan spans, and architecturally representations of different styles: one a formal classical design, the other a more informal and rustic look imitating a stone arch. The ornament of these bridges may be as important as their technology, as it varies so distinctly for two bridges built at the same time. Specifications (Figures 4.5–4.7) reveal that the beams in the single-span White Bridge are larger than those in the Coach House Bridge. The two bridges are likely the oldest Melan arches in New York State.

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[171] Hammond, "Cultural Landscape Report for Vanderbilt Mansion National Historic Site; Volume II: Treatment," 30.

[172] Ibid., 91.

[173] "Two Recent Melan Arch Bridges" (*Engineering News*, November 10, 1898), 290.

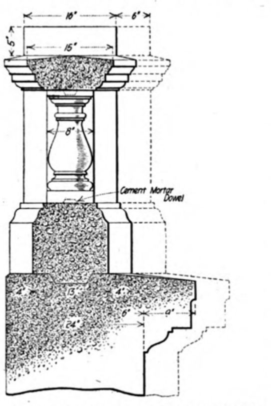

Figure 4.4: White Bridge Baluster. Source: *Engineering News,* November 10, 1898, page 291.

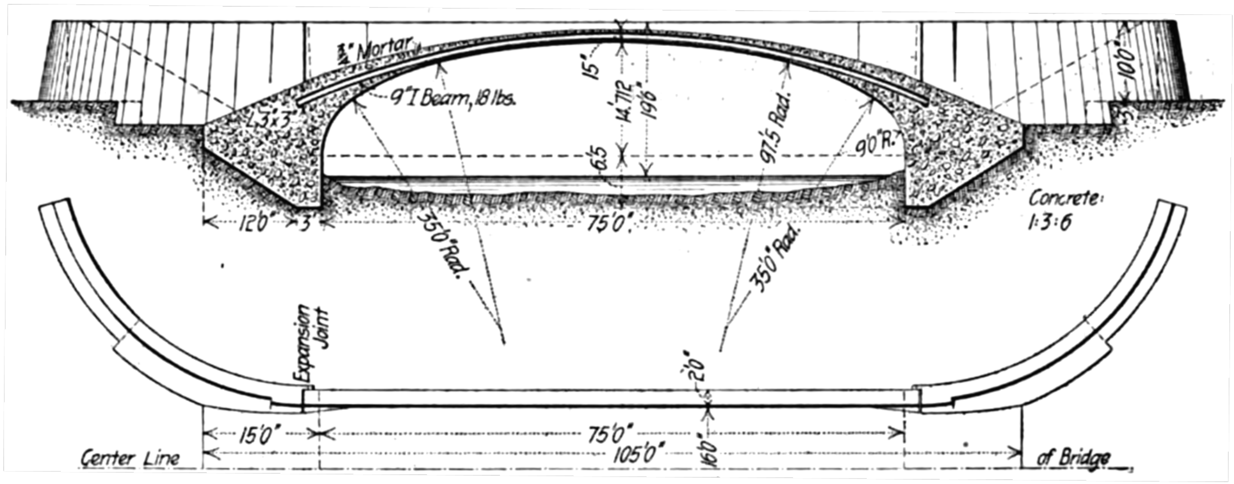

Figure 4.5: White Bridge Section. Source: *Engineering News,* November 10, 1898, 291.

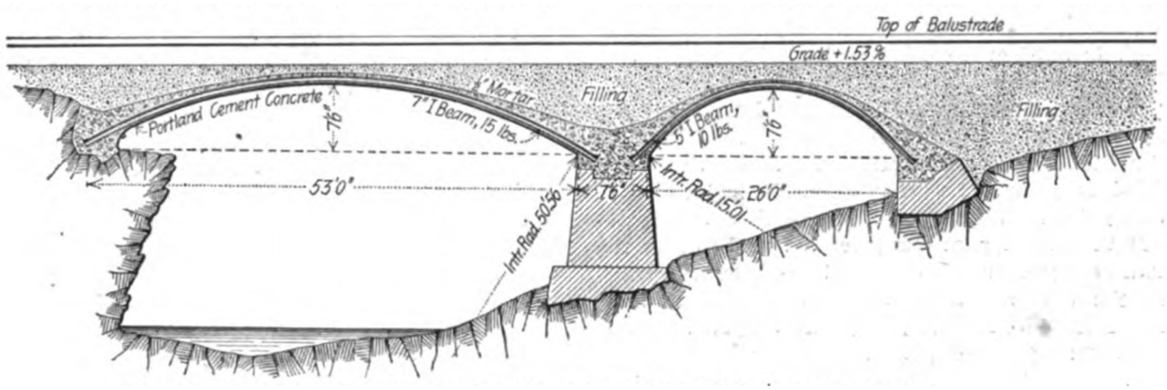

Figure 4.6: Coach House Bridge Section. Source: *Engineering News,* November 10, 1898, 291.

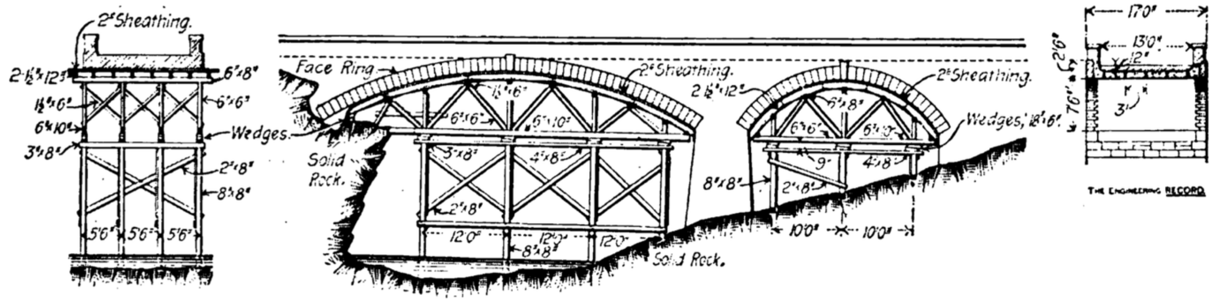

Figure 4.7: Coach House Bridge forms diagram. Source: *Engineering Record*, January 14, 1899, 144.

Repairs and Maintenance

The 1992 Cultural Landscape Report gives some details on repairs undertaken on the White Bridge by the National Park Service circa 1961–63:

> By 1961, it was evident that the White Bridge had suffered severe structural problems from water seeping into the concrete arch, a situation that was threatening the stability of the arch. The arch was waterproofed, the wing-walls supported with stone masonry, sub-surface drainage installed, and the exposed concrete repaired where needed. The road was also resurfaced over the bridge.[174]

This early work was under the auspices of the National Park Service, and as such would likely have followed the organization's standards for historic preservation. The NPS has plans and specifications in their archive, but it is closed due to the pandemic.

The 1992 Cultural Landscape Report continues to detail later 20th century work on the White Bridge. In 1973, the NPS cast twelve new planters for the balustrade from a mold of one of the original ones.[175] Figure 4.8 shows a planter and the balustrade with visible replaced elements. The road surface again became a point of failure for the bridge:

> The Main Entrance drive down to the White Bridge is asphalt, and has been re-topped several times. In this process the Vanderbilt era integrated concrete curb and gutter has been covered with asphalt so that a meager curb remains. The deteriorated curb system drains improperly causing some scouring and erosion on the adjacent turf. This problem continues downhill to cause erosion at each corner of the White Bridge where grading

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[174] O'Donnell et al., "Cultural Landscape Report for Vanderbilt Mansion National Historic Site: Volume 1: Site History, Existing Conditions, and Analysis," 237.

[175] O'Donnell et al., "Cultural Landscape Report for Vanderbilt Mansion National Historic Site: Volume 1: Site History, Existing Conditions, and Analysis," 247.

> and drainage have changed over time and are causing erosion into the Crum Elbow Creek. In June of 1992 a short-term solution was effected through the installation of a formed asphalt curb that will control runoff.[176]

This problem is likely one faced by other historic concrete bridges, in which layers and layers of asphalt have compromised original drainage schemes. Figure 4.9 shows the White Bridge and the asphalt drive from the Main Entrance. In this case, the importance of the bridge was recognized when determining a course of action. The report notes that the bridge will require a major upgrade, and recommends the following:

> The Condition of the White Bridge requires monitoring. Upgrading of the structure and weight capacity will be required in the near future. When the project is undertaken it should address the safety needs while retaining the maximum amount of historic bridge fabric possible. This may be achieved by reconstructing the bridge deck while repairing the side walls and facades.[177]

Figure 4.8: White Bridge Balustrade, January 2021.

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[176] O'Donnell et al, 268.

[177] O'Donnell et al., 354.

Figure 4.9: Main Entrance Drive, January 2021.

The 1998 rehabilitation of the White Bridge involved an extensive scope of work and was documented by the NPS. As with all road projects on Park Service properties, the Federal Highway Administration designed the project.[178] In the course of the restoration, the pavement was removed, and a total of 3.5 inches of concrete was removed from the extrados. Waterproof membranes were installed and cracks were sealed.[179] The description of the repair indicates that the arch is still intact, as it called for removing less than four inches of material. This repair may have exposed the I-beams in the process of restoration, but it clearly did not remove them, or significantly alter the structure of the bridge.

When the second volume of the Cultural Landscape Report was published in 2009, it had been more than ten years since the restoration of the White Bridge. The author denotes White Bridge Preservation as Task 1.2, and it is given a high priority.[180] The report observes that the bridge was restored in 1998 using "both new and original material," and recommends the

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[178] David J. Hayes, "Re: Vanderbilt Mansion Archives Records: 1998 Bridge Restoration," Email, March 26, 2021.
[179] Ibid.
[180] Hammond, "Cultural Landscape Report for Vanderbilt Mansion National Historic Site; Volume II: Treatment," 118.

following: “Continue to monitor the condition of the bridge, making repairs and replacements in kind when necessary. Keep the bridge free of weeds, moss, lichens, and stains.”[181]

The Coach House Bridge is in a much less prominent location, a wooded area (Figures 4.10, 4.11). The NPS also rehabilitated the Coach House Bridge within the last decade, after the 2009 Cultural Landscape Report, although the file on that rehabilitation has not been located.[182] The 2009 Cultural Landscape Report references the Coach House Bridge but does not discuss or evaluate its preservation individually.

Figure 4.10: Coach House Bridge, January 2021.

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[181] Ibid., 88.

[182] David J. Hayes, “Re: Vanderbilt Mansion Archives Records: 1998 Bridge Restoration,” Email, March 11, 2021.


Figure 4.11: Coach House Drive over the Coach House Bridge, January 2021.

Current Conditions

Both bridges have been rehabilitated in the recent past. There is significant cracking and evidence of moisture penetration visible on the spandrel walls of the White Bridge. There is also evidence of color mismatching on replaced parts of the balustrade (Figures 4.12, 4.13). These conditions indicate that the bridge may require further work to prevent moisture intrusion into the arch. The Coach House Bridge intrados is painted white, and it is unclear whether this is an original feature as the intrados is in shadow in Figure 4.2. Some runoff of the white color is visible in Figure 4.14.


Figure 4.12: The White Bridge, January 2021.


