1999

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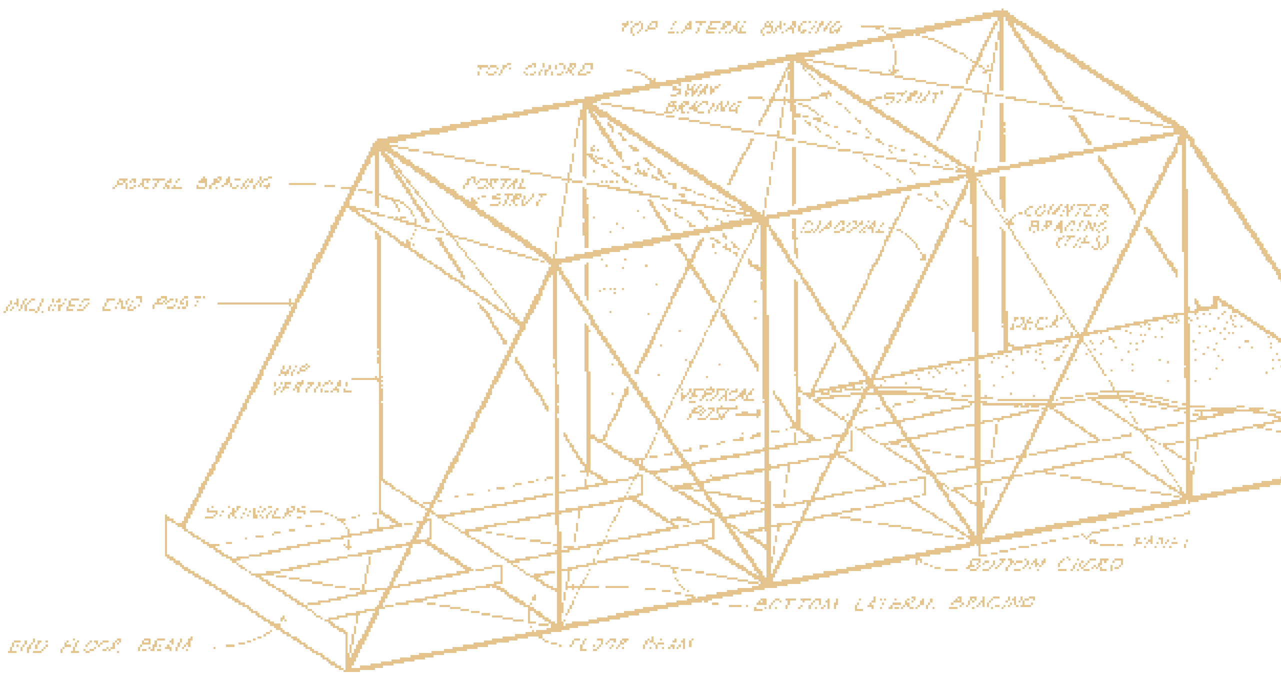
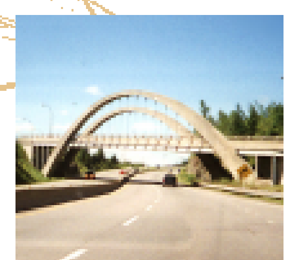
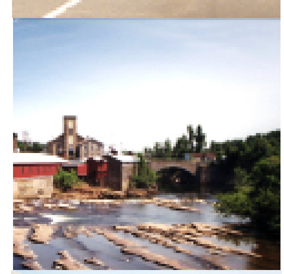
Contextual Study of New York State's Pre-1961 Bridges







PREPARED FOR

New York State
Department of Transportation

Contextual Study of New York State's Pre-1961 Bridges

Prepared for:

New York State Department of Transportation

MEAD & HUNT
ENGINEERS
ARCHITECTS
SCIENTISTS
PLANNERS

November 1999

Acknowledgments

Mead & Hunt, with Allee King Rosen & Fleming, Inc., prepared this study under contract to the New York State Department of Transportation (NYSDOT). Mead & Hunt contributors to the contextual study included: Amy Squitieri, Project Director; Christina Slattery, Senior Architectural Historian; and Stacey Pilgrim, Joy Caudill, and Beth Wielde, Historians. Allee King Rosen & Fleming contributors included: Anne Locke, Senior Architectural Historian; and Kerry Ehlinger and Garrick Landsberg, Architectural Historians. The NYSDOT Project Manager is Mary Ivey; the Consultant Manager is Robert Ewing. Many administrators, librarians, preservationists, historians, and engineers contributed directly or indirectly to this effort. The contextual study would not have been possible without their valuable assistance.

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1. Introduction

A. Project Overview

The New York State Department of Transportation (NYSDOT), in cooperation with the Federal Highway Administration and State Historic Preservation Office, has committed to a multi-year effort to identify state and locally owned highway bridges with historic value and develop a management plan for them. This effort is known by the project name, Historic Bridge Inventory and Management Plan. The NYSDOT selected Mead & Hunt as its consultant. Allee King Rosen & Fleming, Inc., will assist Mead & Hunt with portions of the project.

The Historic Bridge Inventory and Management Plan is intended to simplify NYSDOT's treatment of nearly 11,000 pre-1961 bridges. The completion of this effort will allow the NYSDOT to be pro-active and cost-effective and will greatly reduce the need for case-by-case review of individual bridge rehabilitation and replacement projects. Currently, NYSDOT reviews bridge projects individually for compliance with Section 106 of the National Historic Preservation Act and Section 14.09 of Chapter 36B, New York State Consolidated Laws. These regulations require NYSDOT to take into account the effects of its projects on bridges that are listed on or eligible for the National Register of Historic Places.

Through this project, NYSDOT is condensing the procedures it typically follows for individual bridge projects into a comprehensive approach that covers the entire pre-1961 bridge population. The Historic Bridge Inventory and Management Plan project involves four principle steps:

1. Develop a contextual study for historic bridges in New York State.

2. Prepare a methodology for the inventory of pre-1961 bridges and criteria for determining which bridges are eligible for listing in the National Register of Historic Places.

3. Conduct an inventory, including field survey, to identify historic bridges and make recommendations for inclusion in the National Register of Historic Places.

4. Prepare a management plan for state and locally owned historic bridges.

This contextual study represents the first step. It will lay the foundation for the development of selection criteria for identifying eligible bridges and provide a background to support the evaluation of New York's bridges. The Historic Bridge Inventory and Management Plan's overall objective is to identify, categorize, and prioritize historic bridges; it does not involve any engineering analysis of the structural condition of studied bridges.

B. Definition of Historic Bridge

For purposes of this project, bridges of historic value are defined as those that are listed on or eligible for listing on the National Register of Historic Places. The National Register of Historic Places is the official federal list of districts, sites, buildings, structures, and objects significant in American history, architecture, archaeology, engineering, and culture. Properties are eligible for listing on the National Register of Historic Places if they possess integrity and meet one or more of the following criteria established by the National Park Service:

- *Criterion A – Association with events or activities that have made a significant contribution to the broad patterns of our history.*

- *Criterion B – Association with the lives of persons significant in our past.*

- *Criterion C – Association with the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction.*

- *Criterion D – Potential to provide important information about prehistory or history.*

National Register Bulletin 15 defines integrity as "the ability of a property to convey its significance." Though the evaluation of integrity is sometimes subjective, it must be grounded in an understanding of a property's physical features and how they relate to its significance. The National Register criteria recognize seven aspects or qualities that, in various combinations, define integrity:

- *Location – The place where the historic property was constructed or the place where the historic event occurred.*

- *Design – The combination of elements that create the form, plan, space, structure, and style of a property.*

- *Setting – The physical environment of a historic property.*

- *Materials – The physical elements that were combined or deposited during a particular period of time and in a particular pattern or configuration to form a historic property.*

- *Workmanship – The physical evidence of the crafts of a particular culture or people during any given period in history.*

- *Feeling – A property's expression of the aesthetic or historic sense of a particular period of time.*

- *Association – The direct link between an important historic event or person and a historic property.*

A property that retains historic integrity will possess several, and usually most, of these aspects. Determining which of these aspects are most important to a particular property requires knowing why, where, and when the property is significant.

Listed or eligible properties can be significant at the local, state, or national level. To qualify for the National Register of Historic Places, a property must generally be at least 50 years old; otherwise, it must possess exceptional importance.

Bridges are one of the types of structures that may be eligible for listing on the National Register of Historic Places. Nearly 11,000 bridges built in New York State before 1961 will be studied to determine which meet National Register criteria, including integrity, and are eligible. The NYSDOT chose to inventory pre-1961 bridges to provide a reasonable margin around the National Register's 50-year age minimum, allowing its results to have greater lasting power. Occasionally, a bridge of exceptional importance that is less than 50 years old may be recognized as National Register-eligible. For example, a bridge may be of exceptional importance if its type is so fragile that a survivor of more than 50 years is unusual or if it is associated with an extraordinary event.

C. Included and Excluded Bridges

Pre-1961 bridges that are currently located on public roads and for which NYSDOT has management responsibility will be addressed in the Historic Bridge Inventory and Management Plan project. The project includes bridges owned by the following groups:*

10 – NYSDOT
2A – Genesee State Parks and Recreation Commission
2B – Interstate Bridge Commission
2D – Lake Champlain Bridge Commission
2E – Lake George Park Commission
2F – Long Island State Parks and Recreation Commission (except bridges on eligible or listed parkways)
2J – Niagara Frontier State Park Commission
20 – Other State Department
21 – Authority or Commission
25 – Capital District State Park Commission
26 – Central New York State Park Commission
27 – City of New York State Park Commission
29 – Finger Lakes Parks and Recreation Commission
30 – County
40 – Town
41 – Village
42 – City
50 – Federal
51 – Bureau of Indian Affairs
52 – U.S. Forest Service
53 – National Park Service

54 – Bureau of Land Management
55 – Bureau of Reclamation
56 – Military Reservation/Corps of Engineers
72 – Other

* *Groups are organized by NYSDOT owner coding*.

Bridges owned by authorities or railroad companies are excluded from the project because the NYSDOT does not hold management responsibility for these structures. The project excludes bridges owned by the following groups:*

2G – Metropolitan Transportation Authority
2H – Monroe County Water Authority
2I – Niagara Falls Bridge Commission
2K – New York State Bridge Authority
2L – New York State Thruway Authority
2M – Ogdensburg Bridge and Port Authority
2N – Palisades Interstate Park Commission
2O – Port of New York Authority
2P – Power Authority
2Q – Seaway International Bridge Authority
2R – Taconic State Park Commission
2S – Thousand Islands Bridge Authority
2T – Transit Authority
2U – Triborough Bridge and Tunnel Authority
2V – Tri-State Transportation Commission
22 – Allegany State Park Authority
23 – Nassau County Bridge Authority
24 – Buffalo and Fort Erie Public Bridge Authority
28 – East Hudson Park Authority
43 – New York City Department of Water Supply, Gas and Electric
60 – Railroad
61 – Long Island Railroad
62 – Conrail (former Penn Central)
70 – Private-Industrial
71 – Private-Utility

* *Groups are organized by NYSDOT owner coding.*

Most canal systems and parkways will not be addressed in this project because their importance is understood due to previous evaluation for inclusion on the National Register of Historic Places. Bridges on and over parkways and over canals will only be addressed if they have not been previously evaluated for the National Register. Bridges on the following parkways are eligible for or listed on the National Register of Historic Places:*

Region 8

- Palisades Interstate Parkway
- Taconic State Parkway – eligible section from N.Y. 202 north to Berkshire Exit
- Bronx River Parkway

Region 10

- Loop Parkway
- Ocean Parkway
- Wantaugh Parkway
- Bethpage Parkway – includes interchange with Southern State Parkway
- Meadowbrook Parkway

Region 11

- Bronx River Parkway

* *The NYSDOT has divided the state into 11 management regions. The location of the parkway references the NYSDOT region within which the parkway lies.*

In 1999 NYSDOT is completing a Programmatic Agreement that will address the eligibility and management of canal bridges. This agreement covers the New York State canal system and the extant remains of its predecessors: the Erie, Champlain, Oswego, Genesee, Chemung, Chenango, Black River canals; and the related private Western Inland Navigation, Chenango Extension, and Junction canals.

The Historic Bridge Inventory and Management Plan project also excludes bridges that have already been listed on the National Register either for individual significance or as a component of a historic district.

D. Objectives for Contextual Study

The contextual study is intended to facilitate sound decision-making about the eligibility of bridges in New York for the National Register of Historic Places. As the first product of a four-step effort, the study establishes a framework for understanding the historic and engineering significance of New York's bridges and provides the foundation material upon which decisions about the National Register-eligibility of New York's bridges will be based. It was not envisioned as a definitive history of bridge engineering in the state. Historical information is presented in three chapters:

- Chapter 2: *History of Bridge Engineering in the United States* – This chapter describes national developments in bridge engineering. It explores types, periods, and methods of bridge construction found in the United States before 1961. For each type of bridge, the design configuration is presented and its prevalence of use established. The evolution of materials found in bridge construction is presented with an emphasis on when materials were adopted for broad use and when they fell out of favor. Technological innovations identified in the United States are introduced and tied to trends they stimulated. Though many innovations in bridge engineering were introduced for the railroads, their influence is discussed only within the context of highway bridges. The chapter contributes to an understanding of the once built bridge population and allows remaining resources to be evaluated within their historic context. This background information on types, materials and technology will facilitate the application of National Register Criterion C to New York's bridges in step three of the project.

- Chapter 3: *History of Bridge Design and Construction in New York State* – Significant trends in bridge design and construction in New York State are covered in this chapter. Dates that marked transitions in New York State bridge-building activity are emphasized. Legislation affecting bridge construction is examined. Authority-owned bridges that are outside of NYSDOT jurisdiction are only described as they pertain to the broader context of bridge engineering in New York. This chapter also describes bridge-building companies known to have been active in New York, and designers and planners that influenced New York bridge building. Each of these topics will be useful in ascribing and interpreting the significance of bridges. The chapter relates to three National Register criteria: Criterion A for bridges that made significant historical contributions; Criterion B for those associated with significant persons; and Criterion C for examples of a period's building practices or works of a master.

- Chapter 4: *Development of New York's Transportation Networks* – This chapter presents significant trends in the development of transportation networks that influenced bridge construction. Networks are considered statewide, as interstate and international linkages, and on regional and urban levels. The chapter also considers the role and importance of government agencies and of state and federal legislation in the development of transportation networks. Transportation networks within and between smaller communities are not fully explored due to the magnitude of this task. This chapter provides a foundation for the application of the National Register criteria, especially Criterion A, to bridges of local, regional, or national significance in New York's settlement and transportation history. It also allows bridges to be considered within the context of transportation networks, such as regional corridors, parkways or canals.

The specific utility of each chapter in evaluating bridges for National Register-eligibility is described further in the chapter introductions.

Since the contextual study is the first step in a multi-year effort, it should be seen as a working document that will be informed by subsequent steps. Historical information about bridges that will be discovered in steps two and three of the project, including the prevalence of the work of bridge-building companies or bridge designers in New York, is not available for inclusion. In theory, the study could be expanded or revised to incorporate the results of steps two and three.

E. Research Methods

Due to the large number of bridges in New York, the vast amount of information pertaining to them, and a constrained time frame, research necessarily focused upon the collections of major libraries and the results of database searches. To gain greater insight into significant regional trends in transportation, bridges that are locally valued, and bridges that may be part of a potential historic district, the consultants mailed about 800 questionnaires to historical societies and preservation organizations throughout New York. Research for the contextual study drew from the following sources:

- Textbooks, design manuals, and articles in engineering journals published pre-1961
- Recent books and articles about bridge engineering
- Legislative documents and departmental reports
- State and National Register of Historic Places nominations and landmark designations
- Historic American Engineering Record surveys and documentation
- Information received from local historical societies and preservation organizations
- Bridge surveys completed by other states or previously completed in New York
- Personal contacts with bridge enthusiasts

F. Subsequent Steps

The contextual study provides guidance for sorting the state's nearly 11,000 pre-1961 bridges into appropriate categories defined by bridge types. In step two, a methodology for sorting and subsequently inventorying bridges will be developed. This methodology will include a list of bridge categories and an explanation of the level and kind of data that will need to be collected to evaluate the eligibility of bridges in each category. The entire bridge population will be sorted into appropriate categories. Categories are expected to be informed by historic events, trends and innovations in bridge design and materials, developments in transportation, and activities of prominent individuals and companies disclosed in the contextual study.

Next, Mead & Hunt will recommend evaluation criteria, based on the State and National Register Criteria, to be applied to surveyed bridges. The bridge evaluation criteria will be developed using the contextual study's framework for understanding the historic and engineering significance of New York's bridges. The methodology for inventorying bridges and bridge evaluation criteria will be products of the second step.

The third step of the project involves sorting and identifying New York's historic bridges. Up to 2,100 bridges will be selected for field survey. Bridges will be selected for field survey based on the potential significance of the category to which they belong. One category for consideration will be bridges that are recognized as components of potential historic districts. To identify these districts, a public outreach effort was undertaken. This effort included questionnaires to local historical societies, preservation organizations, and county and town historians; press releases; and a request for information from the New York State Historic Preservation Office staff.

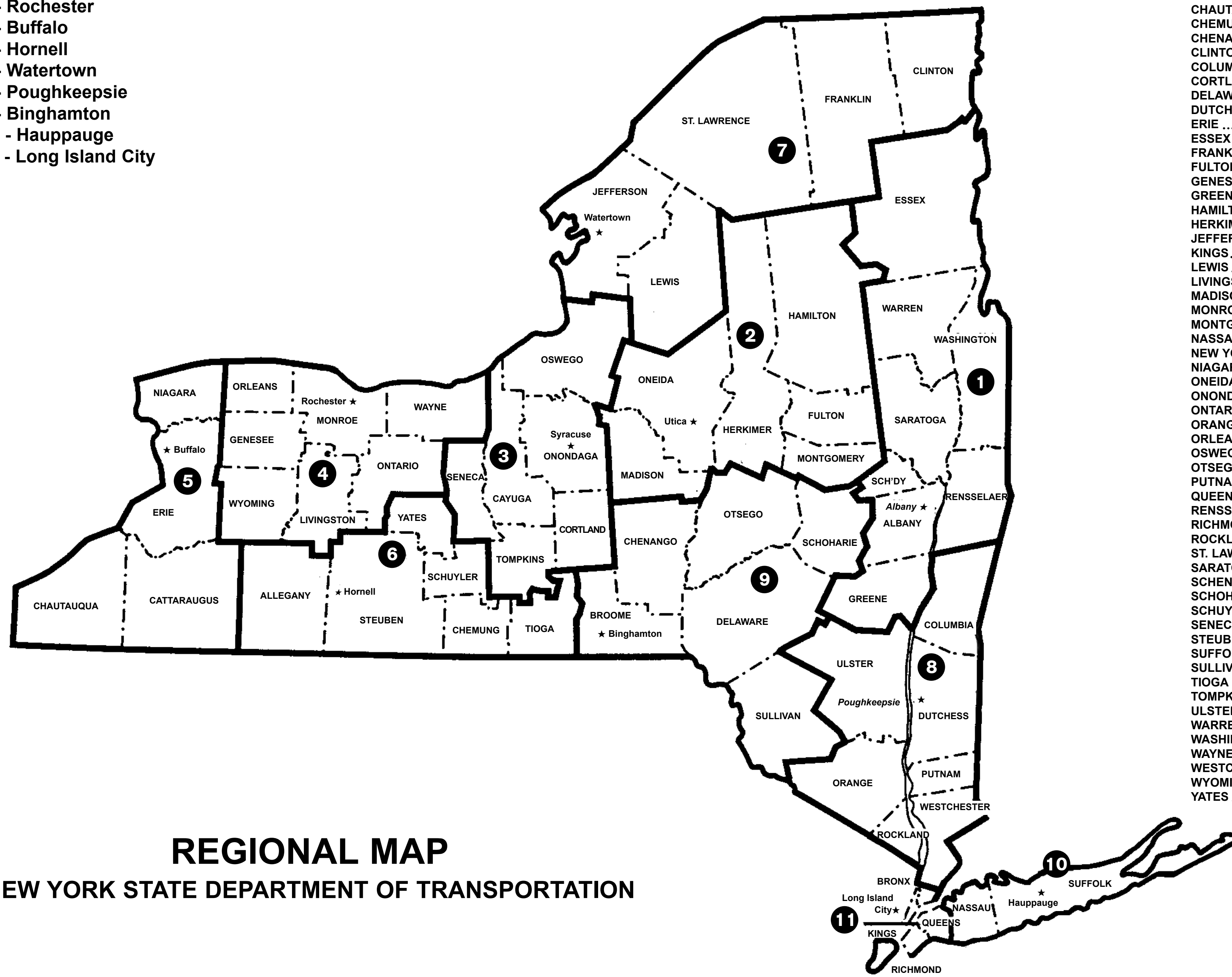
During the field survey, the settings of bridges will be reviewed to identify the potential presence of a historic district. Bridges will be evaluated for National Register-eligibility based on an analysis of data obtained through:

- Field review
- Public outreach efforts
- Contextual study development

In step four, a management plan will establish practices consistent with the needs of transportation and preservation that the NYSDOT can apply to its eligible and listed bridges. The plan will simplify NYSDOT's consideration of alternatives for subsequent bridge projects.

Location of NYSDOT Regional Offices

1 - Albany
2 - Utica
3 - Syracuse
4 - Rochester
5 - Buffalo
6 - Hornell
7 - Watertown
8 - Poughkeepsie
9 - Binghamton
10 - Hauppauge
11 - Long Island City



COUNTY	REGION
ALBANY	1
ALLEGANY	6
BROOME	9
BRONX	11
CATTARAUGUS	5
CAYUGA	3
CHAUTAUQUA	5
CHEMUNG	6
CHENANGO	9
CLINTON	7
COLUMBIA	8
CORTLAND	3
DELAWARE	9
DUTCHESS	8
ERIE	5
ESSEX	1
FRANKLIN	7
FULTON	2
GENESSEE	4
GREENE	1
HAMILTON	2
HERKIMER	2
JEFFERSON	7
KINGS	11
LEWIS	7
LIVINGSTON	4
MADISON	2
MONROE	4
MONTGOMERY	2
NASSAU	10
NEW YORK	11
NIAGARA	5
ONEIDA	2
ONONDAGA	3
ONTARIO	4
ORANGE	8
ORLEANS	4
OSWEGO	3
OTSEGO	9
PUTNAM	8
QUEENS	11
RENSSELAER	1
RICHMOND	11
ROCKLAND	8
ST. LAWRENCE	7
SARATOGA	1
SCHENECTADY	1
SCHOHARIE	9
SCHUYLER	6
SENECA	3
STEUBEN	6
SUFFOLK	10
SULLIVAN	9
TIOGA	6
TOMPKINS	3
ULSTER	8
WARREN	1
WASHINGTON	1
WAYNE	4
WESTCHESTER	8
WYOMING	4
YATES	6

REGIONAL MAP

NEW YORK STATE DEPARTMENT OF TRANSPORTATION

2. History of Bridge Engineering in the United States

A. Introduction

Bridges are defined by their basic form and structural materials. This chapter provides a background on these essential elements of bridges, including an introduction to bridge types and a discussion of construction materials. *Section 2B – Basic Bridge Types* includes a description of their form and introduction of their use. *Section 2C – Construction Materials* covers the properties and use of various bridge-building materials, including wood, iron, steel, and concrete.

The discussion of bridge types and materials is complemented by a description of technological developments in bridge engineering. *Section 2D – Technological Developments* encompasses not only "firsts" and "longests" in the field of bridge engineering, but also outlines other important innovations in bridge construction, such as the introduction of new methods of construction, improved bridge-building materials, and unique design features. Technological developments are grouped either by the bridge type or material that influenced their evolution. For example, the invention of prestressed concrete is discussed under evolution of concrete as a bridge-building material. A list of additional firsts and innovations in regards to bridge engineering is provided in a table at the end of the section (see Table 2).

Information in this chapter will assist in the application of National Register Criterion C by identifying those bridges that "embody the distinctive characteristics of a type, period, or method of construction" as defined in *National Register Bulletin 15*. The structures may demonstrate innovations in the field of bridge engineering through distinctive characteristics, which include the following:

- The pattern of features common to a particular class of resources
- The individuality or variation of features that occurs within the class
- The evolution of that class of resources
- The transition between classes of resources

The information within this section will aid in the understanding of the common versus rare bridge types, unique bridge features and variations, choices and availability of materials and technology, and important firsts and innovations. These factors will inform the development of bridge evaluation criteria.

B. Basic Bridge Types

(1) Overview

A bridge's type defines its basic configuration. There are five basic bridge types: arch, truss, suspension, movable, and beam/girder (see Figures 1-5). These types can be further divided into subtypes based on the function of component members or on the material used. A bridge with multiple spans may use more than one structural type.

In analyzing the form of a bridge, its structural and support systems provide important distinctions. At a basic level, bridges can be separated into two categories according to the placement of their structural system:

- *Deck* – The structural system lies beneath the deck.

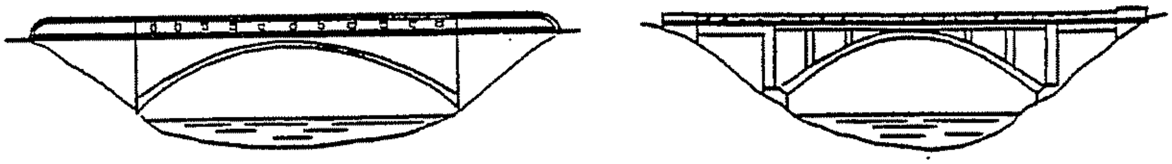
- *Through* – The deck passes between members of the structural system, which extend above the deck and may connect horizontally above the path of vehicles.

Bridges can also be distinguished by their type of support system. Three means of support exist:

- Simply supported
- Continuous
- Cantilevered

Continuous and cantilever design were introduced in the United States in the late 1870s. Although first applied for truss construction, these particular support methods were later applied to many bridge types.[1] The difference in these support systems is shown in Figure 6.

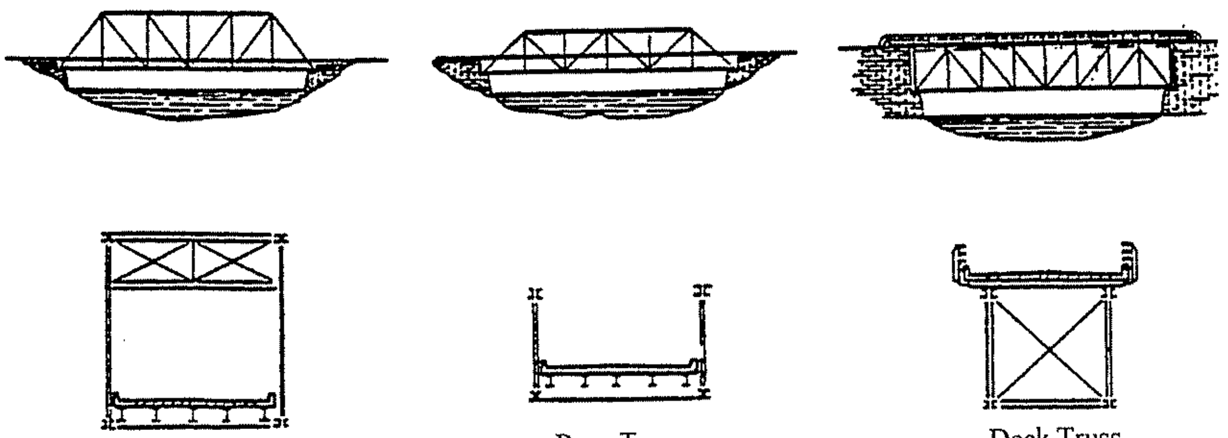
The various bridge types expected to exist in New York are described below. The types are arranged in general chronological order as they made their appearance in the United States. Some types, such as the beam or retractile bridge, had been previously used in their simplest forms in Europe. Variations and adaptations to these early designs are included in this chronology as they appeared in the historic development of New York and United States transportation systems.