Figure 4.13: The White Bridge, January 2021.

Figure 4.14: The Coach House Bridge Pier, January 2021.

Analysis

The White Bridge and the Coach House Bridge serve as examples of a well-documented and preserved historic bridges, although they are not without challenges. The Coach House Bridge or Rustic Bridge is arguably as important as the White Bridge, although it has not been identified as such in contemporary documentation. Due to its location in a “rustic” part of the estate, it features a less formal stylistic treatment, but it is still an important landmark.

This example indicates that if a reinforced concrete arch bridge maintained by the National Park Service can still be underrecognized, this can easily happen with bridges elsewhere.

The two Vanderbilt Estate bridges present with the seven components of integrity outlined in the National Register Bulletin and specified for bridges in the “DRAFT Secretary of Interior’s Standards for Bridges in Pennsylvania” document. For both bridges, the character defining features are both the arch reinforcement and the disparate aesthetic treatments. The locations and settings of both bridges are maintained to closely represent the appearance at the time of their construction—the landscaped entrance drive for the White Bridge, and the rustic woodland road for the Coach House Bridge. The original materials are largely intact in both bridges, although some replaced concrete elements are visible on the White Bridge. Both bridges maintain their original designs, both stylistically and technologically. Both have evidence of the original workmanship and feeling, as their forms are unchanged since construction. Finally, both bridges are directly connected to their commissioner, Frederick William Vanderbilt, the Melan Arch Construction Company, and W. T. Hiscox. In publications and in future restoration work, the important provenance of the White Bridge and the Coach House Bridge should be recognized.

The New York State historic bridge survey did not evaluate or even list either of these bridges, because they are maintained by federal agencies, the National Park Service and the Federal Highway Administration. This arrangement serves as an example of different bodies maintaining their own bridges and failing to communicate or cross-reference their data. An individual trying to identify the oldest reinforced concrete bridges in New York State might not find these bridges if they were only to consult the New York State bridge inventory. The bridges should be recognized as the oldest reinforced concrete arch bridges in New York State.

Chapter 5: The West Broadway Bridge (1898)

The West Broadway Bridge (originally the West Street Bridge) was built between 1897 and 1898 to carry West Street, now West Broadway, over the Passaic River in Paterson, N.J. The bridge is 282.5 feet long, and consists of three arches: the center span is 89 feet, while the two outer spans are 88.25 feet, with a rise of 9 feet, 5 inches, and a crown thickness of 15 inches (the three spans are shown in Figure 5.1).[183] It was designed by Edwin Thacher, using the Melan system and the Melan Arch Construction Company patents.[184] At the time of construction, Thacher was in a partnership with W. H. Keepers, which lasted until 1899.[185] The bridge is maintained by Passaic County and has been determined to be eligible for the State Register and the National Register by the New Jersey SHPO.[186] It is also a contributing structure to the Great Falls/Society for Establishing Useful Manufactures Historic District.[187] The Society for Establishing Useful Manufactures was a public–private entity founded to harness the power of the Great Falls and the Passaic River for industry.

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[183] "Three-Span Melan Arch Bridge Across the Passaic River, Paterson, N.J." (*Engineering News*, March 16, 1899), 175.

[184] "Three-Span Melan Arch Bridge Across the Passaic River, Paterson, N.J.," 175.

[185] G.M. Zamiskie and J.G. Chiara, "Rehabilitation of the West Broadway Bridge over the Passaic River, Paterson, New Jersey" (*Sustainable Bridge Structures: Proceedings of the 8th New York City Bridge Conference, 24-25 August, 2015, New York City, USA*, K. Mahmoud (Ed.), CRC Press, 2015), 317.

[186] A. G. Lichtenstein & Associates, Inc. "The New Jersey Historic Bridge Database," 1397.

[187] G.M. Zamiskie and J.G. Chiara, "Rehabilitation," 316.

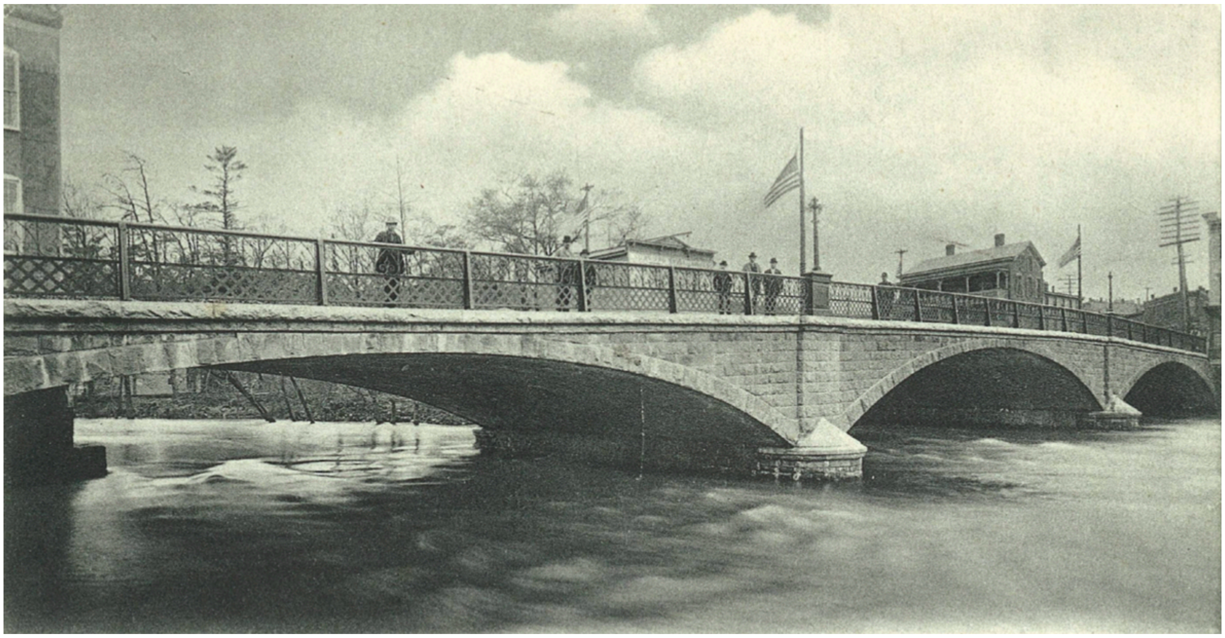

Figure 5.1: Historic Postcard Image, c.1900. Source: "Rehabilitation of the West Broadway Bridge over the Passaic River, Paterson, New Jersey," 318.

History and Significance:

The West Broadway Bridge was a technologically advanced bridge at the time of its construction; it was the second longest Melan-type bridge in the country.[188] Like the White Bridge and the Coach House Bridge, it was featured in *Engineering News*.[189] Taylor and Thompson also list a Melan-type bridge in Paterson with a 54-foot span, which was the now-demolished 1902 Arch Street Bridge.[190] The West Broadway Bridge spandrel walls are built with New Jersey brownstone, and it originally featured three-inch iron pipes within its superstructure for water drainage. The foundation for the southern pier necessitated the use of pilings, while the foundations for the northern pier and the two abutments did not require them. The bridge originally featured a double track electric railway running down its center.[191] Its use of a shallow Melan arch allows the bridge to maintain the grade on either side of the river. Figure

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[188] A. G. Lichtenstein & Associates, Inc. "The New Jersey Historic Bridge Database," 1397.
[189] "Three-Span Melan Arch Bridge Across the Passaic River, Paterson, N.J.," 175.
[190] Taylor and Thompson, *A Treatise on Concrete* (1907), 546: "Reinforced Concrete Highway Bridges in New Jersey" (*The Engineering Record*, September 10, 1904), 303.
[191] "Three-Span Melan Arch Bridge Across the Passaic River, Paterson, N.J.," 175.

5.2 shows a longitudinal section of one of the spans, featuring a large concrete abutment, interconnected I-beams, and earth filling above the arch ring.

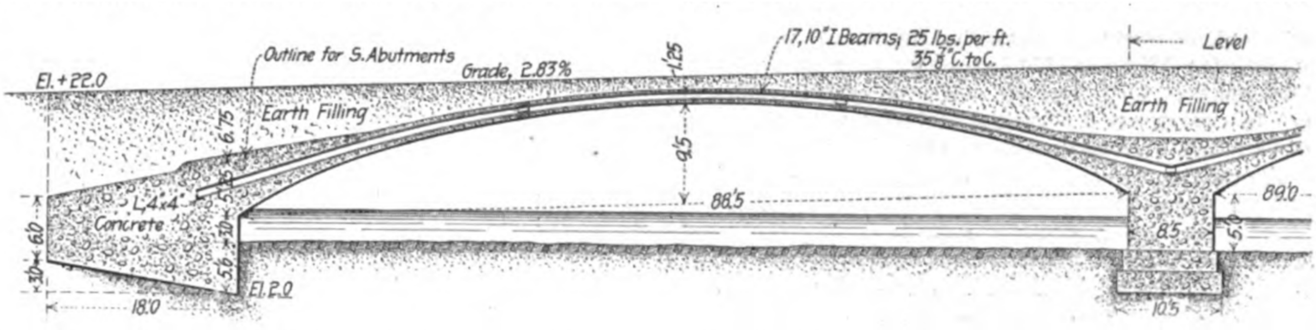

Figure 5.2: Section of the West Street Bridge. Source: *Engineering News*, March 16, 1899, page 175.

The bridge became an important thoroughfare in Paterson. The area around the bridge was built up in the 19th and early 20th centuries, but many of the surrounding structures were removed as part of urban renewal campaigns in the 1960s and 70s.[192] Today, there is a high-rise subsidized housing complex near one side of the bridge, and parking lots on the other side (Figure 5.3). Despite the loss of surrounding historic fabric, the bridge remains a highly visible historic structure, with signage for public awareness (Figure 5.4). The bridge also crosses an island in the center of the river; the two sides of the island are visible in Figures 5.3 and 5.5.

Figure 5.3: A portion of the southwest side of the West Broadway Bridge, January 2021.

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[192] G.M. Zamiskie and J.G. Chiara, "Rehabilitation," 317.

Figure 5.4: Plaque with bridge details, January 2021.

Figure 5.5: The northwest side of the West Broadway Bridge, January 2021.

The significance of the West Broadway Bridge has been recognized in the New Jersey bridge inventory. The bridge was evaluated by the New Jersey Historic Preservation Office and determined to be individually eligible for the National Register of Historic Places in 1995.[193] It was also determined eligible for the New Jersey Register of Historic Places in 2002.[194] The 2002

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[193] A. G. Lichtenstein & Associates, Inc. "The New Jersey Historic Bridge Database," 1404.

[194] City of Paterson, https://www.patersonnj.gov/egov/documents/1395859208_441833.pdf

report in the New Jersey Historic Bridge database notes the bridge is "one of the most technologically significant steel and concrete bridges in the state based on its designer, type, date, and state of preservation."[195] These determinations allow for a clear evaluation of any subsequent preservation or rehabilitation efforts.