Filled Spandrel

Open Spandrel

Figure 1: Arches *(Source: New York State Department of Transportation [NYSDOT], Bridge Inventory Manual. December 1990, Amended November 1991).*



Through Truss

Pony Truss

Deck Truss

Figure 2: Trusses *(Source: NYSDOT, Bridge Inventory Manual).*

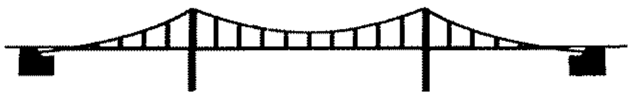


Figure 3: Suspension Bridge *(Source: U.S. Department of Transportation, Federal Highway Administration, Safety Inspection of In-Service Bridges, Participant Notebook, Volume II, Publication No. FHWA-HI-91-021. Washington, D.C. Federal Highway Administration, 1992).*

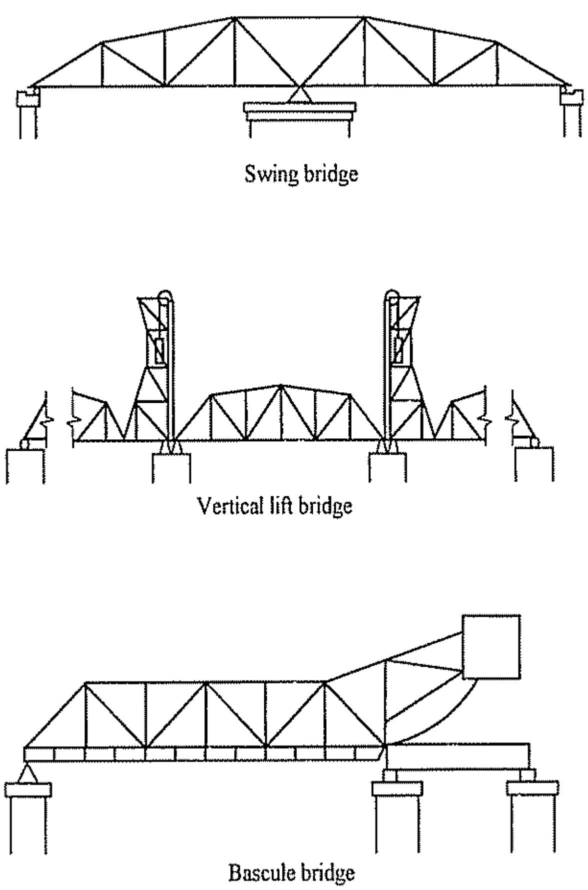


Figure 4: Movable Bridges *(Source: Ann B. Miller and Kenneth M. Clark, A Survey of Movable Span Bridges in Virginia. Charlottesville, VA.: Virginia Transportation Research Council, July 1996).*

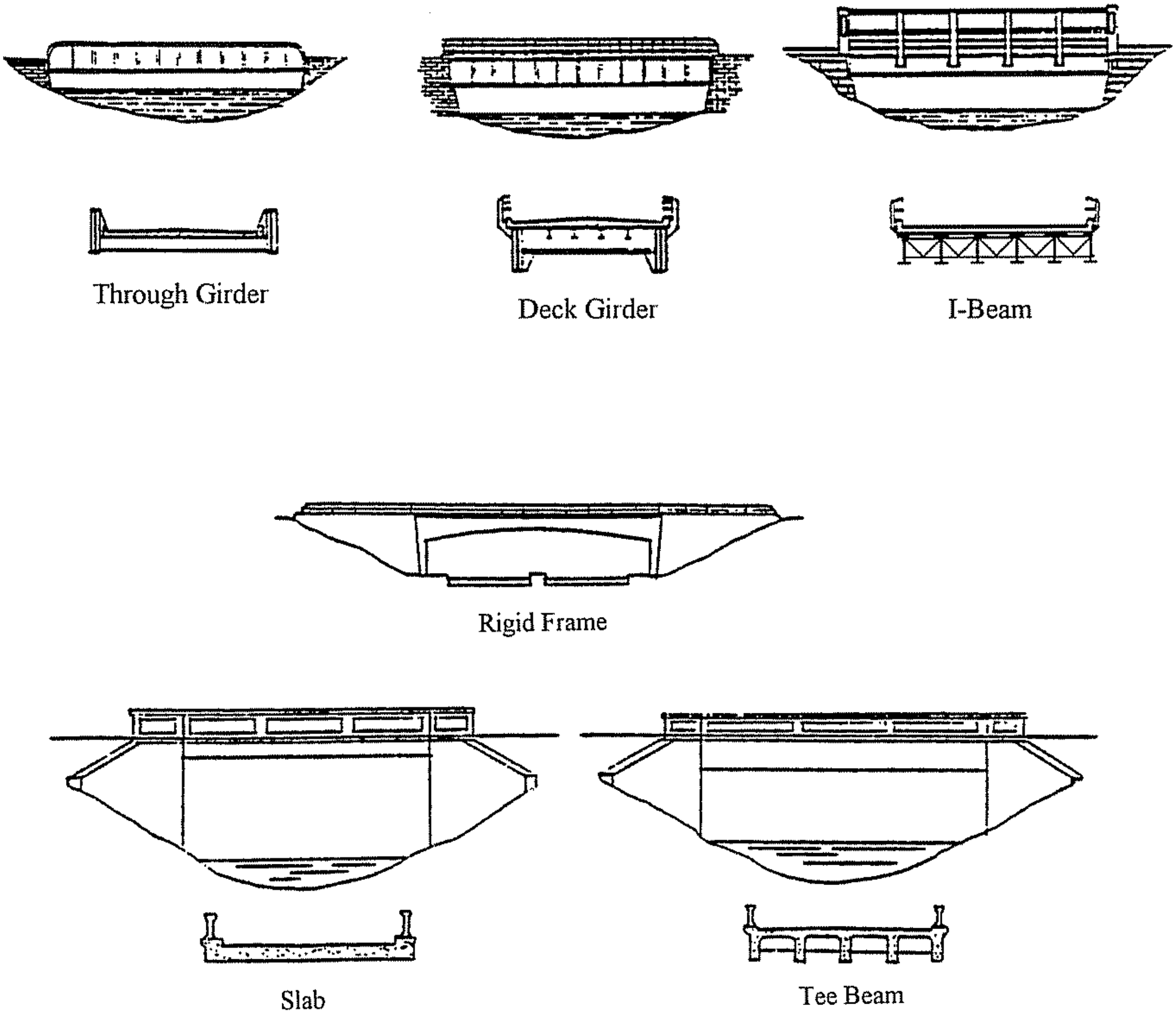


Figure 5: Girders and Beams *(Source: NYSDOT, Bridge Inventory Manual).*

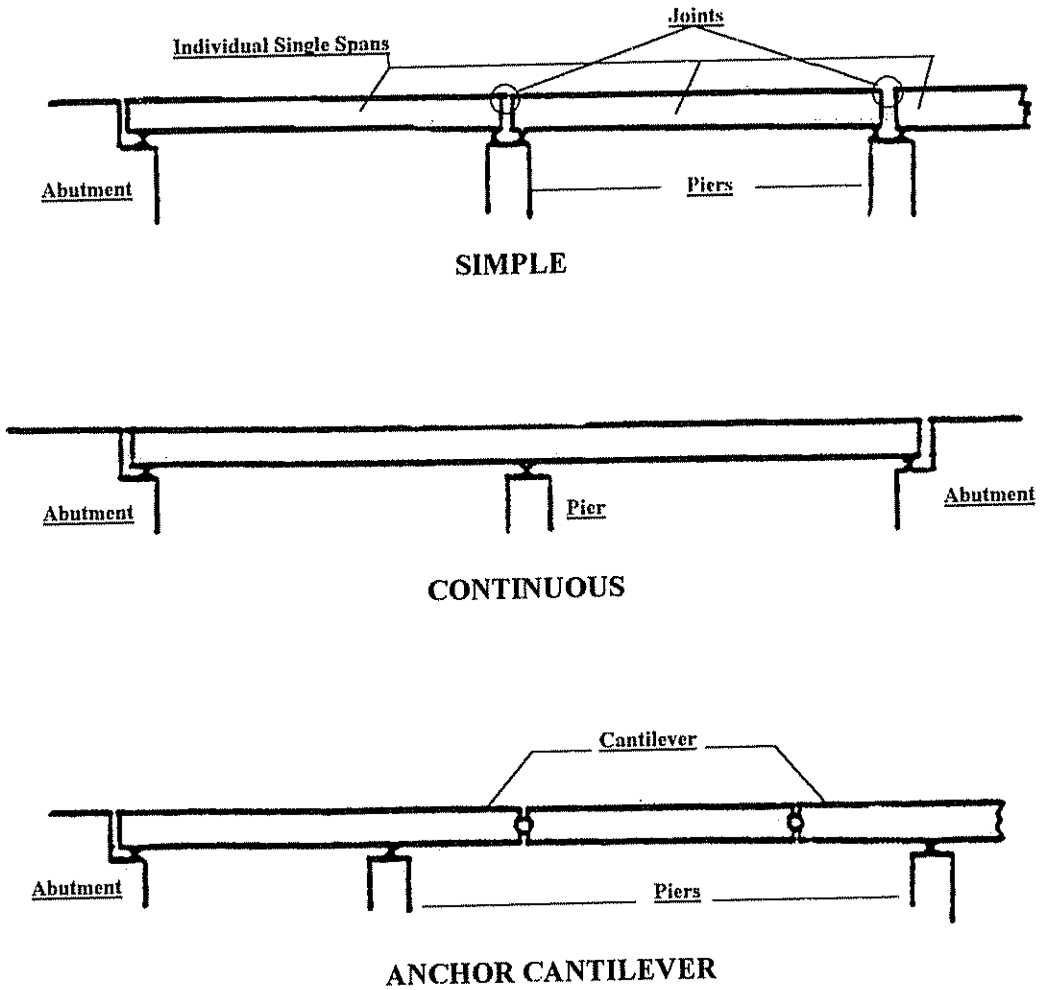


Figure 6: Methods of Support *(Source: NYSDOT, Bridge Inventory Manual).*

(2) Arch

The arch bridge, whose basic technology dates back to ancient Rome, is a semi-circular form which can be composed of masonry, brick, steel, timber, or concrete. The arch rib or ring spans an opening, providing support for the roadway. The space between the arch ring and the roadway, or deck, is the spandrel. The spandrel may be walled and filled, known as a filled or closed spandrel, or open. Deck arches have either open or closed spandrels with the spandrel located above the arch and below the roadway. A through arch, or less commonly a half-through arch, has the roadway at the bottom, or mid-point, of the arch.

(a) Masonry Arch

The stone masonry arch was already used in the United States by the 1700s. This bridge type continued to be used into the twentieth century where suitable materials and skilled labor could be found. The wedge-shaped stones that comprise the arch are called voussoirs; a keystone at the center locks the voussoirs into place. The solid spandrel walls usually support a filled roadway section. Relatively short spans were normal. When a series of small arches were placed in a continuous line, a type of construction commonly known as viaduct resulted. The multiple-span masonry arch is supported by heavy piers placed at frequent intervals. When built of masonry, the arch is typically the deck type, although a stone or brick railing may extend above the deck. Although capable of carrying heavy loads safely and requiring minimal maintenance, masonry arches were expensive and time-consuming to build. For masonry arches, brick was sometimes used instead of, or in combination with, stone.

(b) Steel Arch

Introduced in the late 1860s, steel arches allowed for increased spans, which previously had been limited with masonry arches. The arch ribs can be formed using I-beams tied with plates and angles, girders, or riveted trusses.

The steel arch is often accompanied by a hinge system, using one to three hinges. In one-hinged arches, the hinge is used at the top of the arch to provide flexibility. In a two-hinged arch, the hinges are pinned at the base of the arch to limit rotational effects between the structure and the foundation. The use of two hinges keeps abutment movement under control, and allows lighter construction materials to be used for the arch.[2] The three-hinged arch proved too flexible for rail traffic and was subsequently limited to highway bridges. One hinge is located in the center of the arch and two are found at the base of the arch, compensating for the stress of expansion or contraction.[3]

With the hingeless or "fixed" arch, the abutments and length of the span are assumed to remain fixed, because the arch is unable to adjust to stresses.

(c) Concrete Arch

Concrete arch bridges became popular after Josef Melan and Fritz von Emperger's reinforcing systems were introduced in the late 1890s. Prior to this time, concrete arches had many of the same limitations as the masonry arch. As shown in Figure 1, the arch ring was constructed either as a single barrel vault, which could be filled or void, or as a series of separate and parallel ribs.[4] In shorter spans, the spandrel is typically filled and retained by the spandrel walls. In longer spans, the spandrel is usually open and periodic longitudinal walls or columns are used to support the deck.

As with steel arches, concrete arches come in the fixed, one-, two-, and three-hinged varieties with the later types introducing increased flexibility. The use of concrete offers opportunities for a graceful arched form and for cast design details.

(3) Truss

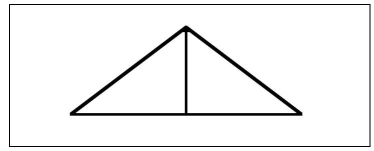
A truss uses diagonal and vertical members to support the deck loads. The diagonal and vertical members are joined with plates and fasteners (rivets or bolts) to create several rigid triangular shapes. This configuration allows relatively light units to be created for large spans. As shown in Figure 2, there are three basic arrangements of trusses – pony, through, and deck – and a wide variety of types. The arrangement is called a pony truss (or, less commonly, a low truss) when the structural system lies alongside the deck. A through truss may also be referred to as an overhead truss.

Most covered bridges, popularized in the late 1700s and used into the twentieth century, used truss forms.[5] The roofing and siding attached to these trusses shielded the load carrying truss elements from the environment, helping to increase the bridge's life expectancy. These "covered bridges" for the most part were through trusses. The overhead end piece, known as a "portal" often allowed the bridge designer to incorporate his own unique style and shape. A number of New York's covered bridges had lateral supports, which protruded from the side of the bridge for added strength.[6] Among the truss styles commonly found in covered bridges are the king post, queen post, Palmer arch, Burr arch, Town lattice, Warren, and Howe.[7]

The use of the various truss types had much to do with the span length. The following individual discussion of the various truss types identifies some span ranges for which the specific type of truss was considered appropriate. The continuous and cantilevered design approach also produced changes in the range of spans for trusses. The description of different truss types given below is based largely on T. Allen Comp and Donald Jackson, "Bridge Truss Types: A Guide to Dating and Identifying," published in History News (May 1977).

Rare truss types, within this report, refer to those types for which less than 12 extant examples are expected to be found in New York during the subsequent bridge survey.

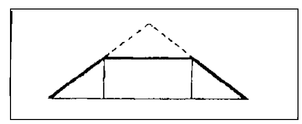
(a) King Post



Source: Historic American Engineering Record (HAER), National Park Service. Trusses. Poster, HAER T1-1. Delineated by Arnold David Jones, 1976.

This is the earliest form of the truss, dating back to the middle ages. The king post has a central vertical member, with diagonal beams extending from the top of the vertical member to the deck abutments to form conjoined triangles. The earliest forms were constructed of timber, though iron and steel were used for later king posts. The king post usually spans between 20 to 60 feet.

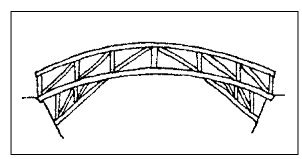
(b) Queen Post



Source: HAER

Closely related in design to the king post, the queen post is another early truss form. Typically constructed in timber, the top chord bisects the triangle horizontally, creating a trapezoid (or "hipped") form. The queen post truss usually has a slightly longer span range than the king post, generally about 20 to 80 feet.

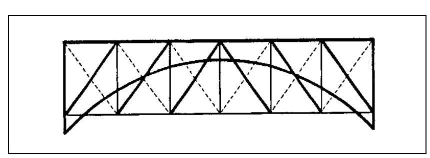
(c) Palmer Arch-truss



Source: Allen, Covered Bridges of the Northeast.

An early combination of the timber arch and the truss, the Palmer, developed in the 1790s by Timothy Palmer, used king post support systems with additional diagonal and vertical beams in the spandrels. The spandrels support the truss from underneath, while the arch was embedded into the entire length of the truss. This truss type was often used in early American covered bridges.[8]

(d) Burr Arch-truss

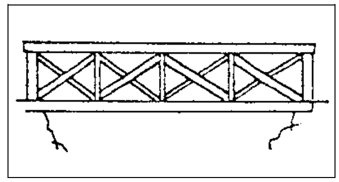


Source: HAER

The Burr arch-truss, patented in 1804 by Theodore Burr, is a vertical and diagonal system of conjoined king posts, creating a rectangular form, which is supported by a continuous arch that extends past the bottom chord. A Burr arch-truss generally spans from 50 to 175 feet and was often found in covered bridges.

(e) Long

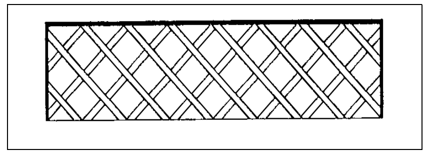
Colonel Long eliminated the arch from the truss, using only panels to comprise the support system. The Long truss, used in the early to mid-1800s, was comprised of crossed diagonals (X-form) within each panel. The end posts on a Long truss are vertical, creating an overall rectangular form. The Long truss was usually used in covered bridges.



Source: Allen, Covered Bridges of the Northeast.

(f) Town Lattice

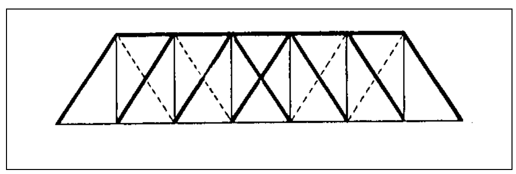
This usually timber bridge, patented by Ithiel Town in 1820, uses closely spaced crossed diagonals to support both compressive and tensile stresses. The span of this lattice reaches 50 to 220 feet. This truss is usually used for through bridges, and can frequently be found as the support system of a covered bridge. This truss type was popular in the state because it used light timbers and was cheap and easy to construct.[9]



Source: HAER

(g) Howe

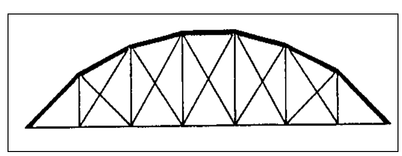
The Howe truss, introduced in 1840 by William Howe, was generally constructed of iron and wood, using a series of triangles to form the overall hipped shape seen in many later truss styles. The truss panels (except the center panel) use a single diagonal member extending from one corner of the panel to the other. The Howe truss uses a crossed diagonal pattern in the central panel to prevent buckling.[10] The timber diagonals of this truss are in compression, and the iron verticals are in tension. The span of a Howe truss generally ranges from 30 to 150 feet.



Source: HAER

(h) Bowstring Arch-truss

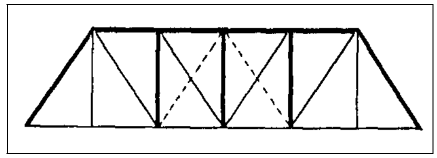
The bowstring arch-truss, also known as the Whipple bowstring truss, was patented by Squire Whipple in 1841.[11] In this tied arch, the diagonal members serve as the bracing and the verticals support the deck. The diagonals in each panel are crossed, extending from the four corners. The top chord



Source: HAER

creates an arched, or polygonal form. Once Whipple's patent expired in 1869, a number of bridge contractors and companies began erecting bowstring arch-trusses.[12] The bowstring generally reached spans ranging from 70 to 175 feet.

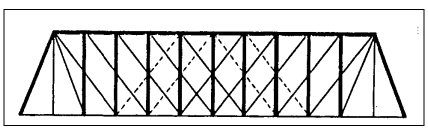
(i) Pratt



Pratt Truss *Source: HAER*

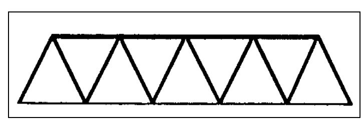
Introduced in 1844 by Thomas and Caleb Pratt, the Pratt truss was originally designed in timber, using iron for the diagonals, though by 1852 the first all-iron Pratt was produced.[13] In fact, the Pratt is the only truss form to be executed in wood, iron, and steel.[14] The Pratt truss reverses the load bearing system of the Howe truss, using its verticals in compression and the diagonals in tension. The panels in the Pratt have a diagonal that extends from the upper corner downwards away from the center. The mid-point panel, and sometimes several adjacent panels of the Pratt often include a crossbar system, which extends from each corner of the panel to reduce buckling.[15] The span length of this truss generally ranges approximately 25 to 150 feet.

Pratt trusses can be found in several variations. A regular full-slope Pratt has hip verticals in tension adjacent to the inclined end posts. The end posts of a Pratt half-hip are less inclined than those of a full-slope Pratt, and do not horizontally extend the length of a full panel. Introduced in the late nineteenth century, the Pratt half-hip truss generally ranges from 30 to 150 feet in span length. On the double-intersection Pratt, introduced in 1847, the end posts are again inclined such as the half-hip, and the structure's diagonals extend across two panels to create the double intersection.



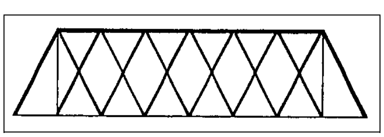
Double-intersection Pratt Truss
Source: HAER

(j) Warren



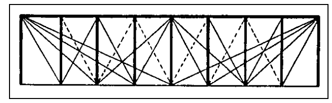
Warren Truss *Source: HAER*

This truss, patented in 1848 by two British engineers, eliminates the verticals found in most other truss forms, using the diagonals to withstand both tensile and compressive forces. Warren trusses can include verticals, but they serve more as a bracing unit than as a load-bearing system. The span of this truss ranges generally from 50 to 400 feet. A Warren truss comes in double- and triple-intersection variations as well. In the double intersection – a regular Warren is superimposed upon itself to create a lattice form – the diagonals cross each other to create diamond-shaped elements. This form of the Warren often spans from 75 to 400 feet.



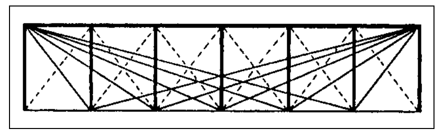
Double-intersection Warren Truss *Source: HAER*

(k) Fink


Source: HAER

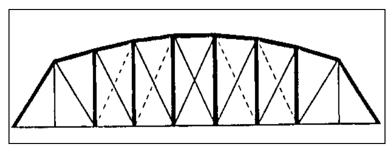
This rare truss form, patented in 1851 by Albert Fink, a Baltimore and Ohio Railroad engineer, finds the verticals in compression and the diagonals in tension. The diagonals originate at the top of the end posts and extend to the bottom of each vertical member. A similar system of diagonals extends from the top of the center vertical to the bottom of each vertical. On Fink deck trusses, there is generally no bottom chord. The Fink truss form has rarely been found in through bridges. The Fink truss, usually of iron construction, generally spanned from 75 to 100 feet.

(l) Bollman


Source: HAER

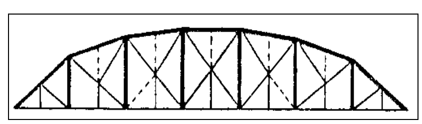
The Bollman truss was designed by Wendel Bollman, a self-taught Baltimore and Ohio Railroad engineer. In the Bollman truss design, introduced in the 1850s and used until 1875, diagonals of this truss run from the end posts to every panel point across the truss. In this form, the verticals are in compression and the diagonals are in tension, much like the Pratt form. The Bollman truss fell out of favor due to its inability to handle live load vibrations.[16] The Bollman truss generally spanned 75 to 100 feet, and is considered to be a rare type.

(m) Parker


Source: HAER

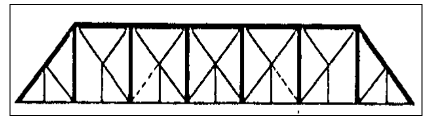
An adaptation of the Pratt truss (verticals in compression and diagonals in tension), the Parker, developed in the mid-nineteenth century, has a polygonal top chord. The diagonals in the Parker originate at the lower corner and radiate upwards away from the center panel. The Parker spanned between 40 to 200 feet.

(n) Pennsylvania


Source: HAER

Using a Pratt truss (verticals in compression, diagonals in tension) as the basic form, the Pennsylvania truss adds sub-struts that bisect the diagonal members. Like the Parker, the Pennsylvania truss has a polygonal top chord. The petit version introduced sub-ties. Invented in 1875, the Pennsylvania truss commonly spanned 250 to 600 feet.

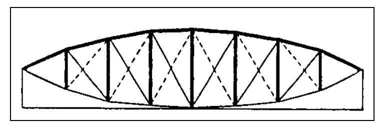
(o) Baltimore



Source: HAER

The Baltimore truss, patented in 1871 and closely related to the Pennsylvania truss, also uses a Pratt system (verticals in compression, diagonals in tension) for the inner bracing. Like the Pennsylvania, the Baltimore truss is subdivided with sub-struts providing auxiliary framework along the diagonals. However, the upper chord remains flat instead of polygonal. If the Baltimore truss has sub-ties, it is called a petit truss. Baltimore trusses often ranged from 250 to 600 feet.

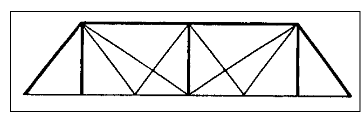
(p) Lenticular



Source: HAER

Lenticular trusses, patented in 1878, also use the Pratt system (verticals in compression, diagonals in tension) for its inner bracing. Both top and bottom chords are in parabolic curves over the length of the bridge. The span length generally ranges from 150 to 400 feet. The lenticular truss is recognized as a rare type.

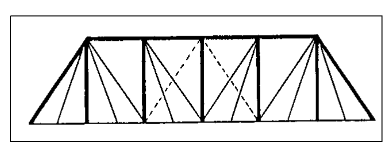
(q) Stearns



Source: HAER

The Stearns truss, patented in 1892, uses Fink inner bracing (verticals in compression, diagonals in tension; diagonals extend from the top chord of the end posts to the center of each inner panel), and eliminates the verticals at alternate panel points. The span usually reaches from 50 to 200 feet. The Stearns truss is considered to be rare.

(r) Kellogg

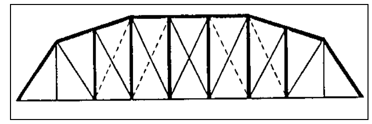


Source: HAER

The Kellogg truss consists of Pratt inner bracing (verticals in compression and diagonals in tension) supplemented with additional diagonals running from the upper chord panel points to the center of the lower chord. The Kellogg truss, used in the late 1800s, generally spanned between 75 to 150 feet and is recognized as a rare truss type.

(s) Camelback

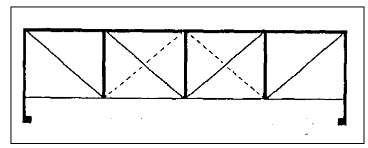
The camelback truss, introduced in the late 1800s, is a Parker with a polygonal top chord of exactly five slopes. The diagonals in the camelback, like the Parker, originate at the lower corner and radiate upwards away from the center panel. The camelback was commonly used for spans between 100 and 300 feet.



Source: HAER

(t) Truss Leg Bedstead

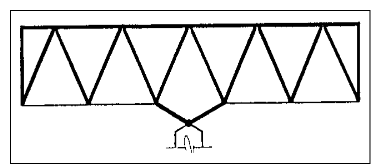
This form, introduced in the late 1800s, is basically a non-hipped Pratt truss with vertical end posts. Verticals are in compression and the diagonals are in tension. The vertical end posts extend past the bottom chord and are embedded into their foundations. Spans range from 30 to 100 feet. The truss leg bedstead is recognized as a rare truss type.



Source: HAER

(u) Wichert

The Wichert truss, invented by E.M. Wichert of Pittsburgh in the early 1930s, uses diagonals to carry both compressive and tensile stresses on all but the end posts. The Wichert truss expands continuously over two or more piers. Its form is characterized by a pin connected, rhomboid-shaped structural arrangement.[17] This truss spans from 400 to 1,000 feet and is recognized as a rare type.



Source: HAER

(4) Suspension

Introduced in the United States in 1801, suspension bridges use towers to provide vertical support for a system of iron chains or wire cables, which suspend the deck of the bridge and are anchored in their extreme ends.[18] The suspension bridge was especially designed to accommodate long spans. The decks were often stiffened by deck trusses to prevent collapse due to external forces induced by traffic and/or wind loads. In wire cable suspension bridges, the main cable runs from the anchorage at the abutments over the tops of the towers for the entire span length. Vertical cables hung from the main cable support the deck system.

(5) Movable

Movable bridges, usually found over waterways, allow ships and boats passage along the water route, and a flow of traffic over the crossing. Depending on its height over the water, the bridge may allow small craft to pass under it while in-place and carrying vehicles over the river. When larger vessels need to pass, the bridge simply moves out of the way, then returns to its position after the vessel has slid through. The four primary types of movable bridges are: retractile, swing, lift, and bascule. The pontoon is a less common movable structure.

(a) Retractile

In retractile bridges, introduced in the 1850s, the span retracts horizontally onto the adjacent roadway to clear the channel for ship passage. These bridges are also known as Boston draw; pull-back draw; or traversing, sliding, diagonal sliding, and rolling draw.[19] Despite their efficiency, retractile bridges never gained great popularity due to the amount of land they required.