Repairs and Maintenance

The bridge underwent a major repair a few years after its construction, as a result of significant floods of the Passaic River in 1903. The West Broadway Bridge was unharmed in the major flood of 1902, but two out of the three spans were compromised in the 1903 flood.[196] In both northern and central spans, about one third of the width of the bridge was destroyed on the upriver section (Figure 5.6). The southernmost arch was completely unharmed.[197] These sections were "repaired in kind at the time."[198]

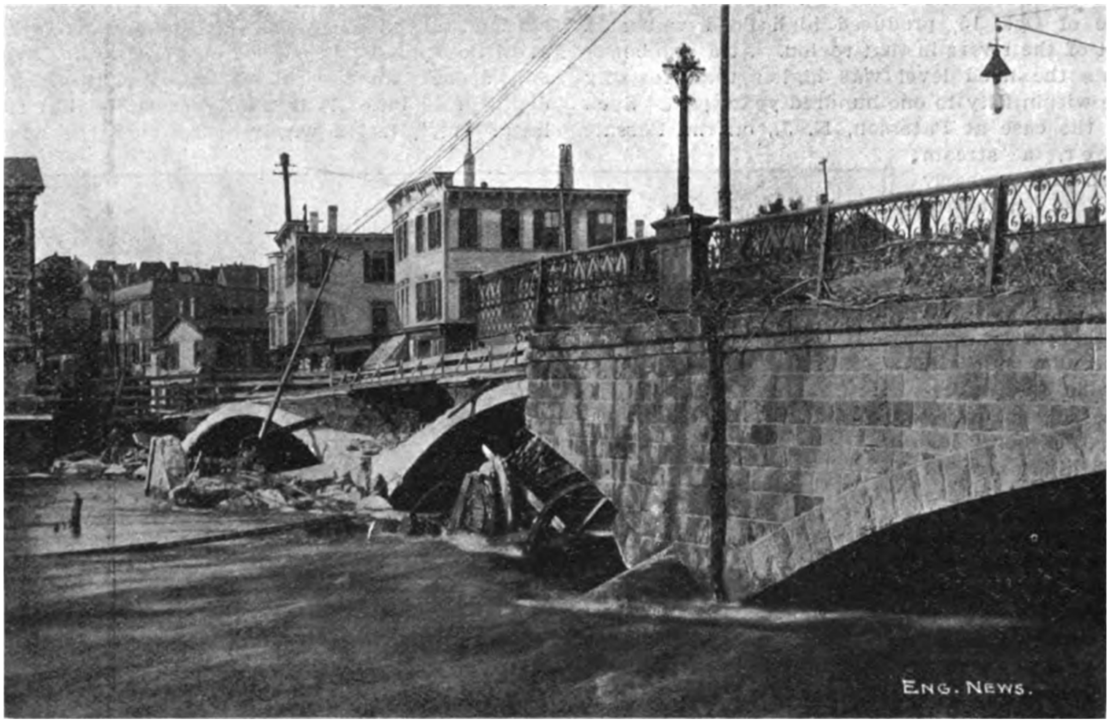

Figure 5.6: Damage from the 1903 Flood. Source: *Engineering News*, October 29, 1903, 378.

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[195] A. G. Lichtenstein & Associates, Inc., "The New Jersey Historic Bridge Database," 1404.
[196] "Flood Damage to Bridges at Paterson, N.J." (*Engineering News*, October 29, 1903), 378.
[197] "Flood Damage to Bridges at Paterson, N.J.," 378.
[198] A. G. Lichtenstein & Associates, Inc. "The New Jersey Historic Bridge Database," 1404.

Passaic County completed a $5.2 million rehabilitation of the structure in 2008.[199] The county hired TranSystems Corporation, and a study of existing conditions and possible solutions began in 1999. At that time, the bridge was classified as structurally deficient according to an NBIS report.[200] I-beams were corroded and partly exposed on the intrados, indicating moisture intrusion throughout the arch. TranSystems began the design process in 2004, and construction in 2006.[201] G.M. Zamiskie and J.G. Chiara of TranSystems published a report on the project as part of proceedings from the Eighth New York City Bridge Conference in 2015. The report notes that rehabilitation was determined to be the prudent and feasible course of action, and that the project complied with the Secretary of the Interior's Standards for the Treatment of Historic Structures, although it does not discuss specifically how it did so.[202]

The rehabilitation was extensive, involving work on the arch, abutments, and bridge piers. The new design added a cast-in-place relief arch several inches above the original arch, which now bears the weight of the road.[203] This course of action was chosen because with no detailed original plans surviving, the concrete depths and shape of the original arch were unknown, and it would be difficult to calculate load sharing in a combined construction. It is possible that the combined arch may have spurred further deterioration of the original arch.[204] The new arch increased the necessary height of the spandrel wall at the crown, and is hidden with two courses of granite slabs, which were added underneath the capstones on the spandrel

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[199] G.M. Zamiskie and J.G. Chiara, "Rehabilitation," 315.
[200] Ibid., 321.
[201] Ibid., 315.
[202] Ibid., 322.
[203] Ibid., 323.
[204] Ibid., 324.

wall, creating a “discreet” feature that “expresses where new fabric has been placed.”[205] This new course of granite is visible underneath the capstones in Figure 5.7.

Another important feature of this bridge is the new railing (Figure 5.7). The railing design is based on photos of the original railing, which was lost in 1937 or earlier. The reconstruction features rivets and square bolts to simulate the turn of the century construction methods, while the end posts of the new railing are cast from the surviving originals.[206] The report credits Passaic County for its commitment to the rehabilitation, including the reconstruction of the original ornamental pedestrian railings.[207] This serves as an important example because, as discussed earlier, reconstructions are uncommon with historic bridges.

Figure 5.7: West Broadway Bridge, central and southern spans, January 2021.

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[205] Ibid., 324.
[206] Ibid., 326.
[207] Ibid., 315.

Analysis

The West Broadway Bridge serves as an example of successful rehabilitation, applying the Secretary of the Interior's Standards to historic reinforced concrete arch bridge. First and foremost, this meant keeping historic features while allowing the bridge to serve its modern role. The character defining features of this bridge are both its shallow Melan-type arches and its New Jersey brownstone spandrel wall. The 2008 rehabilitation preserved these character defining features, and the addition of the reconstructed railing further enhances the integrity of the structure. Although the added course of granite has slightly changed the profile of the bridge deck, the three arch intradoses maintain their original form. The height added to the bridge spandrel is visible, and yet subtle. The reconstructed railings add to the historic sense of the bridge for pedestrians and vehicles alike. Along with the brownstone spandrel walls, they are very important for this bridge, which could be classified as part of the City Beautiful Movement. The association with Edwin Thacher, concrete-steel construction, and the Melan patent is also preserved. The signage placed along the bridge makes clear its significance for the public. The West Broadway Bridge serves the busiest roadway of all the case study bridges, and it shows that preservation is possible even for a structure with dense traffic patterns. The project is a successful rehabilitation of a historic structure, allowing it to continue in operation as a modern road into the future.

Chapter 6: The North Main Street Bridge (1901)

The North Main Street Bridge was commissioned by the town of West Hartford, Connecticut, in 1901. It carries North Main Street over the West Branch of the Trout Brook, and has remained a municipally-owned structure. The bridge consists of three 15-foot spans with two foot rises, approximately two foot crown thickness, and an overall length of 78 feet.[208] It was designed by local civil engineer Algernon B. Alderson and built by the Hartford Paving and Construction Company.[209] It was included in the 1991 Connecticut Preservation Plan, and was determined to be eligible for the National Register under both Criterion A and Criterion C (see below).[210] It is currently in the process of being rehabilitated, although it has not been subject to either Section 106 or Section 4(f) review.[211] The appearance of the new west side of the bridge elevation raises questions about whether the rehabilitation would conform to the Secretary of the Interior's Standards for the Treatment of Historic Properties.

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[208] Matthew Roth and Bruce Clouette, "Historic Bridge Inventory Form: Bridge 3651" (Connecticut Department of Transportation, 1990): Stacey S. Vairo, "State Level Documentation, Bridge No. 3651, North Main Street Crossing West Branch of Trout Brook, West Hartford, Hartford County, Connecticut," February 2021.

[209] Roth and Clouette, "Historic Bridge Inventory Form: Bridge 3651."

[210] Roth and Clouette, "Historic Bridge Inventory Form: Bridge 3651."

[211] Mark McMillan, Questions about Historic Bridges in Connecticut, Telephone, March 8, 2021.

Figure 6.1: The eastern side of North Main Street Bridge, January 2021.

History and Significance:

The 1991 Connecticut Preservation Plan notes, “This is the earliest known surviving concrete bridge in Connecticut; in fact, it was probably among the first built in the state, since the Town of West Hartford's concrete bridge program was considered pioneering at the time.”[212] The report notes that there are no similar structures in the preservation plan from such an early date. West Hartford had a concrete bridge program before other municipalities, and this was the first concrete bridge in West Hartford.[213] The town does not have any original plans or specifications for the bridge.[214] Before the bridge was built, there were multiple mills in the area, and a wooden bridge crossed over the Trout Brook. The construction of the North Main Street Bridge was completed quickly, and was noted for its financial savings.[215] For these reasons, the

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[212] “Connecticut Historic Bridge Inventory: Final Report: Preservation Plan” (Connecticut Department of Transportation, Office of Environmental Planning, May 1991), 173.

[213] Roth and Clouette, “Historic Bridge Inventory Form: Bridge 3651.”

[214] Stacey Vairo, Email, February 1.

[215] Stacey S. Vairo, “State Level Documentation, Bridge No. 3651, North Main Street Crossing West Branch of Trout Brook, West Hartford, Hartford County, Connecticut,” February 2021.

bridge is eligible for the National Register under both Criterion A and Criterion C, for its connection with important historical events in addition to the details of its construction.

The design of the bridge is simpler than the previous two case studies, although still significant because of its early date of construction. The three symmetrical arches are shallow. The spandrel walls feature an incised line in the concrete that follows the curve of each arch, and concrete railings featuring recessed panels (Figure 6.1).[216] These spandrel walls are not original to the bridge, as illustrated by Figures 6.1 and 6.2. The bridge designer, A. B. Alderson, described gas pipes being used as railings on the bridge when it was constructed, and these are visible in Figure 6.2. One of the engineers from the Hartford Paving and Construction Company noted that the arches were "the longest, shallowest arches his company had ever built without using reinforcing steel."[217] This comment, quoted by researchers at the Public Archaeology Survey Team, suggests the possibility that plain concrete arches were used. The bridge is significant whether or not it has steel reinforcement, because the use of concrete alone was novel. Figures 6.3 and 6.4 show the wooden forms used in the construction of the arches and the deck.

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[216] Roth and Clouette, "Historic Bridge Inventory Form: Bridge 3651."