(b) Swing

The swing bridge, introduced in the United States by the 1870s, employed a through truss, which was anchored by a central pier that pivoted 90 degrees to allow vessels to pass through. When the swing bridge is open, each half acts as a cantilever suspended over the water. Two channels are cleared for a ship to pass.[20] As ship traffic increased, swing bridges fell out of favor due to the amount of space they occupied in the channel, giving way to the bascule and lift bridges, and eventually the high fixed bridge.

(c) Lift

A lift bridge rises and descends vertically, with the span maintaining a constant horizontal position. Lift bridges, introduced in the 1890s, typically used beams or trusses to span between two towers. The bridge deck is raised using support cables that are attached to rotating drums in the towers. These cables raise the deck vertically, creating a channel for ships to pass through. The bridge is then lowered to allow vehicles to cross the waterway.

(d) Bascule

Bascule bridges, introduced in the 1890s, use a beam or truss deck that can be raised to an inclined or vertical position. To clear the waterway, the deck is either raised in a vertical plane or rolls back on a segmental rack. Bascule bridges can be single-leafed, where the entire bridge is lifted to one side, or double-leafed, where the bridge is bisected and separates from the center. The rotating leaf is counterbalanced by a weight. Types of bascule bridges include the simple trunnion, Scherzer-type rolling-lift, and Strauss trunnion.

The Scherzer-type rolling-lift bascule, developed in the 1890s, has double leaves that rest on curved supports (segmental girders) that roll in their tracks backwards and forwards to raise and lower the leaves. The simple trunnion, introduced in the early 1900s, features a plate-girder construction with a bottom- or rear-mounted segmental operating rack. The trunnion operates as a counterbalanced lever with the weight of the bascule leaf counterpoised with weight affixed to the rear end. This lever moves in a vertical plane on a horizontally set pivot. The Strauss trunnion, introduced in 1905, is a variation of the trunnion bascule that places all of the lever's counterweight at the extreme end of the leaf, using a pivoted, parallelogram framework. The simple trunnion became the most common form for a highway bascule.[21]

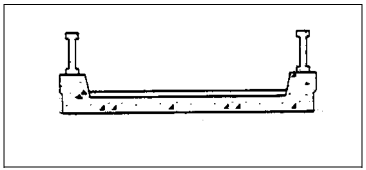
(e) Pontoon

The rare pontoon bridge, developed in the early twentieth century, is usually supported by aluminum or concrete box pontoons that are anchored to the shoreline with cables. These cables hold the bridge's horizontal alignment and the pontoons support it vertically. Most pontoon bridges are temporary in nature and used chiefly by the military or in times of disaster by emergency relief crews.

(6) Beam and Girder

Beam or girder bridges have become a prevalent bridge type in the United States in the twentieth century. The terms beam and girder are interchangeable as girder simply refers to a large beam of metal or concrete. Based on the post and lintel structural system, the earliest simple beam bridges were constructed of timber and often consisted of a plank stretched over a waterway supported by a basic pier or block system. As material technology advanced, the favored materials for beam and girder bridges became steel and concrete.

(a) Concrete Slab

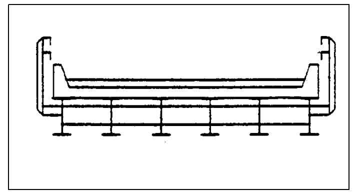


Source: New York State Department of Transportation (NYSDOT), Users' Manual for Structural Rating Program for Bridges. (New York State Department of Transportation, 1995.)

Introduced in 1909, the concrete slab type is generally favored for shorter spans, and is the simplest and most economical of concrete bridge designs. The concrete slab structure includes a rigid horizontal piece that serves as the deck and a structural member carrying stresses to the abutments and/or piers. The introduction of prestressed concrete allowed the concrete slab form to be used for spanning longer distances.[22]

(b) Girder, Stringer, or Multi-beam

Using the same structural form as the simple beam structures, girders are fixed structures consisting of a series of steel or concrete beams placed parallel to traffic, supporting the roadway directly on their top flanges. Beam and girder bridges are supported by abutments at the ends of the bridge. The placement of intermediate piers allows for an almost unlimited total overall bridge length. Limits on shipping, splicing, and girder depths usually limit the maximum unsupported distance for this type of construction to the 320-foot range. Beam and girder bridges typically span between 100 and 320 feet, but they can be found up to 1,000 feet.[23]



Source: NYSDOT, Users' Manual. . .

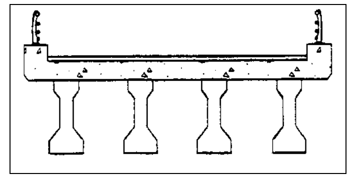
The basic form of the concrete girder was developed by the first decade of the twentieth century, resembling a steel-beam structure encased in concrete. Concrete girders employ large horizontal members beneath the deck spanning from abutment to abutment or abutment to pier carrying the load in a post-and-lintel system. Concrete girders rose to be the most common type of bridge in the United States and can be constructed in various forms, including simple; continuous; and cantilever girders, box girders, and rigid frames.[24]

A steel girder consists of steel beams or plates laid horizontally and utilized as the deck and as an integral structural component. Small spans, typically less than 80 feet, used rolled beam sections. Built-up welded plate girders were fabricated for larger spans. The increased demand for bridges and an economical construction method increased the popularity of the simple steel plate girder form.

The two basic forms of girder bridges are the deck and through girder. With a through girder, the girder extends above the deck and forms a parapet along each face of the bridge. The through girder was prevalent in the early 1910s to 1930s. As the roadway sections widened and concerns for vehicle accidents rose, deck girders became the norm. Through girders are still used for railroad bridges and pedestrian structures.

(c) I-beam

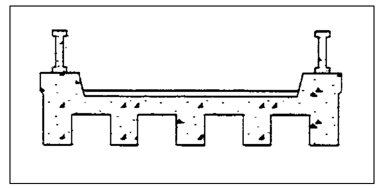
I-beam bridges, composed of steel I-beams encased in concrete, were used by the New York State Department of Highways as standard designs as early as 1910. Prestressed concrete I-beams have been used as bridge superstructures since the 1950s.



Source: NYSDOT, Users' Manual. . .

(d) Concrete T-beam

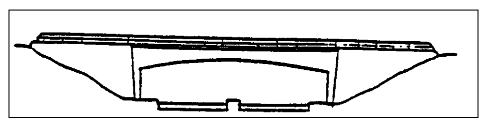
Introduced in the 1910s, T-beams were prevalent from the 1920s to the late 1960s. A T-beam structure features rectangular concrete "T-shaped" beams supporting an integral deck slab or a cast-in-place concrete deck that is used for the roadway surface.



Source: NYSDOT, Users' Manual. . .

(e) Rigid Frame

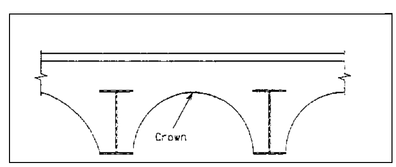
Introduced in the United States in 1922, the rigid frame form appears as a simple beam bridge. However, instead of the deck resting on two abutments, the deck and abutments are a continuous form – poured monolithically in one mold. The rigid frame, commonly used for highway and freeway bridge construction, generally spans up to 100 feet.[25] Both concrete and steel ridge frames exist; however, concrete is the most common.



Source: NYSDOT, Bridge Inventory Manual

(f) Jack Arch

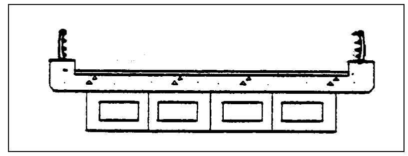
In the late 1920s and early 1930s, the state of New York developed a standard sheet for short span – 25- to 45-foot – bridge systems that became commonly known as the jack arch. Steel beams were encased in concrete and the void between the beams was filled with an arch-shaped concrete filler slab. The most common material used as form work for this arch shape was corrugated iron. Brick and timber were also used, but on a much more limited basis.[26]



Source: NYSDOT, Users' Manual. . .

(g) Box Beam or Box Girder

A box beam or box girder bridge is a fixed bridge consisting of steel girders fabricated by welding steel plates into various "box-shaped" sections. The present box girder form – with its thin-walled, arc-welded structural member – is a post-World War II development. Due to its adaptability to prefabrication and standardization, the steel box girder has become a popular bridge type.[27] The box girder has good load-distribution characteristics that are easily adaptable to curved geometric configurations and various span lengths.[28] The orthotropic box girder uses a single plate extending the width of the box. Prestressed concrete box units were also used, but to a limited extent prior to 1960.



Source: NYSDOT, Users' Manual. . .

C. Construction Materials

(1) Wood

The earliest American bridges were constructed of timber due to the low cost and abundant supply of this material during the eighteenth and nineteenth centuries. Simple wood beams could span about 20 feet; used in an arched truss, truss, or trestle form, wood was used for longer spans. The pile-and-beam trestle was common for long spans where piers could be placed frequently, and was especially popular for the railroads. Wood trusses were the major load carrying components of most covered bridges.

In New York State, builders used local timber to erect bridges, which were often covered, following patented truss designs. Single-spans reached upwards of 200 feet in length. The covered wood, Long truss bridge at North Blenheim, which opened to horse-drawn traffic in 1855 and operated as a toll bridge, had an unusually long span at 228 feet.[29] At one time, New York had as many as 250 covered bridges with the majority concentrated in the Hudson, Mohawk, Delaware, and Susquehanna Valleys and near the Great Lakes and St. Lawrence River. Though covered bridge building peaked in the third quarter of the nineteenth century, scattered examples continued to be built in the state. In New York City, wood was also used to construct movable bridges.[30]

An exposed wood bridge may be expected to last 20 to 30 years if it is not damaged by fire or a flood. Its impermanence was an accepted fact of bridge-building practice in early America. Wood fell out of favor for highway bridge construction as the transportation loads increased and new materials became economical. By the twentieth century, wood was rarely used for road bridges.[31]

(2) Stone

Stone is a strong bridge-building material, particularly as used for arch construction. Except for the simplest stone slabs over narrow streams, all stone bridges are arches. Although the material requires little maintenance, stone was not readily used for highway bridges. The requirements for skilled labor and suitable material made the construction of stone bridges costly and time-consuming. However before poured concrete became common, stone was widely used in the construction of bridge piers and abutments. When stone was selected for bridge building, it was typically because the material was available locally or the sponsoring town desired an aesthetically pleasing structure – perhaps to accentuate an important main street crossing.[32]

Most stone arch road bridges in New York dated from the 1840s through 1890s and were built by local craftsmen. For example, brothers who were recent immigrants from Germany built a three-arch bridge in Jefferson County of hand-cut stone.[33] By the late nineteenth century, three stone arch bridges traversed the Genesee River in Rochester: the 1857 Main Street Bridge, the 1893 Court Street Bridge, and the 1893 Andrews Street Bridge. The segmental arch design of each bridge complemented the nearby Erie Canal Aqueduct, built in 1842.[34]

(3) Iron

Iron was introduced into bridge construction in 1779 at Coalbrookdale, England, and first used in the United States for members in 1840. In this year, William Howe used turnbuckled iron rods for the vertical tension members in a structure.[35] The same year, Squire Whipple used cast iron for compression and wrought iron for tension members in a bowstring arch-truss over the Erie Canal at Utica.[36] Used by both railroad and highway bridge builders, iron was originally combined with wood in bridge construction. Later, iron stood alone, supporting heavy live load. Iron became the dominant material for bridges by the 1850s and held this position until it was replaced by steel by the end of the nineteenth century.

Many of the earliest iron bridges built on roadways in New York used the bowstring arch-truss design. Following Squire's patent, bowstring arch-trusses seem to have been built throughout the state with known examples spread from Allegany to Dutchess Counties and many locations in between. For example, the Van Wyck Lane Bridge was a two-span Whipple truss built in Claverack in 1870 along the original post road from New York to Albany.[37]

The classification system to determine whether metal is cast iron, wrought iron, or steel (a derivative of iron) depends on the carbon level found in the metal. Cast iron has the highest percentage of carbon; wrought iron has been worked further to reduce the carbon level; and steel has the least amount of carbon. Carbon in metal reduces the ability to withstand tensile forces, making the metal more brittle and likely to fail under tensile stress. Each form of metal possessed strength in compression.[38]

(4) Cast Iron

Cast iron, found in bridges by the late 1700s, was not commonly used for bridge building due to the difficulty in obtaining the material. By 1840 cast iron had become more prevalent in bridge construction, and was combined with wood and sometimes stood alone. Cast iron withstands compressive forces well enough, but performs poorly under tension. With its use of compressive forces, the arch bridge was most suited for cast iron construction. In America, the cast iron arch never gained popularity – probably because foundries were not able to cast the large pieces required to assemble an arch. By the 1850s cast iron lost favor to wrought iron, which had a lower carbon content creating a less brittle material.[39]

(5) Wrought Iron

By the mid-1800s wrought iron was readily used in bridge construction; however, the high temperature required to eliminate carbon made wrought iron production difficult and expensive. In the nineteenth century an indirect method of producing wrought iron was introduced in America that used less fuel and allowed the material to be produced in larger quantities. Purer than cast iron, wrought iron has superior tensile strength and ductility. The material was far from reliable, however, suffering from impurities that caused numerous bridge failures. Wrought iron was the preferred metal until the 1890s when steel, with its minimal carbon content, was introduced.[40]

(6) Steel

With the introduction of new manufacturing processes, steel became available for structural use, such as in bridge construction. Steel demonstrated strength and versatility, resisting the failure that had plagued its iron predecessors. Rolled steel beams were introduced in 1885, facilitating the material's use for short bridge spans. By 1895 steel overtook iron as the metal of choice.

Improvements to steel in the late 1930s through 1960 increased the material's strength and durability. As a result, span lengths were able to increase and new designs were used.

(7) Concrete

Concrete was first used in American bridges as early as the 1870s. First used without reinforcement, plain or mass concrete worked solely under compression and was only applicable to the arch form. Concrete became more common for bridge building after methods of reinforcement with metal wire and steel were introduced, improving concrete's tensile strength. For example, in the Melan system developed in the 1890s, parallel steel I-beams were embedded into the concrete. By the 1930s prestressing was adopted as a method of concrete reinforcement. Prestressing involves compressing concrete with heavily loaded wires or bars to improve its tensile strength.[41]

Reinforced and prestressed concrete is used in several types of highway bridges – from arches to beams and girders. Concrete allows a great deal of flexibility in bridge form. For example, arches can span longer distances and beams and girders can be built quickly and efficiently, in many forms. Aesthetics can be added to the supporting form if desired, giving the bridge a decorative look while remaining sturdy and functional.

(8) Aluminum

By 1925 aluminum was an established metal for construction. Its use was facilitated by production during World War I and a search for new applications following the war. As a bridge construction material, the advantages of aluminum include its economy, strength, ease of handling, corrosion resistance, and minimum maintenance. In 1946 the Aluminum Corporation of America built an aluminum girder railroad bridge. The material has not been commonly used for highway bridges, though a few examples were built in New York. Modern aluminum bridges appear to be used primarily for pedestrian bridges and utility crossings.[42]

D. Technological Developments in Bridge Engineering

(1) Development of Truss Bridges

Trusses were introduced for railroad bridges in the early 1800s, and the railroad companies set the pace for bridge building for much of the nineteenth century. The history and development of truss bridges is closely related to the country's early bridge designers, including railroad engineers, who experimented and perfected numerous structural forms that often resulted in patents. Different truss configurations were initially invented and patented for railroad use and these truss types were soon applied to carriage, pedestrian, and road bridges. Of the many truss types, the Warren and Pratt types came to dominate road bridge construction by the late nineteenth century.

The evolution of construction materials during the nineteenth century also affected truss types. Initially, wood was selected due to its availability and durability. New truss types were facilitated by introduction of metal to bridge construction. To strengthen the bridge, cast iron was integrated into simple wood truss forms. Metal truss road bridges were first built of cast iron and then wrought iron, which was favored by the mid-nineteenth century due to its ability to adjust to changes in the way a truss distributes its loadings. By the 1890s steel was available and overtook iron as the material of choice.[43]

Truss members can be joined with pins, rivets, or bolts. The use of pin connections, introduced in the 1840s, allowed for easier erection of bridges, much of which could be completed off-site. The first bridge utilizing pin connections was built in 1858 for the Lehigh Valley Railroad, designed by their chief engineer John W. Murphy. Pin connections remained popular until the end of the nineteenth century when they were replaced by riveting.[44] Factory riveted connections emerged in the 1880s and field riveted joints were introduced in 1908.[45] The Quebec Bridge (contract let in 1911) was the first major truss in North America to use riveted connections instead of pin.[46] Riveting was replaced by high strength bolts, developed and used after World War II, which connect steel by a tight clamping action produced by the high tension stress in the bolt. The high strength bolt is favored because it is as strong as a rivet, yet easier to install and remove.

(2) Development of Steel Arch Bridges

Innovations in bridge design leading to the steel arch resulted from advancements in the development of steel, the use of welding, the invention of the high-strength bolt to replace the hot-driven rivet, and erection methods that eliminated the need for falsework.[47] Completed in 1874, the Eads Bridge in Saint Louis was the forerunner of modern steel arch bridges. The Eads Bridge was the first important use of steel for any type of bridge construction using steel for the iron ribs that typically had been wrought iron.

The Eads Bridge was also notable for its foundation design and erection methods. James Eads improved the European method of using pneumatic-caissons, and the Eads Bridge was the first significant use in America of compressed air and the deepest use of compressed air at that time anywhere.[48] Innovations in erection included the first use of cantilever principle for bridge construction. Construction of the arch did not use falsework below the structure, but was constructed by cantilevering the falsework above the abutment or the pier to balance the arch's thrust. Plowden's praise for the Eads Bridge states:

> "Almost everything about it was without precedent; the choice of material, the decision to use arches instead of using trusses for suspending the bridge, the length of the spans, the methods of construction, the use of pneumatic caissons, the depth of the foundations, the cantilevering of the arches, the stringent

> specifications that forced the mills to produce high-quality steel, and the proof that steel could be used as a structural material."[49]

Although the Eads Bridge was the first important use of steel, the railroad bridge over the Missouri River at Glasgow, South Dakota, was the first bridge to be built exclusively of the new metal. Completed in 1878 by General William Sooy Smith, the Glasgow Bridge had all-steel spans.[50] Developments in steel arch construction led to the completion of the 1889 Washington Bridge in New York City. This bridge was the first in the United States to use plate girders for the arch ribs, creating a two-hinged arch that is rigid throughout but hinged at the abutments.[51]

The steel arch form continued to be used and the 1916 Hell Gate Bridge in New York City, spanning 977 feet, was the longest steel bridge in the world at the time of its completion. This arch bridge was erected by cantilevering each half using a steel tieback system.[52] The Hell Gate Bridge, constructed using massive steel members, was built to support four ballasted railroad tracks. Additional innovations of the Hell Gate Bridge included the use of high-carbon steel, large rivets, heavy splicing, special pivot or rocker joints at chord splices, braking girders in the floor, and cantilever arrangement of the floor laterals.[53]

The 1931 Bayonne Bridge over the Kill van Kull between Staten Island and Bayonne, New Jersey, was built as the longest steel arch in the world at 1,675 feet from center-to-center of arch bearings.[54] Designed by Othmar Hermann Ammann with Cass Gilbert, the parabolic two-hinged arch was structurally similar to the Hell Gate Bridge. An arch was chosen over a suspension or cantilever because a suspension bridge would require more steel than other types and the cantilever required major excavations for anchorage because of the rock river bottom. The span needed to provide a high vertical clearance for the busy waterway without an intermediate pier.[55] The Bayonne Bridge was the first major bridge to use a new steel of carbon-manganese, instead of nickel, which was about 50 percent stronger and cheaper for its main structural members. Another technological innovation of the Bayonne Bridge was the prestretching of the wire rope prior to cutting.[56]

(3) Development of Suspension Bridges

Although the construction of suspension bridges began in the early nineteenth century, the early history of this type was tarnished by bridge failures. Beginning with the collapse of the Wheeling and Belmont Bridge over the Ohio River in 1854 (5 years after its completion), the principles of aerodynamic stability posed challenges to bridge designers and engineers.

Suspension bridge construction began with the use of iron chains. Judge James Finley of Uniontown, Pennsylvania, designed and built the first all-metal suspension bridge in 1801 over Jacob's Creek at Uniontown, Pennsylvania. This 70-foot-span bridge was the first suspension bridge in the world to use a rigid, level deck for vehicular traffic.[57]

Due to the failure of some early nineteenth-century chain suspension bridges, iron chains were deemed not fully suitable for suspension bridges. In both the United States and France, wire cables replaced iron chains in the first half of the nineteenth century and proved to be superior for long-span bridges. Based on French technology, Charles Ellet designed the first successful wire suspension span in the United States – the 1842 Fairmount Park Bridge over the Schuylkill at Fairmount, Pennsylvania.[58]

In the mid-nineteenth century, the suspension bridge underwent a major technological transformation made possible by the use of a new material – wrought iron. As a result, suspension bridges were able to exceed a clear span of 1,000 feet.[59] Another mid-nineteenth century invention that advanced suspension bridge technology was John Roebling's introduction of aerial spinning for the construction of the 1854 Niagara Falls railroad and carriage suspension bridge.[60] Plowden refers to the Niagara Bridge "as the first modern suspension bridge, and it proved beyond doubt that the wire suspension system was reliable when properly understood and properly erected."[61]

Roebling's Brooklyn Bridge, completed in 1883, also made significant contributions to the future of suspension bridges and bridge engineering. The Brooklyn Bridge was the first to use steel cables, which allowed it to span 1,595 feet, becoming the longest suspension bridge.[62]

Early twentieth century innovations were demonstrated in the 1903 Williamsburg Bridge over the East River in New York City, which was the first large suspension bridge to be built with steel towers rather than iron, concrete, or stone towers, and surpassed the length of the Brooklyn Bridge by 5 feet.[63] The 1909 Manhattan Bridge over the East River in New York City also demonstrated several innovations. The Manhattan Bridge was the first application of Melan's 1888 deflection theory, which proved that as the dead weight of a span increases, the need for stiffness in the bridge's deck decreases and, therefore, deep trusses were unnecessary for stability.[64] By incorporating fixed steel towers and air-spinning the cables, the construction of the Manhattan Bridge was more mechanized than methods employed for the two earlier East River spans – the Brooklyn and Williamsburg Bridges.[65]

Suspension bridge construction was advanced by innovations of the late 1920s and early 1930s. The self-anchoring suspension bridge was introduced in the United States by V.R. Covell in 1926-28 for the design of the Sixth, Seventh, and Ninth Street Bridges over the

Allegheny River at Pittsburgh.[66] David Barnard Steinman and Holton Duncan Robinson introduced subsequent innovations on the 1930 Waldo-Hancock Bridge at Bucksport, Maine, including the application of the Vierendeel truss to tower construction and the use of prestressed wire-rope cable to the United States.[67] These innovations led to the erection of monumental suspension bridges in the 1930s. The 1931 New York City George Washington Bridge almost doubled the free spans of all previous suspension bridges at 3,500 feet – a feat made possible by improvements in steel wire.[68]

In his design for the George Washington Bridge, Ammann proved that suspension bridges did not need stiffening trusses attached to the side if the dead weight of the bridge's road deck and cables were properly configured. The elimination of stiffening trusses led to the evolution of suspension bridges that were lighter and less expensive.[69] Another engineering innovation introduced in the George Washington Bridge was the use of rigid towers replacing the towers designed as steel bents or frames fixed at their base and flexible to withstand bending from unequal cable pull.[70]

Continued technological developments are evidenced in the simultaneous construction of two suspension bridges in San Francisco – the 1937 Golden Gate Bridge and the 1937 San Francisco Bay Bridge – which set new records, including feet between towers, tower height, and total length of deck cable.[71] Another 1930s bridge, New York City's 1939 Bronx-Whitestone Bridge, with a main span of 2,300 feet, was the first bridge to use solid plate girders as stiffening members in a long suspension span.[72] However, this bridge was later rebuilt with conventional trusses over the plate girders for increased safety.[73]

The 1940 collapse of the Tacoma Narrows Bridge led the engineering profession to reevaluate the design, stability, and construction of suspension bridges. With bridge construction at a standstill during World War II, a new era of suspension bridge design emerged in the 1950s.[74] Steinman's 1957 Mackinac Strait Bridge, according to Plowden, "may be the most aerodynamically stable suspension bridge." It employed 38-foot-deep stiffening trusses that were 68 percent stronger than the Golden Gate Bridge's.[75] Post-1960 suspension bridges in New York continued to demonstrate the evolution of suspension bridges. A list of New York's ten longest suspension bridges is found in Table 1.

Table 1
Ten Longest Suspension Bridges in New York[76]

Date	Bridge	Length (feet)
1883	Brooklyn	1,595
1903	Williamsburg	1,600
1909	Manhattan	1,470
1930	Mid-Hudson, Poughkeepsie	1,000
1931	George Washington	3,500
1936	Triborough	1,380
1939	Bronx-Whitestone	2,300
1960	Ogdensburg-Prescott International	1,150
1961	Throgs Neck	1,800
1964	Verrazano-Narrows	4,260

(4) Development of Cantilever Bridges

The first cantilever bridge in the United States was the 1876-77 Kentucky River Bridge at Dixville, completed by Louis Frederic Gustav Bouscaren, chief railroad engineer, and Charles Shaler Smith of the Baltimore Bridge Company. The bridge was really a composite continuous and cantilever truss, because a hinge was introduced at the points of contraflexure.[77] Charles Conrad Schneider helped develop the cantilever form in the United States with the design of the counterbalanced cantilever with arms supporting a simple suspended span. Early notable bridges by Schneider include the 1883 Niagara River Bridge and the 1880s Fraser River Bridge of the Canadian Pacific located in British Columbia.[78] The 1889 Poughkeepsie Bridge over the Hudson River was notable for the depth of its foundations, which were constructed in timber caissons using the open dredging process.[79]

The cantilever became popular for medium-span bridges because it eliminated the high cost of building anchorages for suspension bridges and saved materials. The 1909 Queensboro Bridge over the East River in New York City was the longest cantilever in the United States. The Queensboro Bridge had no suspended spans, which was unique among cantilevers of its size designed with a single hinge to prevent the reversal of stresses.[80] Development of the cantilever form led to the 1955 Tappan Zee Bridge, connecting Tarrytown and South Nyack, New York.

(5) Development of Movable Bridges

Whipple's designs for short lift spans to cross the canals in New York beginning in 1872, were an early use of the swing span in the United States.[81] Later developments in movable bridges included John Waddell's 1893 patent for a vertical lift bridge first applied to the 1894 vertical lift bridge crossing of the South Chicago River at South Halsted Street in Chicago.[82]

In the late nineteenth century, bascule bridges became dominant for movable bridges with a number of patents for the two main types – trunnion and rolling lift. The Harman bascule design of William Harman was patented in 1888 for a double-leaf jackknife span. Developed by Chicago city engineer John Ericson, the first trunnion type bridge, which became known as the Chicago type bascule, was completed in 1902 at Cortland Street. The first Scherzer type rolling-lift bascule bridge was built in 1894 over the Chicago River for the Metropolitan Elevated Railroad based on the 1893 patent by William Scherzer . . .[83] In 1893 and 1895, Max G. Schinke applied for patents for a rolling-lift type bascule and the first bridge built was the 1895 Sixteenth Street Viaduct crossing the North Menominee Canal in Milwaukee.[84]

Later patents for variations on the simple trunnion design were granted to Joseph B. Strauss in 1905 and 1906. Commonly referred to as the Strauss type, these bascules link the counterweight to the leaf with pivoted framework so as the leaf moves up and down, the counterweight maintains at the end of the leaf.[85] The improvement of machinery also led to the development of bascule bridges. The Hopkins Bascule Bridge patent of 1936 provided a common base for operating machinery that could be assembled in the shop and simplified field erection.[86]

Movable bridges in New York allowed for vehicular crossing and water navigation of the state's canals and rivers. For example, New York City included a number of movable bridges erected over the Harlem River. In the 1930s, the state set two records for largest and longest lift spans (see Table 2).