[217] Public Archaeology Survey Team, "Connecticut's Historic Concrete Bridges: North Main Street Bridge, Bridge No. 3651," n.d. http://web.archive.org/web/20110607205650/http:/www.past-inc.org/historic-bridges/concrete-no.mainst.html


Figure 6.2: The North Main Street Bridge in 1901. Source: Town of West Hartford, we-ha.com

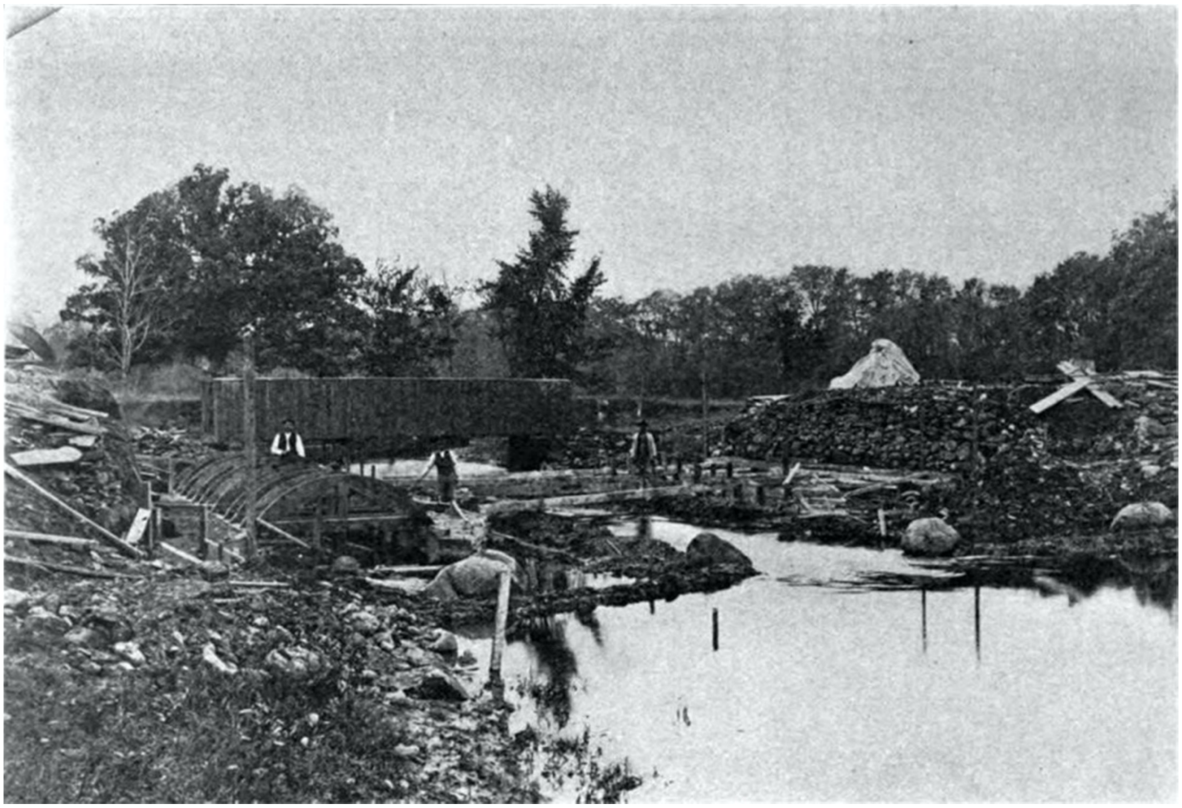
Figure 6.3: Bridge construction, 1901. Source: Town of West Hartford, we-ha.com.

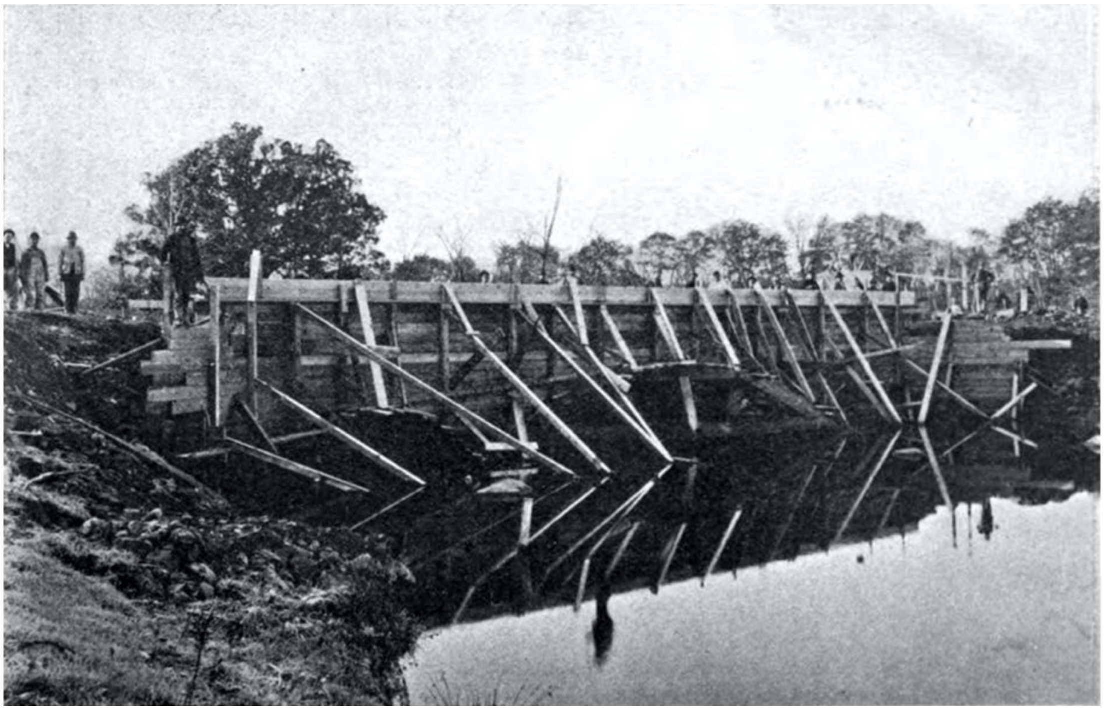
Figure 6.4: Bridge construction, 1901. Source: Town of West Hartford, we-ha.com.

Repairs and Maintenance

Historic photos and documentation show that the bridge has been altered since its construction in 1901 (Figures 6.1, 6.2). The West Hartford town engineer believes the concrete parapet railings date to circa 1930–40 when the street was widened.[218] According to the recent State Level Documentation Report, there is "no physical evidence" that the bridge itself was widened.[219] The added reinforced concrete railings are a red or brown color and appear to be monolithic with the façade. It is clear that the entire side of the bridge was modified because Figure 6.2 shows a deep lip at the road deck and wing walls, which do not appear in the later photos of either the east or west sides of the bridge. The removal of the wing walls indicates that the bridge was probably widened when the new spandrel walls and railings were added. There is evidence of rebar within the piers, abutments, and railings in the widened part of the bridge

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[218] Vairo, "State Level Documentation, Bridge No. 3651."
[219] Ibid.

(Figure 6.7). It is possible that the main bridge structure does not use rebar, and it was included for the first time when the new spandrel walls were added in the 1930s.

On the west side, the bridge features “debris fins,” also known as cutwaters, on the two piers.[220] Figures 6.6–6.8 show this portion of the bridge over a period of more than twenty years, including significant deterioration of the spandrel wall between 1990 and 2018, and the completed replacement in 2021. In Figure 6.7, sets of steel reinforcement bars running from the pier around the arch are exposed.

Figure 6.6: The western spandrel wall, photographed in 1990. Source: 1990 CT DOT Historic Bridge Inventory Report, Bridge 3651.

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[220] Vairo, “State Level Documentation, Bridge No. 3651.”

Figure 6.7: Damage to the western spandrel wall, 2018. Source: CT DOT Update of 1991 Connecticut History Bridge Inventory, Bridge 3651.

Figure 6.8: The west spandrel wall after reconstruction, January 2021.

The bridge engineer, A. B. Alderson, described using different concrete mixing ratios for the foundations and spandrel walls and for the arches themselves.[221] The 2021 State Documentation Report speculates that this could explain why the arches are in good condition, but the spandrel walls are not.[222] This could be part of the problem, although the spandrel walls were added long after Alderson's initial work on the bridge.

Current Condition

The rehabilitation of the bridge is ongoing (Figure 6.9), with plans prepared by an engineer from Tectonic Engineering.[223] In March 2018, the bridge was inspected and determined to be in poor condition, with a sufficiency rating of 48.2, just less than the rating of 50 required for federal rehabilitation funding.[224] The west spandrel wall has already been replaced as of January 2021 (Figure 6.10), and the contractor is beginning work on the east façade in Spring 2021.[225] The replacement material is concrete, designed to simulate rubble stone. While this is historically inaccurate, the spandrel does allude to the concrete nature of the arches, as there is a band of concrete that approximates each arch, although it incorrectly simulates a keystone. (Figures 6.7, 6.9). The simulated rubble stone filling and keystone, spurious in themselves, have no relation to the earliest or later historical materials and appearance of the bridge; neither does the concrete and shiny steel railing.

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[221] Vairo, "State Level Documentation, Bridge No. 3651."

[222] Vairo, "State Level Documentation, Bridge No. 3651."

[223] Jeff Scala, "North Main Street Bridge," Email, January 18, 2021.

[224] BridgeReports.com National Bridge Inventory Data. "NORTH MAIN STREET over WEST BRANCH TROUT BROOK," n.d. https://bridgereports.com/1074453.

[225] Jeff Scala, "Re: North Main Street Bridge," Email, March 12, 2021.

Figure 6.9: The roadway looking south with temporary Jersey barriers, January 2021.

Figure 6.10: The west side of the bridge after reconstruction, January 2021.

Analysis

The work on the North Main Street Bridge is a rehabilitation in terms of bridge engineering, but not in terms of historic preservation. The bridge is being rehabilitated to bring it up to specifications and prevent further deterioration. This process is preserving the original concrete arches, but it is not applying the Secretary of the Interior's Standards for Preservation. As a municipally funded project, the North Main Street Bridge was reviewed under the Connecticut Environmental Policy Act (CEPA), but not under Section 106 or Section 4(f).[226] The review process has allowed the current plans to move forward. With this background, it follows that the bridge is being rehabilitated in a manner which conserves only the arches, and no other historic fabric. It would have been preferable for there to have been increased communication between the DOT, SHPO, and the Town of West Hartford as it undertook this rehabilitation. Additionally, the availability of documents discussing varying definitions of rehabilitation, and the application of the Secretary of the Interior's Standards to historic bridges may have helped to change this situation.

As the oldest concrete arch bridge in the state of Connecticut, it would have been preferable for the rehabilitation to adhere to the Secretary of the Interior's Standards. If the Standards were followed, a decision would have to be made either to rehabilitate and restore the 1930s–40s spandrel walls and railings, or to restore and partly reconstruct to achieve the original 1901 appearance as shown in Figure 6.2. One argument would be to restore the 1930s–40s spandrel walls because they have characterized the bridge for most of its existence. The other choice might be more appropriate for the significance of this bridge because, as the oldest extant concrete arch bridge in the state, the original design is most significant. The CT DOT

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[226] Mark McMillan, Questions about Historic Bridges in Connecticut, Telephone, March 8, 2021.

Preservation Plan categorizes this bridge as a “Simple Highway Concrete Arch” as opposed to a “Decorative Concrete Arch.”[227] Returning to an original design is not unprecedented, the reconstructed railings of the West Broadway Bridge show. Close examination of Figure 6.2 shows the 1901 appearance would highlight the arch dimensions, with a thinner deck and railings which were not solid. The railing would require modifications for safety. While it is too late to incorporate these ideas in the current rehabilitation of the North Main Street Bridge, they are applicable to other bridges of the type.

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[227] “Connecticut Historic Bridge Inventory: Final Report: Preservation Plan,” 26.

Chapter 7: The Seeley Street Bridge (1903)

The Seeley Street Bridge is a single-span reinforced-concrete arch bridge, which carries Seeley Street over Prospect Avenue in Brooklyn, New York (Figure 7.1). It is located in the Windsor Terrace neighborhood, between Prospect Park and Green-Wood Cemetery. The bridge was built in 1903 (completed January 1, 1904) as part of the city's efforts to improve the street grid. It was designed by E. J. Fort, an Assistant Engineer in the Brooklyn Department of Highways, and built by Donato Cuozzo & Co.[228] The New York State Cultural Resource Information System (CRIS) lists it as not eligible for the National Register of Historic Places, as a result of NY DOT's "Evaluation of National Register Eligibility" report, although the New York SHPO has never evaluated the bridge.[229] This bridge has all seven components of integrity, and is highly significant as the oldest reinforced concrete arch bridge in New York City. It is also notable for its bar and stirrup reinforcement using corrugated steel bars. However, because the bridge's dating has been misunderstood following a 1930 subway project, the Seeley Street bridge has not received the preservation review its true age and significance warrant.

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[228] "A Concrete Arch Bridge with Bar and Stirrup Reinforcement" (*Engineering News*, December 31, 1903), 589: "No, The Builder of Seeley St. Bridge Is Not Forgotten" (*The Brooklyn Daily Eagle*, June 22, 1952), 19.

[229] Linda Mackey, "RE: Seeley Street/Prospect Ave Bridge 'Not Eligible' Determination," March 29, 2021; New York Cultural Resource Information System, https://cris.parks.ny.gov (The determination is only shown when "DOT BINs" is selected within the CRIS menu).

Figure 7.1: The north side of the Seeley Street Bridge over Prospect Ave, January 2021.

History and Significance

The Seeley Street Bridge is likely the oldest extant reinforced concrete bridge in New York City. In the 1907 *Proceedings* of the Municipal Engineers of New York, George W. Tillson, City Engineer for the Borough of Brooklyn, said, “This bridge was probably the first large piece of reinforced concrete work in bridges that was built in New York City.”[230] Tillson describes the bridge’s original newel post railings, and its ornamental stairway, with bronze light posts and railings. He even notes deterioration from soon after completion:

> The bridge is not in a very fashionable locality and 24 hours after the first globe was put up the boys in that vicinity broke it and we put up more, but those did not last much longer, and finally bronze gratings were made to cover the globes. These, however, only lasted a week or two when they were knockt [sic] to pieces. Then I decided that such ornamental work was a little too much in advance of the community and we would wait before placing any more.[231]

The description indicates that this bridge was a point of pride for the city, as it was outfitted with fine ornamental details, both in the concrete and in the bronze metal work, shown in Figure 7.2.

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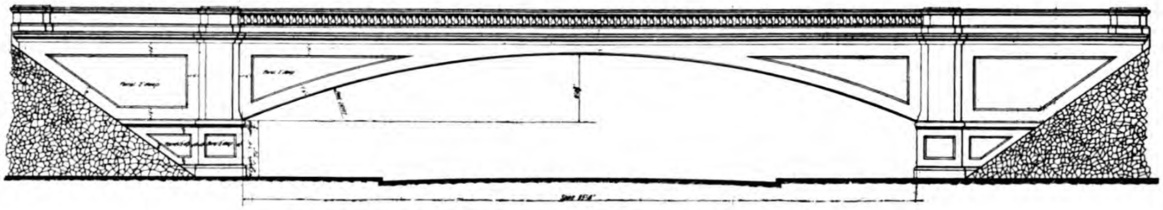
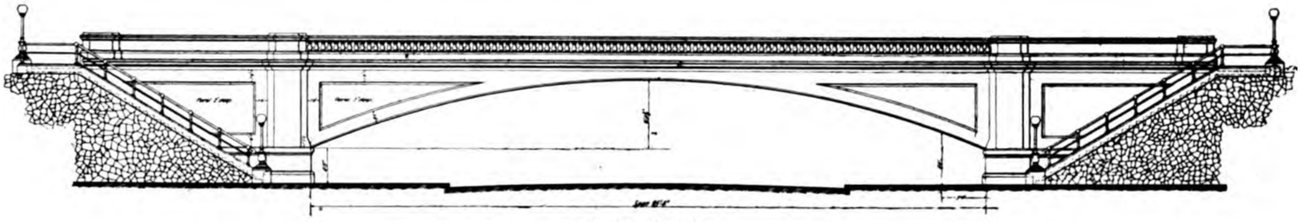
[230] Publication and Library Committee, ed., *The Municipal Engineers of the City of New York: Proceedings for 1907* (New York: The Municipal Engineers of the City of New York, 1908), 18–19.

[231] Ibid., 19.



Elevation South Face



Elevation North Face

Figure 7.2: North and South Elevations of the Seeley Street Bridge. Source: *The Municipal Engineers of the City of New York: Proceedings for 1907*, Plate 4.

At the time of the bridge's construction, rebar and mesh reinforcement systems were common for bridges in Europe, but not in the United States, where the Melan System had been more prevalent.[232] The bridge was included as an example in Taylor and Thompson's treatises on concrete, which references an *Engineering News* article from December 31, 1903.[233] As discussed in the first chapter, Monier-type arches were uncommon in the U.S. until well into the first decade of the 20th century. The Seeley Street Bridge span is 85 feet 4 inches, and the rise is 8 feet 6 3/8 inches; it is shown in Figure 7.3. The longitudinal reinforcement bars are 1 ¼ inches square and the transverse bars are ½ inch square.[234] A lattice of longitudinal and transverse bars is used at the intrados and the extrados of the arch, and they are connected with ¼ inch square bars looped over the intrados and extrados netting (Figure 7.4).[235] This detail is also mentioned in a discussion on steel rebar reinforcement for bridges in the 1903–05 *Encyclopedia Americana*:

> In the Seeley Street Bridge over Prospect Avenue in the borough of Brooklyn, New York City—a fine example of the method—additional reinforcement is obtained by stirrups of

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[232] "A Concrete Arch Bridge with Bar and Stirrup Reinforcement," (*Engineering News*, December 31, 1903), 588.

[233] Taylor and Thompson, *A Treatise on Concrete* (1916), 834.

[234] Ibid., 589.

[235] Ibid, 589.

> vertical tie bars, which are located at the intersections of the longitudinal and transverse bars, and connect the longitudinal bars of the extradosal and intradosal layers.[236]

The reinforcement system of the Seeley Street Bridge is well documented. The intrados mesh also extended beyond the arch, bending to run vertically into the corbelled abutments. Figures 7.5 and 7.6 show the construction process.

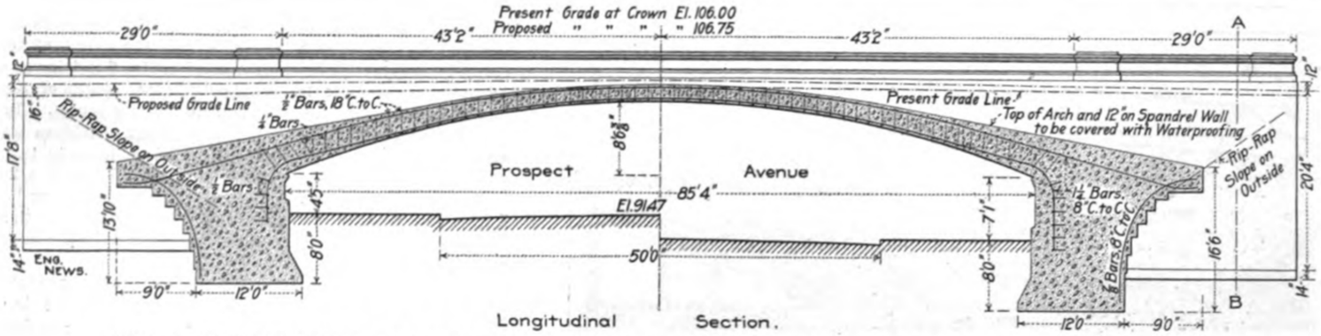

Figure 7.3: Seeley Street Bridge Arch Reinforcement Section. Source: *Engineering News*, December 31, 1903, 588.

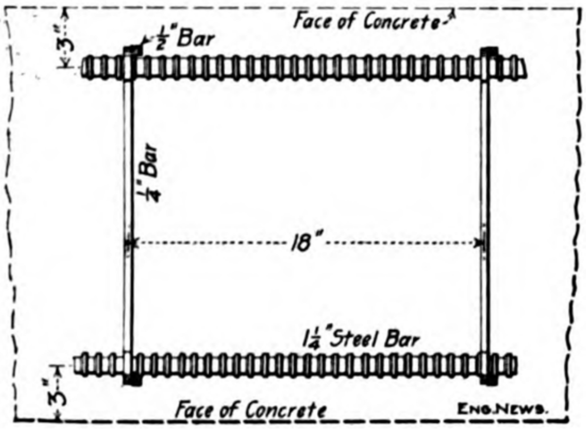

Figure 7.4: Diagram showing tie bars. Source: *Engineering News*, December 31, 1903, 588.

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[236] William Morey Jr. "Bridge Construction, Modern Methods Of" (*The Encyclopedia Americana*. Vol. 3, New York: Scientific American, May 1903). No numbers.

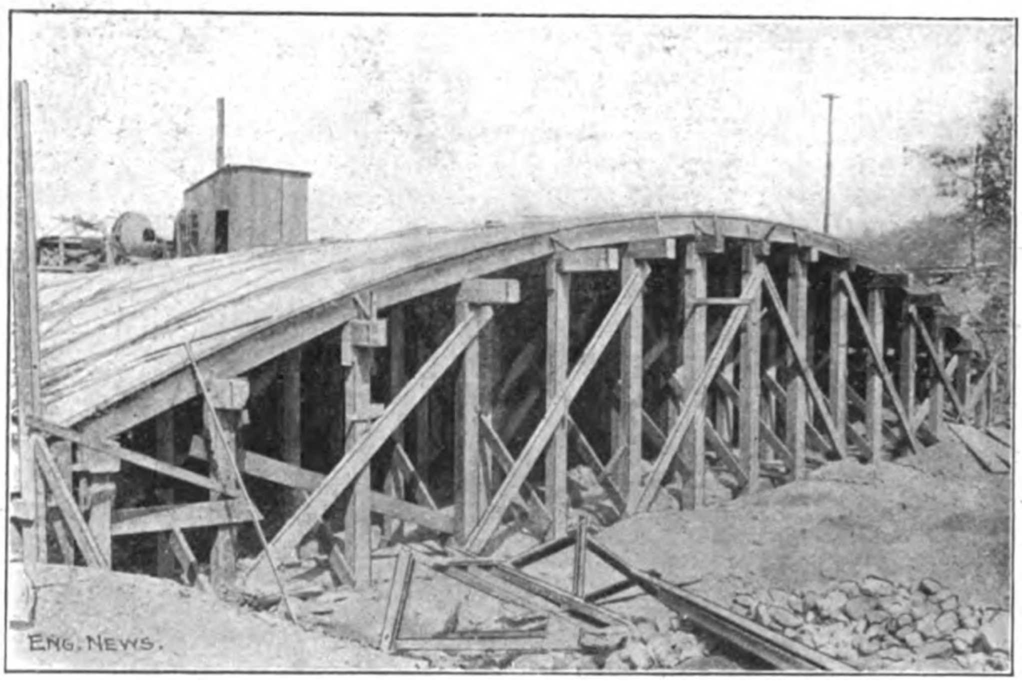


Figure 7.5: Wooden forms used for construction. Source: *Engineering News*, December 31, 1903, 588.