(6) Developments and Innovations of Concrete

America's first use of concrete was for the 1872 pedestrian Cleft Ridge Bridge in Brooklyn's Prospect Park using plain or mass concrete in an arch form. Until reinforced concrete was developed, the arch was the only form available for concrete bridges. The bridge was constructed of a newly patented, precast "artificial stone" known as béton aggloméré or béton Coignet, named after its French inventor. The new material could be cast on-site and offered economy in cost and allowed for ease in the production of ornamental details.[87]

The development of reinforced concrete allowed for many innovations in both materials and bridge construction methods. German native R. Jean Monier's patents for reinforced concrete were purchased by Gustav A. Wayss and introduced in the United States in 1884.[88] As early as 1885, the design competition for the Washington Bridge over the Harlem River in New York City included Thomas Clarke's unsuccessful proposal for a reinforced concrete bridge. Clarke's untested design recommended a two-span concrete arch in which the arch barrel would be reinforced with wrought-iron I-beams inserted at the crown and the haunches. Four years later in 1889, the first reinforced concrete arch in the United States was constructed in Golden Gate Park, San Francisco. Designer Ernest L. Ransome's Alvord Lake Bridge used a system of twisted bar reinforcing for the 20-foot bridge.[89]

Varied methods of reinforced concrete were developed and used for bridge construction throughout the United States and in New York. In 1894 the first bridge in the United States using the Melan system – a 30-foot highway bridge – was completed at Rock Rapids, Iowa. The Melan system, which used curved rolled steel I-beams parallel to each other imbedded within the concrete, became a common concrete construction method.[90] Emperger received two patents in 1897 for modifications to the Melan system – one added horizontal I-beams as reinforcing into the deck slab, and one inserted radial bars into the spandrel walls to join the arch and deck beams.[91] Edwin Thacher, engineer of the Melan Arch Company, also modified the Melan patent to create the Thacher system, which used a two-tier system of reinforcement and was thereby more flexible than the Melan system.[92] Another variation of reinforced concrete was the Kahn system, which used a flat bar with the outside edges cut and bent upward to form shear reinforcement. The first concrete cantilever bridge in the United States – the 1905 Marion Street Railway Bridge in Marion, Iowa – used a pair of cantilever girders reinforced with Kahn trussed bars.[93]

A number of other patents for reinforced concrete bridges in the late nineteenth and early twentieth centuries led to technological improvements and innovations. Patented features included: cored abutments, double arches, pavement ties, hinges, unsymmetrical end spans over sloping ground, portal features, T-shaped arches, trussed slabs, and collapsible centers.[94]

Flat-slab construction, invented in 1900 by Swiss engineer Robert Maillart, contributed an innovation to concrete construction by combining the supporting arch with the stiffening wall and the deck into a single cohesive unit to meet the demands of increasing loads.[95] The Maillart system later proved to be "cost effective" because it eliminated all but functional material and the concrete slab became an active bearing surface.[96] In 1908 another flat-slab construction method using mushroom columns to support a slab was developed by Claude A.P. Turner.[97]

American concrete bridge development evolved in the early twentieth century with the Oregon State Highway Department's introduction of a new method of reinforcement largely developed by Frenchman Armand Considere.[98] At Latourelle Falls, Oregon, the 1914 Columbia Highway Bridge's three spans applied Considere's method of reinforcing with tension bars used in the square-section of the rib and bonded to the rib by specially designed hooks.[99] This bridge, according to Carl W. Condit, "established the essential form of the concrete arch throughout its subsequent history in the United States."[100]

The use of rigid frame in concrete construction was introduced in the United States in the early 1920s with the construction of 74 bridges on New York's arterial parkway system in Westchester County under the direction of Arthur G. Hayden, county engineer. Hayden developed a standard form for the rigid frame bridges, which allowed for efficiency and economy of materials. The achievements of rigid frame construction were surpassed in coming decades by prestressing, which proved to be more economical.[101]

Early developments in prestressed concrete included patents in the late nineteenth and early twentieth centuries; however, the material was not readily used for bridge construction until innovations by Eugéne Freyssinet in the late 1920s. Freyssinet's 1928 patent was significant, as it demonstrated the necessity of high-strength steel for successful prestressing, which increased the overall strength of concrete.[102] The prestressed-concrete girder, developed by Freyssinet, was both economical and versatile being applicable continuously or as a cantilever, a box girder or rigid frame.[103] The first large prestressed girder in the United States was Philadelphia's 1950 Walnut Lane Bridge. Contributions of both Maillart and Freyssinet allowed for concrete bridges to break away from the arch form leading to the popular concrete girder.

Begun in the late 1950s, the use of precast bridge elements was another advancement that provided for economical bridge construction.[104] Concrete bridge construction advancements during the late nineteenth and early twentieth centuries were achieved because of the development of high-strength steel, high-strength concrete, means of prestressing, and development of heavy equipment to handle precast and preassembled pieces.[105]

(7) Aluminum – Introduced as New Building Material

Aluminum was first used in bridge construction in 1933 to replace the wood and steel floor beams, stringers, and deck on the 1882 Smithfield Street Bridge in Pittsburgh, Pennsylvania. The new high-strength aluminum alloy floor system was designed and tested by the Aluminum Company of America in hopes of promoting the use of its product.[106]

Early bridges of aluminum construction followed, including the Aluminum Corporation of America's 100-foot deck girder span to carry a spur railroad track to its plant at Massena, New York, in 1946 and a 90-foot double-leaf bascule for railroad and highway use in England in 1948. The first all-aluminum highway bridge, an arch bridge with a 290-foot-span, was completed in 1950 in Arvida, Quebec.[107] In 1958 a welded aluminum girder highway bridge was constructed for the Interstate Highway in Des Moines, Iowa. The bridge's structural members were constructed of flat-plate, non-heat-treatable structural aluminum alloys, supporting a composite concrete deck.[108]

In the late 1950s the New York State Department of Public Works studied the use of aluminum in bridge construction as a means of more effective and economical methods of construction. Prior to 1961, a few aluminum bridges were completed by the New York State Department of Public Works: a rolled aluminum section to carry the Long Island Expressway over Jericho Turnpike in Nassau County in 1959, and two aluminum highway bridges of semi-monocoque design (type of construction in which the outer skin carries all or a major part of the stresses) were under construction over the Sunrise Highway Extension on Long Island in 1960.[109]

Additional technological firsts and important dates are given in Table 2.

Table 2
National Technological Firsts and Important Dates

Date	Innovation/Firsts	Bridge and Location
1836	First all-metal bridge in the United States.[110]	National Road over Dunlap Creek in Brownsville, Pennsylvania
1858	First bridge utilizing pin connections.[111]	Lehigh Valley Railroad Bridge at Phillipsburg, New Jersey
1860	First suspension bridge with metal towers.[112]	Allegheny River Bridge at 6th Street in Pittsburgh, Pennsylvania
1905	Possibly the first concrete arch bridge reinforced with Kahn trussed bars.[113]	Lake Park Pedestrian Bridge, Milwaukee, Wisconsin
1911	Construction begins of first major truss in North America using riveted connections.[114]	Quebec Bridge over the St. Lawrence River, Canada
1924	Record for the longest suspension span (1,632 feet) in the world.[115]	Bear Mountain Bridge across the Hudson River, below Albany, New York
1928	First all-welded bridge.[116]	Westinghouse Company Railway Bridge, Chicopee Falls, Massachusetts
1929	First true rigid-frame girder bridge in the United States.[117]	Bronx River Parkway over railroad tracks at Mount Pleasant, New York

Table 2
National Technological Firsts and Important Dates

Date	Innovation/Firsts	Bridge and Location
1931	Introduction of the tied concrete arch in the United States.[118]	Oregon
1931	First long span three-hinged steel arch bridge.[119]	New Croton Reservoir, Taconic State Parkway, New York
1933	Largest and heaviest lift span in the world at 3,000 tons.[120]	Albany-Rensselaer Bridge over the Hudson River, New York
1936	Largest hingeless arch in the world – 800 foot span.[121]	Henry Hudson Bridge over the Harlem River at Spuyten Duyvil, New York
1936-37	First steel Vierendeel girder bridges constructed in the United States.[122]	Flood control project in Glendale, Los Angeles County, California
1937	Longest highway vertical lift bridge in the world.[123]	Marine Parkway Bridge across Jamaica Inlet in New York City
1937	Introduction of the continuous girder in the form of a hollow box in the United States.[124]	Washington State Department of Highway bridge over the Henderson Bay at Purdy
1950	Longest girder lift span in the United States – spans 312 feet.[125]	Pedestrian bridge over the Harlem River from Manhattan to Ward’s Island, New York City
1959	Longest plate girder in the United States with a main span of 450 feet.[126]	American Rapids Bridge over the Niagara River, New York and Canada
1959	Construction began on the longest post-tensioned concrete bridge – a 320-foot structure.[127]	Binghamton-to-Canada Expressway Bridge over the Oneida River at Brewerton, Onondaga County, New York

3. History of Bridge Design and Construction in New York State

A. Introduction

This chapter outlines significant trends in bridge design and construction in New York State. These trends are presented chronologically and separated into four sections: *3B – Early Period of Bridge Construction (Pre-1908); 3C – Introduction of Standardization (1908-29); 3D – Depression Era Bridge Construction (1930-40)*; and *3E – Modern Bridge Building (1941-60)*. The information contained within this chapter is primarily based on annual reports of New York State transportation agencies. Dates that marked transitions in bridge-building activity are emphasized. For example, during the years of World War II, bridge construction came to a halt in New York because materials were unavailable. The chapter also examines legislation affecting bridge construction, particularly where it concerns the provision of state and federal funds to local governments.

Although the earliest surviving bridges in New York were built in the mid-nineteenth century, bridge-building activity commenced much earlier. This history of bridge construction in New York looks briefly at the late seventeenth and eighteenth centuries to provide a context for later bridge-building activity. Its main focus is on standing bridges that were built before 1961 and continue to carry vehicular traffic on the state's public highway system.

The chapter is intended to facilitate the application of National Register Criterion A to surveyed bridges during a subsequent phase of this project. Criterion A recognizes bridges that are associated with single events, a pattern of events, repeated activities, or historic trends that are significant within the context of New York's bridge-building history. To qualify, a bridge must have an important association with the event or historic trend, and it must retain integrity.

Chapter 3's background on bridge building may also aid the application of Criterion C to surveyed bridges. According to *National Register Bulletin 15*:

> "A structure is eligible as a specimen of its type or period of construction if it is an important example (within its context) of building practices of a particular time in history. For properties that represent the variation, evolution, or transition of construction types, it must be demonstrated that the variation, etc., was an important phase . . ."

The trends in bridge design and construction in New York State presented in this chapter contribute to an understanding of building practices at specific times.

The history of bridge building in New York is followed by two related sections. First, biographical information on designers and planners that influenced New York bridge building is presented alphabetically. Second, bridge-building companies known to have been active in New York are presented, also in alphabetical order. The application of Criterion B, for an association with persons significant to New York's past, and Criterion C, for the work of a master or for a bridge's expression of distinctive characteristics of a construction practice, will benefit from these final sections.

B. Early Period of Bridge Construction (Pre-1908)

(1) New York's First Bridges

Bridge building went hand-in-hand with the early European settlement of New York as new land became accessible to pioneers. Bridges were chosen for crossings when their construction was feasible and economical. For example, Dutch settlers built the first wood bridges over canals in lower Manhattan in the 1650s. For larger crossings, ferry service was often the practical transportation choice. Although many designs were proposed for a bridge linking Manhattan and Brooklyn in the eighteenth century, New York City's East River remained elusive to bridge builders until well into the nineteenth century. Instead, ferries accommodated early commuters to Manhattan from Brooklyn and New Jersey.

Bridges were constructed to aide the military and facilitate settlement. The 1777 bridge – described as a floating structure more than 350 feet long – that crossed Lake Champlain between the Ticonderoga, New York, and Mount Independence, Vermont, facilitated communication between two revolutionary forts and blocked passage of enemy ships.[128] The state erected a bridge over the Ausable Chasm in 1793 to carry a road connecting the villages on the western side of Lake Champlain.[129] The 1812 bridge crossing the Genesee River at Rochester joined the east and west sides of a main route for settlers.[130]

Many towns bore responsibility for the construction and maintenance of bridges in New York. In 1797 residents of the town of Homer, Cortland County, elected to build a bridge that would be funded by local taxes. This bridge, which was the town's first, was constructed of wood.[131] It soon became apparent that towns could not withstand the entire expense and, by 1801 an act was passed to give each county board of supervisors the power to assist towns.[132]

The state's major involvement in transportation development during the nineteenth century was the building of the canal system. Though the state legislature held the power to lay out highways and build bridges for public use, the state did not typically engage in bridge building. Instead, the legislature delegated a county board of supervisors to undertake a publicly funded project, or authorized a private company to build a toll bridge.[133]

In the early nineteenth century public bridge projects were undertaken statewide with towns and counties taking the lead. The state passed special legislative acts to assign financial responsibility for individual bridge projects, sometimes one town was levied, sometimes two towns, and sometimes an entire county. In 1806 the St. Lawrence County Board of Supervisors authorized the town of Massena to raise taxes for the construction of a bridge over the Grasse River. The state contributed less than a third of the cost.[134] In 1812 the commissioners of highways for the towns of Northfield and Southfield, Richmond County, agreed to rebuild their local bridge of wood at joint expense.[135]

Bridge building was a business venture for some individuals, beginning in the late eighteenth century. In 1799 the town trustees of Southampton granted James Mitchell the right to build a bridge from Sag Harbor to North Haven. In 1831 the Payne Bridge Company was incorporated to build a wood drawbridge at this same site. When the toll company dissolved in 1868, the bridge was taken over by Suffolk County.[136]

Many private bridge-building ventures struggled to regain the initial investment. The Cayuga Bridge Company completed a short-lived wood trestle bridge across Cayuga Lake in 1800. The company operated it as a toll bridge for passengers traveling from Cayuga to Bridgeport until the structure collapsed and was replaced by a ferry. In 1813 the private company decided to rebuild, constructing a Long type bridge that lasted for about 20 years. A third bridge, built in 1833, served until 1857, by which time it was impassable and its operators were broke.[137] When the 1817 wood arch bridge over the Genesee River at Carthage collapsed only 3 years after it was built, the businessmen who had erected the bridge still owed the state for a loan issued to help with the construction.[138]

(2) Bridge Building Increases in Mid-Nineteenth Century

In 1838 state law gave the board of supervisors control over bridge projects in their respective counties, ending the frequent application of local governments and corporations to the state legislature for authority to build bridges. County boards gained authority to levy and collect money for bridge projects. If the cost of repairing or erecting “any necessary bridge” would unreasonably burden a town, the county board of supervisors had the authority to raise funds countywide.[139]

Across New York, bridges were built on the initiative of towns that were responsible for their local public highways and bridges. Town commissioners typically assigned an overseer to individual improvement projects. Residents could apply to the town to demand that a bridge be constructed or repaired. Likewise, one town could compel an adjoining town to participate in a bridge project.[140]

The state legislature limited counties' taxing authority and imposed borrowing limits on towns wishing to construct bridges. For example, an 1849 act of the legislature gave towns the right to borrow up to $4,000 for the repair or construction of a road or bridge. In 1859 county boards were able to levy a maximum of $1,000 from the towns per year for public improvements. Though the office of state engineer and survey was established by the legislature in 1846 and given responsibility for engineering work on the canals, railroads, and highways, it seems to have had little involvement with nineteenth century bridge building.[141]

An 1848 state law allowed a minimum of five people to form a corporation for the purpose of constructing and owning a bridge. The director of such a corporation had to be a resident of New York. When any corporation wished to build a bridge, it applied to the county board of supervisors for permission. A board would grant an application when the construction of a bridge would serve public interests. Corporations that built toll bridges were liable for their repair. Every private bridge had to be constructed with a "substantial railing or siding, at least four and a half feet high," and be certified by the county judge as safe before tolls could be collected.[142] If a corporation owning a toll bridge dissolved, the bridge transferred to public ownership.