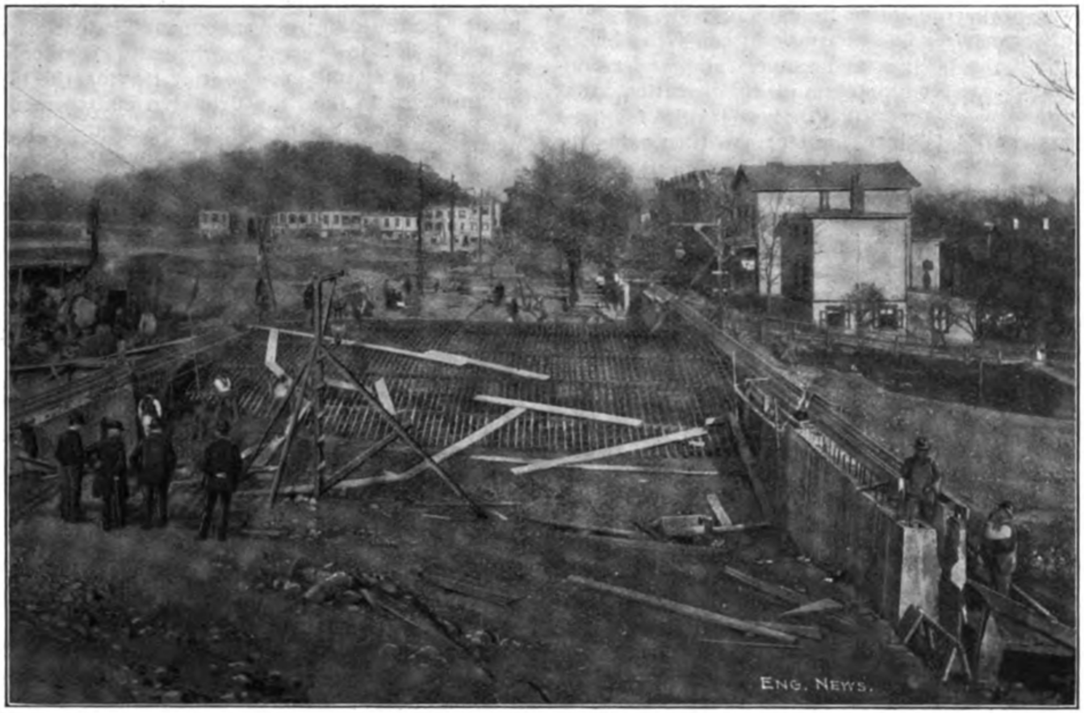
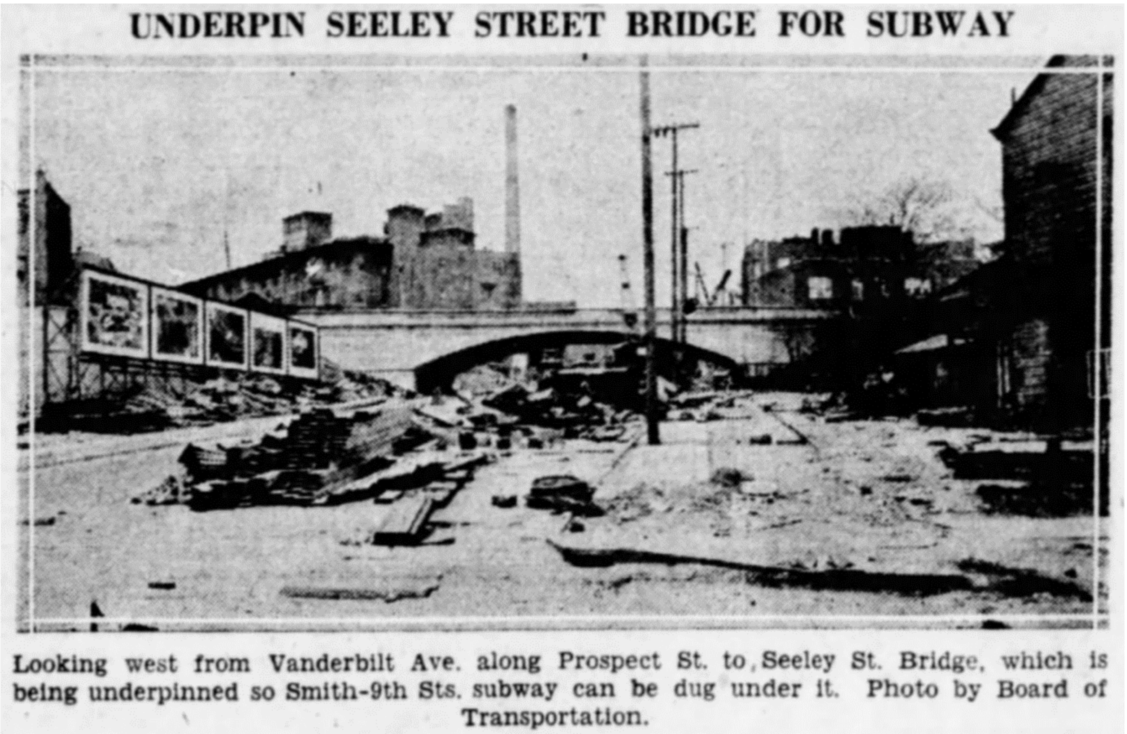


Figure 7.6: Construction of the bridge. Source: *Engineering News*, December 31, 1903, 588.

Repairs and Maintenance

The bridge was underpinned in 1930 to allow for the digging of the IND, now the F and G lines of the subway, underneath the bridge (Figure 7.7).[237] The bridge has subsequently been dated as constructed in 1930; this is inaccurate. When the subway was dug, the bridge parapets were "seriously damaged," with parts falling onto the street.[238] Figure 7.8 shows the bridge after the damage on one side, with what appears to be a temporary replacement railing. The parapet damages were apparently repaired in 1938.[239] Figure 7.9 indicates that by the 1940s a bronze light post had been removed from the top of the stairs. The bridge was "under design" in 2000 with construction set to take place in 2003. This project was removed from the list in September 2004.[240]



UNDERPIN SEELEY STREET BRIDGE FOR SUBWAY

Looking west from Vanderbilt Ave. along Prospect St. to Seeley St. Bridge, which is being underpinned so Smith-9th Sts. subway can be dug under it. Photo by Board of Transportation.

Figure 7.7: "Underpin Seeley Street Bridge for Subway." Source: *Brooklyn Daily Eagle*, May 24, 1930, 3.

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[237] "Underpin Seeley Street Bridge for Subway," *Brooklyn Daily Eagle*, May 24, 1930, 3. https://bklyn.newspapers.com/image/59900872/?terms=seeley%2Bstreet%2Bbridge.

[238] "Hartung Asks for Road Fund" (*The Brooklyn Daily Eagle*, November 3, 1933, sec. Home Talk, The Star), 35.

[239] "42D Anniversary of South BKLYN Board Tomorrow," *Brooklyn Daily Eagle,* June 22, 1938, 25.

[240] Michele N. Vulcan, "2005 NYC DOT Bridges and Tunnels Annual Condition Report" (New York: NYC Department of Transportation, Division of Bridges), 88.

Figure 7.8: Photo of the north side of bridge, labeled 1932. Source: Brooklyn Public Library, Brooklyn Collection.

Figure 7.9: 1940s tax photo showing the top of the northernmost stairwell from Seeley Street. Source: NYC Municipal Archives, DOF: Brooklyn 1940s Tax Photos.

Current Condition

The bridge is currently in poor overall condition. The superstructure (the arch itself) is rated as “poor,” while the substructure is rated as “fair,” and the Sufficiency Rating is 37, less than the 50 that would be required for federal rehabilitation funding.[241] There is currently steel netting under the intrados, due to the danger of falling concrete (Figure 7.10). There are also some large cracks in the concrete surface, such as the one pictured in Figure 7.11 which is exuding material.

Figure 7.10: Steel netting covering the intrados, facing southwest, January 2021.

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[241] National Bridge Inventory, Structure Number 2244470, May 2018.

Figure 7.11: Cracks in the northern side wall of the east abutment, January 2021.

The 2019 NYC DOT Annual report listed the bridge as being "under design," with construction to take place in fiscal year 2024.[242] *The City Record* reported on May 3, 2019, that the city had prepared a contract with STV Incorporated Design and Construction Services for "Total Design and Construction services for the rehabilitation of the Seeley Street Bridge over Prospect Avenue, Borough of Brooklyn."[243] In 2020, STV subcontracted with Environmental Planning and Management Inc. for the rehabilitation of the Seeley Street Bridge with an anticipated duration of 2020–2025.[244] The New York State DOT Statewide Transportation Improvement Program (STIP) for Region 11 reported on March 1, 2021, that the bridge would be rehabilitated "to a state of good repair" in 2021 using combined city and federal funding.[245]

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[242] Michele N. Vulcan, "2019 NYC DOT Bridges and Tunnels Annual Condition Report." (New York: NYC Department of Transportation, Division of Bridges, 20.

[243] "Transportation," *The City Record* CXLVI, no. 86 (May 3, 2019), 2281.

[244] Environmental Planning & Management, Inc. "Snapshot of Recently Awarded Contracts," http://www.epmco.com/copy-of-newly-awarded-contracts

[245] "Statewide Transportation Improvement Program (STIP) for Region 11," New York State Department of Transportation, March 1, 2021, 32.

The most current information from the NYC DOT indicates that the project was paused in May 2020, and remains paused at this time.[246]

Analysis

The Seeley Street Bridge is a significant early reinforced concrete arch bridge, and could be listed on the National Register and designated as a New York City Landmark as the oldest extant reinforced concrete arch in the city. If the Seeley Street Bridge had in fact been built in 1930, it would not carry the same significance for its reinforcing technology. But evidence shows the current bridge to have been built in 1903, and later misdated in the wake of the subway underpinning project. In practice, is relatively rare for a SHPO to reverse a determination of "not eligible" for the National Register without substantial cause.[247] In this case, however, the SHPO has not even made a determination, so a reversal would not be required. When the project is restarted, federal funding would trigger review under Section 106.[248] This may be an opportunity for the SHPO to evaluate the significance of this bridge. This is also an indication that there is a need for better communication between different levels of government, and a need for more in-house staff at state and city DOTs to evaluate historic bridges.

If the bridge is rehabilitated, the Secretary of the Interior's Standards should be followed. The character defining features are both the 85-foot reinforced concrete arch and the ornamental concrete designs, indicative of the City Beautiful Movement. The arch is low on the sides of the street, and the cavernous space over the sidewalks is decorated with murals and used by a children's art camp.[249] The bridge maintains its two sets of stairs, and is highly accessible to pedestrians, which helps it fit within its residential neighborhood. In addition to its technical

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[246] Joannene Kidder, "Re: Questions about Seeley Street Bridge, Brooklyn," Email, March 9, 2021.
[247] Zephreny Parmenter, NYC DOT Historic Bridges, Telephone, March 26, 2021.
[248] Zephreny Parameter, "Re: 1903 Seeley Street Bridge, Brooklyn," Email, March 12, 2021.
[249] "FAQ," Brooklyn Arts for Kids, https://www.brooklynartsforkids.com/faq-2/

significance, the design reflects the work of the New York City engineers and builders in the early 20th century. The original materials should be preserved and replicated where necessary.

Chapter 8: The Route 188 Hop Brook Bridge (1904/1944)

The Route 188 Hop Brook Bridge is a 1904 reinforced concrete arch with later modifications, which crosses Hop Brook on Route 188 in Middlebury, Connecticut. It not a well-known bridge, and is most often referred to by its Department of Transportation number, CT-05106. In 1944, the Connecticut Highway Department widened the bridge with concrete T-beams on either side of the original arch.[250] Original plans for the 1904 arch have not been located, but the 1944 widening records describe it as a reinforced concrete arch with a clear square span of 40 feet, a clear height of five feet, and a clear width of 18 feet.[251] The bridge, which is maintained by the state of Connecticut, was not listed in the 1990 Connecticut Historic Bridge Inventory. A February 2020 CT DOT survey recommended that the bridge be determined eligible for the National Register of Historic Places.[252] The SHPO has not yet made a determination of eligibility. A routine inspection of the bridge was carried out in August 2020, recording a sufficiency rating of 77.8, meaning it is just within the category in which it is eligible for funding for rehabilitation.[253]

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[250] Connecticut State Highway Department, "Plan for Construction of Widenings to Existing Bridges on Routes No. 188 & 63 in the Town of Middlebury," 1944.

[251] Connecticut State Highway Department, "Plan for Construction of Widenings…," 3.

[252] Edward Conners, "Update of 1991 Connecticut Historic Bridge Inventory: Pre-1941 Bridges, Bridge No. 01506," Connecticut Department of Transportation (February 13, 2020), 1.

[253] Team 6, "Bridge No. 01506, 46940 - Middlebury, Route 188 over Hop Brook Routine Inspection" (Connecticut Department of Transportation, August 20, 2020), 2.


Figure 8.1: View of the South Façade of the bridge, March 2021.

History and Significance

The Route 188 Hop Brook Bridge was likely commissioned by industrialist John Howard Whittemore, as it is on the route of his landscaped eight-mile parkway from Middlebury to Naugatuck (now a state road).[254] The parkway connected Whittemore's iron business in Naugatuck with his estate in Middlebury, known as Tranquility Farm.[255] There are several postcards showing different bridges with the label "Whittemore Bridge, Middlebury Road, Conn.," as the parkway had to cross multiple streams along its route. Figures 8.2 and 8.3 indicate the general form of these bridges prior to widening. A larger example of one of these bridges is within the Hop Brook Lake Recreation Area.

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[254] Leland M. Roth, "Three Industrial Towns by McKim, Mead & White" (*Journal of the Society of Architectural Historians* 38, no. 4, December 1979), 340.
[255] Alison Gilchrist, "Tranquility Farm" (National Register of Historic Places Nomination, 1982), 2.

Figure 8.2: This image is from an undated postcard, before 1944. Source: Postcard offered for sale on eBay.com.

Figure 8.3 This image is also from an undated postcard before 1944. Source: postcard offered for sale on Cardcow.com.

The 1944 plans show the railings, arch, and width of the original bridge. The plans call for the widening of the abutments, the removal of the old bridge railings, and channel excavation in the stream above the bridge.[256] Figure 8.4 shows the locations of the previous railings and the connections with the T-beams. Figure 8.5 shows an elevation of the current bridge, with a dotted line representing the intrados and extrados of the 1904 arch. The clearance under the center of the arch is higher than the T-beams. Figure 8.6 is a plan of the additions, which illustrates the splayed form of the old railing at either end of the bridge.

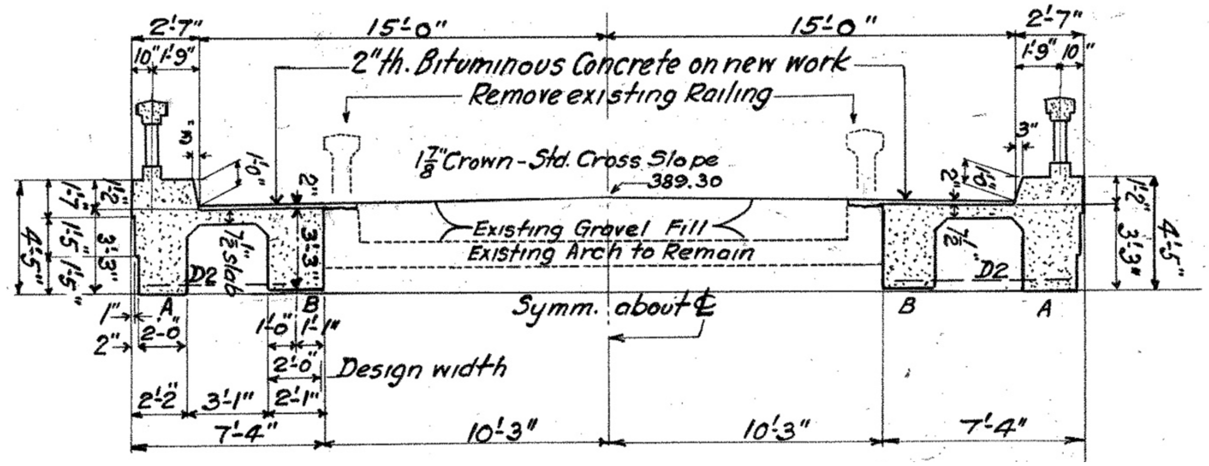

Figure 8.4: Section from the 1944 Plans. Source: Connecticut State Highway Department Plan for Construction of Widenings to Existing Bridges on Routes No. 188 & 63 in the Town of Middlebury," 7.

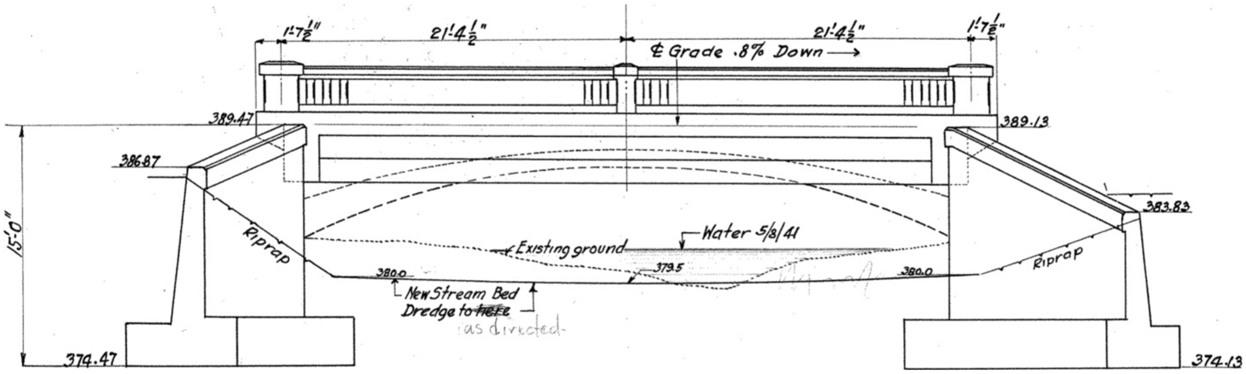

Figure 8.5: Elevation from the 1944 plans. Source: Connecticut State Highway Department Plan for Construction of Widenings…," 7.

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[256] Connecticut State Highway Department Plan for Construction of Widenings to Existing Bridges on Routes No. 188 & 63 in the Town of Middlebury."

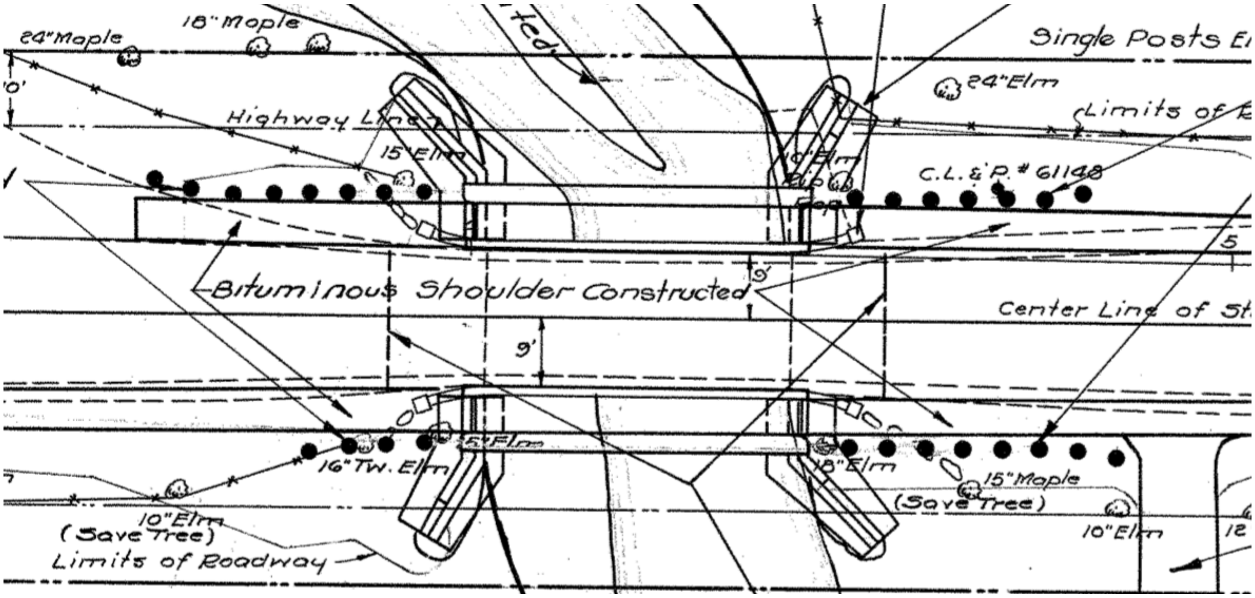

Figure 8.6: Plan view. Source: Connecticut State Highway Department Plan for Construction of Widenings…," 3.

The February 2020 DOT Survey recommended that CT-05106 (he Route 188 Hop Brook Bridge) be eligible for the National Register of Historic Places, with the following description:

> It presents from the roadway and in elevation as a well-preserved 1940s tee beam bridge and is deserving of NR consideration for that reason alone. Taking into account the (barely visible) early concrete arch, this bridge merits further study as an adaptation of an early concrete arch bridge to mid-20th-century highway demands.[257]

The author of the survey, Edward Connors' assertion that the arch is barely visible is correct, and must be accounted for: any review would have to take this into consideration. Additionally, as we know, the 1904 span was a part of J. H. Whittemore's 8-mile parkway, the bridge can also be seen as an element of early 20th century landscape architecture. This might make the bridge eligible under both criterion A and criterion C, as a structure that is significant both for its technology and for how it relates to the history of parkway landscape architecture.

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[257] Edward Conners, "Update of 1991 Connecticut Historic Bridge Inventory: Pre-1941 Bridges, Bridge No. 01506," Connecticut Department of Transportation, February 13, 2020, 1.

This bridge may be the third oldest concrete arch in Connecticut, after the 1901 North Main Street Bridge in West Hartford and the 1903 Forbes Street Bridge in East Hartford.[258] These three are the only recorded extant concrete arches in the state from before 1905. The Route 188 Hop Brook Bridge may be more significant, despite its modifications, in Connecticut than it would be if it were in a different state where there are more early bridges.

For comparison, the New Jersey Preservation Plan lists three early reinforced concrete arch bridges in Bergen County, which were all subsequently widened. One in Franklin Lakes Borough is a 40-foot arch built in 1902, widened in the 1930s with concrete T-beams on extensions of the abutment. It was determined eligible by the New Jersey SHPO in 1991.[259] Another in Franklin Lakes was built in 1903 and widened on both sides in 1960. This bridge is believed to also be of the Monier type, but that is uncertain. The report concludes that this span has lost its integrity, and that the other bridge in Franklin Lakes will be the eligible example.[260] The third bridge is in Mahwah Township, a 1902 Monier-type arch, widened on both sides in 1915. Again, the report notes that the 1902 bridge in Franklin Lakes is the eligible example, and this one is not.[261] Connecticut does not appear to have any remaining bridges similar to the Hop Brook Bridge, but if any is found, a determination similar to that of the New Jersey SHPO might be necessary.

Current Condition

Inspection in August 2020 recorded the bridge as being in adequate condition, although it noted some spalling, and partially exposed rebar on the arch intrados.[262] The 1944 T-beams show

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[258] "Connecticut Historic Bridge Survey: Inventory-Phase Final Report: Project Narrative, Inventory and Recommendations," 64.

[259] A. G. Lichtenstein & Associates, Inc., "The New Jersey Historic Bridge Database," 89.

[260] A. G. Lichtenstein & Associates, Inc., "The New Jersey Historic Bridge Database," 90.

[261] A. G. Lichtenstein & Associates, Inc., "The New Jersey Historic Bridge Database," 109.

[262] Team 6, "Bridge No. 01506, 46940 - Middlebury, Route 188 over Hop Brook Routine Inspection," (Routine Inspection, Connecticut Department of Transportation, August 20, 2020), 8.

no signs of spalling, although there is some exposed rebar on the balustrade (Figures 8.7, 8.8).[263] The arch springs from far lower than the abutments for the T-beams (Figure 8.7). The arch is board-formed, with indentations visible on the intrados, while the arch ring appears to have been smoothed (Figure 8.8). The spandrel walls may have been smoothed, and indented a few inches in from the arch ring (Figures 8.9, 8.10) There is riprapping, consisting of a row of stones, to prevent scour on the eastern edge of the arch (Figure 8.8).

Figure 8.7: The underside of the bridge, facing west. January 2021.

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[263] Team 6, "Bridge No. 01506, 46940 - Middlebury, Route 188 over Hop Brook Routine Inspection," 8.


Figure 8.8: The underside of the arch, facing east, January 2021.


Figure 8.9: Northeastern haunch of the arch, January 2021.

Figure 8.10: Northwestern haunch of the arch, January 2021.

Analysis:

The Route 188 Hop Brook bridge represents two distinct eras in bridge construction. The first is an early reinforced concrete arch, which was built by a private industrialist as part of an early 20th-century landscaped parkway. The second is a standard reinforced concrete bridge type applied by the State of Connecticut during World War II. The 1904 reinforced concrete arch is almost encapsulated in the 1944 addition. The contributing features are the arch of the 1904 span, and the beams and railings of the 1944 span. The bridge maintains its original woodland setting, although the area has become more suburban with houses in the vicinity. The span is almost three times greater than the 15-foot spans of the North Main Street Bridge. Although the designer of the bridge is unknown, the association with J. H. Whittemore is significant . What is most lacking in the integrity of the bridge is the historic sense of the original span, because there is little to no way for an individual to know that this bridge with “1944” stenciled on the guardrail dates to 1904. The arch is not easily visible, and the area surrounding the bridge is all overgrown brush. A sign on the roadway might raise awareness, and could be part of a series of signs marking features along the former Whittemore Parkway. The 1904 arch is a significant and yet virtually unknown historic resource, and it does not deserve to be left in obscurity.

This bridge was not recognized for its significance in the 1990s Connecticut DOT Inventory. That omission may be corrected in the upcoming revision. These corrections are possible through the work of professionals like Mark McMillan at the Connecticut DOT Office of Environmental Planning, who located the 1944 plans, and understood the significance of this bridge.

Recommendations

Although this thesis examined specific examples of early reinforced concrete bridges in Connecticut, New York, and New Jersey, the following recommendations are applicable to the management of similar bridges across the country.

1. Prioritize and expand the role of Historic Preservation Officers in state and city DOTs

Conversations with current staff make it clear that it is necessary to have more historic preservation professionals working on bridge management in DOTs. In New York, the Seeley Street Bridge has been completely unrecognized, despite being a highly significant historic bridge. If there were more staff working in both the New York State and the New York City Departments of Transportation, this situation might have been avoided. Similarly, in Connecticut, the state DOT might reevaluate the significance of the Route 188 Hop Brook Bridge in Middlebury, something that is only possible when there are knowledgeable preservation professionals working on bridge management. Additionally, SHPO officers are often overworked with their caseloads of buildings, and the staff of engineering consulting firms may not have the long-term focus of in-house DOT preservationists.

2. Improve communication between municipal, regional, state, and federal agencies

There are still examples of historic bridges which for one reason or another are not properly preserved because agencies are not following protocols such as the Secretary of the Interiors Standards. If there were better multilateral communication, some this problem could be mitigated. The unsympathetic design decisions at the North Main Street Bridge in West Hartford make manifest the need for increased communication. The knowledgeable historic preservation officers at the CT DOT were not aware of the rehabilitation. If they had been informed in advance, it is probable that they would have made suggestions to change the proposed design.

Even if bridges are being properly preserved, the lack of communication can lead to missed opportunities. This is the case with the Hyde Park Vanderbilt bridges; they are well-studied structures on a carefully preserved, highly visible and visited site, and yet they have escaped enumeration in the state's tally.

3. Increase the application of the Secretary of the Interior's Standards specifically for bridges

The PennDOT document is helpful as a template for other states. The SOI standards should be in widespread use for bridges, under all jurisdictions and ownership structures, as documenting a common understanding of the tenets of historic bridge preservation. Again, the North Main Street Bridge rehabilitation is an example of the need for wider application of the standards. If more engineers were familiar with the alternate definitions of preservation and rehabilitation, more appropriate designs would likely follow. The standards can also be used on private bridges such as the Smith-Ransome Japanese Bridge. In that case, the previous restoration clearly did not follow the standards, but the current restoration can reverse the damage.

4. Increase public awareness through appropriate preservation work, signage, and public engagement

This need for greater public awareness is evident in all of the bridges, where many people just want to drive over them, and do not care about their history. When people see a well-restored bridge, with proper signage, it will increase awareness and appreciation. The textbook example of this is the West Broadway Bridge in Paterson. The bridge is a landmark that people can be proud of, and its reconstructed railings and signage create a memorable pedestrian experience.

Conclusion

Early reinforced concrete arch bridges in the United States should be better recognized for their significance and their contributions to our roadways and landscapes. These bridges illustrate important technological and aesthetic developments, and they led to far grander spans in later decades. The examination of the case studies indicates that lack of recognition can lead to both improper rehabilitation and loss, despite laws and regulations in place for historic bridges.

Even the earliest reinforced concrete arch bridges can be underrecognized. Of the two Melan-type bridges at the Vanderbilt Estate in Hyde Park, the White Bridge is accorded greater recognition than the Coach House Bridge, when they should both be acknowledged as the oldest reinforced concrete bridges in New York State. This error has not resulted in a loss as the NPS continues to preserve both bridges, but it indicates that problems with recognition are prevalent. The North Main Street Bridge in West Hartford is underrecognized, and consequently its rehabilitation is not preserving the integrity of the structure. The Seeley Street Bridge in Brooklyn is also underrecognized, and could be at risk as a result. The Route 188 Hop Brook Bridge in Middlebury is underrecognized by the Connecticut Department of Transportation, although this may change.

The West Broadway Bridge in Paterson is properly recognized for its significance, indicating that the preservation apparatus for Passaic County and New Jersey worked. Ironically, with the installation of the relief arch, this bridge now has elements of both Melan and Monier type construction, as the original Melan-type bridge is now underneath modern reinforced concrete arches using a lattice of rebar.

The Smith-Ransome Japanese Bridge is an exceptional bridge. It is illustrative of the structural understanding of reinforced concrete circa 1910, with the thinnest arch ring of all of the case studies, and with its use of twisted rebar. It is not a road bridge, but its technology originates in the road bridges. It pushes reinforced concrete toward its aesthetic and structural potential, as it uses reinforced concrete not to imitate stone, but as part of a new vocabulary. This bridge has been recognized for its significance, and this significance is tied to that of each of the case studies which predate it. With those bridges intact, the Smith-Ransome Japanese Bridge can be better understood in comparison to its contemporary structures. Proper restoration of Smith-Ransome Bridge is crucial to its identity as a structural and aesthetic apogee in the early development of reinforced concrete arch bridges.

When these bridges were built, there was a sense that they would last forever, especially when compared with wooden and steel bridges. In reality, concrete still deteriorates, although it does so more slowly than steel and wooden structures. With proper recognition, preservation, and rehabilitation, many early reinforced concrete arch bridges can continue to serve their important roles across the country.

Further Research

Three of the case studies involve bridges funded by private individuals as opposed to public entities. The Hyde Park Melan bridges, the Route 188 Hop Brook Bridge, and the Japanese Bridge on Shelter Island were all commissioned by industrialists. Frederick William Vanderbilt, John Howard Whittemore, and Francis Marion Smith all embraced reinforced concrete arch technology for bridges for their personal use in or leading to their respective estates. This symbiotic relationship of industrialists and engineers and designers in the development of reinforced concrete bridges and other reinforced concrete technology could be further examined.

After the development of early reinforced concrete arches, the technology expanded and large, open-spandrel reinforced concrete arches became common. There are also later closed spandrel arches and other types of historic bridges which could be the subject of a similar analysis. A similar investigation of the significance and preservation of the new classes of arches would be beneficial.

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———. “The New Jersey Historic Bridge Survey.” New Jersey Department of Transportation Bureau of Environmental Services and The Federal Highway Administration New Jersey Division, September 1994.

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