Bridge-building activity increased as individuals and local governments recognized that the economy depended on transporting agricultural goods to market. Increasingly, sound bridges were constructed on vital transportation routes. Since most bridge building was the responsibility of local governments, town officials relied on local expertise and resources to complete new bridge projects.

During the nineteenth century, traditional stone arch construction was common for small crossings, particularly in areas where stone was readily available. Longer crossings were typically traversed with less expensive, wood bridges. Builders used local timber to erect bridges, which were sometimes covered, following patented designs. The Burr arch-truss and the Town lattice truss were especially popular in the state. After metal became popular for bridge building in the 1870s and 1880s, stone continued to be used where material and craftsmen were locally available. In later decades, wood was sometimes favored when an economical solution was needed.

(3) The Proliferation of Bridge-building Firms

The prefabrication of interchangeable parts reduced costs and gave rise to numerous bridge-building companies that were able to produce stock members and ship them by rail for construction on-site. By 1880 the number of bridge engineers and manufacturers proliferated as many new firms were established.

Two productive bridge-building firms in New York were the Groton Bridge Company, founded in Groton, New York, and the Berlin Iron Bridge Company, based in Connecticut. At the end of the nineteenth century, the Groton Bridge Company was one of the largest of the 17 bridge manufacturers reporting their production in New York State. Groton was versatile in the designs it was able to offer. Though the majority of the bridges the firm built were Pratt trusses, the company also built Parker, camelback, bowstring, and Pennsylvania trusses; swing and lift bridges; plate girders; and concrete slab and arch bridges.[143]

The Berlin Iron Bridge Company and its predecessor, the Corrugated Metal Company, built numerous trusses in New York with a lenticular, and later a parabolic profile following William Douglas's 1878 patent. Victor Darnell reported many examples by the Berlin Iron Bridge Company – most built in the 1880s – across the state except near New York City and Albany.[144] When the Homer (Cortland County) Village Trustees decided to build three bridges over the Tioughnioga River in 1881, they ordered three lenticular truss bridges from the Corrugated Metal Company.[145]

Many other small and large manufacturers operated in the state. A bridge-building company's engineers or agents traveled in search of projects, preparing bids at the request of local governments. The King Bridge Company, based in Ohio, built the 1887 Pratt truss across the Sugar River in Constableville. Murray, Dougal, and Company, a Pennsylvania firm, erected an 1877 Pratt truss in Keeseville that displayed decorative finials and portal bracing.[146] Chenango County was home to many Pratt trusses built by well-known manufacturers beginning in the 1880s. In 1890 the Rochester Bridge and Iron Works completed a wrought iron and steel arch bridge across the Genesee River at Carthage.[147]

In the 1890s competition between bridge-building firms increased as steel manufacturers worked to gain control of the market by limiting smaller companies' access to steel. As steel manufacturers took control of and consolidated bridge-building firms, local bridge manufacturers found it harder to obtain materials. When the American Bridge Company – a subsidiary of the U.S. Steel Corporation – purchased 24 bridge-building firms across the United States, much of the local competition came to a halt. A dominant force in bridge building, the American Bridge Company – and Empire Bridge Company, its New York subsidiary – began operations in the state in 1900. However, some companies that had been acquired by the American Bridge Company, like the Groton Bridge Company, reemerged as independent firms in the early twentieth century.[148]

(4) Niagara River Crossings

New applications of metal for bridge building were tested at Niagara Falls where numerous versions of suspension bridges were erected between 1848 and 1899. The first carriage bridge – a suspension span designed by Charles Ellet – across Niagara Falls was built in 1848. When the carriage deck of John Augustus Roebling's carriage and railroad suspension bridge was completed in 1854, Ellet's Bridge was removed. Minor repairs were made to the Niagara Falls Bridge in the late 1850s and engineer Leffert Lefferts Buck was hired to undertake a complete overhaul in 1878. Eventually, Roebling's masonry towers were replaced with steel.[149]

The first bridge over the Niagara Gorge at Lewiston-Queenston was an 1851 suspension bridge that carried horses, carriages, and pedestrians. This structure was destroyed by gale force winds in 1854 and was not replaced until 1899. Designed by Buck, the new 1899 suspension bridge at Lewiston-Queenston had a plank floor that included tracks for electric trolleys and room for carriages, and later for automobiles.[150]

In 1869 a new, longer suspension bridge with wood towers was completed closer to Niagara Falls for the convenience of visitors. The structure only provided space for one-way carriage traffic. Steel towers replaced the original wood towers in 1885 and new cables were installed in 1888. However, these improvements did not prevent the destruction of the bridge by winds in 1889.[151]

Recognizing the impending failure of Roebling's suspension bridge at Niagara Falls, which previously had been overhauled, Buck designed a steel arch bridge with separate decks for railroad and carriages. Construction began in 1896 and the new bridge, which has come to be known as the Whirlpool Rapids Bridge, opened in late 1897. Two years later, Buck's design for a second steel arch bridge was completed at Niagara Falls, providing two tracks for trolleys and room for carriages. Known as the Falls View Bridge, this structure collapsed from the pressures of ice flows in 1938.[152]

(5) Statewide Bridge Building at the Turn-of-the-Century

Expanding rural economies and the systematic improvement of roads by local governments led to an increase in bridge building by the turn-of-the-century. At the same time, changes in state law facilitated bridge construction by giving municipalities new options for raising funds. Amendments to state law in 1898-99 had allowed cities to issue bonds up to $30,000, and towns up to $20,000, for the construction of a bridge in a densely populated area. With financial assistance, communities were better able to respond to pressures for bridge construction. In less populous areas, bonds were limited to $1,000 without special authorization.[153]

To meet their responsibility for constructing free public bridges, towns raised money by levying taxes upon taxable local property. Towns were often able to complete smaller projects on their own. When a town could not independently afford the expense of building a new bridge, the county board of supervisors had the right to raise up to $2,000 to assist a town with its project. If a bridge were destroyed by inclement weather, the board of supervisors could provide for its reconstruction without regard to the $2,000 limit, thus easing the town's obligation. Town commissioners of highways selected the manner of construction and contracted for a bridge's erection. For example, the town board of Oxford, Chenango County, contracted with the Berlin Iron Bridge Company for two truss bridges in 1895.[154]

To ensure the quality of larger, more costly bridges, a state law went into effect in 1902 stating that no town "shall be compelled to accept or pay for an iron or steel bridge exceeding two hundred feet in length . . . until the state engineer or survey shall certify to the completion."[155] This marked the beginning of state review of local bridge design. A further addition to state law required that, for those counties that had their own engineer, bridge construction be supervised by the county engineer. Additionally, the county engineer had to inspect annually all bridges in his county that were greater than 25 feet in length. The state allowed each county board of supervisors to decide to appoint a county engineer or continue to manage public highways and bridges on its own.[156]

Truss bridges continued to be constructed across the state. After repurchasing its assets from the American Bridge Company in 1902, the Groton Bridge Company continued to manufacture and erect bridges. These later trusses tended to use heavier members than did the earlier structures. In 1906 the Groton Bridge Company was awarded a major contract to build bridges across the Erie, Oswego, and Champlain Canals.[157] The American Bridge Company actively built trusses in New York into the 1920s, as did other small and mid-size firms, including the Canton Bridge Company, King Bridge Company, and Weedsport Construction Company.

Truss bridges from the first decade of the twentieth century included: the 1903 Caneadea Bridge across the Genesee River in Allegany County, a camelback through truss; the 1904 Mill Road Bridge in Columbia County, a Pratt through truss; and the 1907 Rapids Road Bridge outside of Buffalo, a Baltimore truss.[158] Concurrently, new bridge types were introduced. The 1905 Lamb Bridge in the Au Sable Valley was an example of an early steel beam bridge.[159]

(6) New York City's Bridge-building Program

(a) Meeting Early Transportation Needs

Bridge building in New York City was distinct from much of the construction activity in the rest of the state. State law governing the role of the county board of supervisors in overseeing bridge projects did not apply to the city. New York City conducted its building program independent of the state engineer. The city's transportation needs were complex, requiring costly and elaborate solutions to the problem of carrying traffic across numerous waterways. Because the city was home to unusual and major bridge projects in the late nineteenth and early twentieth centuries, its bridge-building program is discussed separately from statewide activity.

New York City's early bridge-building program focused on providing subway and trolley links, many of which were later transformed for automobile use. Central Park was home to the city's first over land bridges, designed by Frederick Law Olmsted and Calvert Vaux in the 1860s to blend with the park setting. Some of these structures were built of cast iron.[160] The city's major bridge-building campaign began after the Civil War and was initiated by the construction of the Brooklyn Bridge.

In the mid-nineteenth century, an extensive network of ferries shuttled passengers between the busy cities of Brooklyn and New York. Though many proposals for bridges were considered, the Civil War delayed action on constructing a bridge across the East River. Among the earliest planned and the first built was the Brooklyn Bridge, which was the longest suspension bridge in the world at the time of its completion in 1883. Designed by Roebling and built under the direction of his son, Washington Augustus Roebling, the Brooklyn Bridge marked a substantial feat in the history of American engineering. It was also admired for the ingenuity of its cable system and the beauty of its masonry towers. Based on the clearance of the Brooklyn Bridge, the United States War Department, stipulated that any East River bridge must be at least 135 feet above the high water level in the center of its span.[161]

As the development of upper Manhattan proceeded, plans were initiated for a Harlem River crossing to the Bronx. To secure a design that would be recognized as a civic monument, the Harlem River Bridge Commission initiated a design competition in October 1885. The winning design by Charles Conrad Schneider was modified by the Union Bridge Company and later enhanced by other engineers involved with the project, including William Jarvis McAlpine. Completed in 1889, the Washington Bridge was a two-hinged steel arch that used steel plate girders for the arch ribs. The approaches are handsomely crafted masonry arches. At the time of its construction, Scientific American and the New York Times published praise for the aesthetics of the new bridge. Later, architectural critic, Montgomery Schuyler called it “an admirable and exemplary work, perhaps the most conspicuously successful monument that American engineering has produced . . .”[162]

Movable bridges were constructed to carry vehicles while allowing river traffic to proceed unhindered. Early examples included the 1884 iron swing bridge, designed by Alfred Pancoast Boller, that carried Madison Avenue over the Harlem River; and the 1889 Carroll Street Bridge, a retractile span designed by the Brooklyn Department of City Works, over the Gowanus Canal.[163]

The U.S. River and Harbor Act of 1890 required that the low bridges over the Harlem River be replaced with structures with a minimum clearance of 24 feet. Swing spans were recommended as most accommodating for river traffic. Designed by Boller, the 1890-95 Macomb’s Dam Bridge and 155th Street Viaduct was a major undertaking for the city. The central bridge’s Pratt through truss central swing span was massive and the steel spans – mainly girders and Warren deck trusses with one camelback truss – of the viaduct provided a lengthy approach. Thomas Clarke designed two swing spans over the Harlem River, the 1898 Third Avenue Bridge, and the 1901 Willis Avenue Bridge.[164]

(b) Department of Bridges Established

An 1897 charter established the Department of Bridges for New York City, granting it jurisdiction over all bridges built and maintained by the city. Of 439 bridges identified in the city in 1898, many were part of the street system.[165] The department built 19 bridges in a dozen years, including major bridges over the East and Harlem Rivers. An amendment to the charter in 1901 limited the Department of Bridges’ control to those structures crossing navigable streams or having termini in two or more boroughs. The city’s commissioner of bridges attended to the construction, repair, maintenance, and management of these bridges. Money for new bridge projects was appropriated by the board of estimates and approved by the board of aldermen. For any bridge costing more than $1 million, the art commission was required to approve its architectural and aesthetic features.[166]

The Department of Bridges adopted the War Department minimum height requirements – mandated for East and Harlem River crossings – for bridges over Newtown Creek and the navigable part of the Bronx River. Although it was 24 feet above high water, one bridge over Newton Creek opened an average of 51 times per day by 1915, leading the department to consider its replacement with a higher structure.[167]

In its 1903 "Statement of Facts," the Department of Bridges described the types of bridges in use that were under its jurisdiction:

•	Draw	20	
•	Swing	5	
•	Wood	3	(one of these was also identified as a trestle)
•	Bascule	2	
•	Boston draw	2	
•	Plate girder	1	
•	Steel arch	1	
•	Suspension	1	(the Brooklyn Bridge)

In this year, ten bridges were under construction – seven draw types, two suspensions, and one cantilever. Five of the draw spans would replace existing bridges.[168]

Movable bridges remained a priority for the department. A c. 1890 swing span, originally constructed as the Harlem Ship Canal Bridge, was floated down the Harlem River and reconstructed at 207th Street in University Heights in 1905-08.[169] Acting as consulting engineer for the department, Boller designed swing bridges over the Harlem River at 145th Street (1905) and Madison Avenue (1910).[170] The 1908 Shore Road Bridge over the Hutchinson River in the Bronx, a Scherzer rolling-lift bascule, was built by the American Bridge Company under contract to the Department of Bridges.[171] By 1915 movable bridges in the city included the following types: 11 swing, six bascule, and two retractile.[172]

(c) Commissioner Lindenthal's Aesthetic Campaign

When Gustav Lindenthal – long known for his concepts for a suspension bridge across the Hudson River – was appointed New York City's Commissioner of Bridges in 1902, he initiated a campaign to build aesthetically pleasing bridges. He employed an architect to give the city's bridges "the graces of architectural design."[173] In keeping with this new requirement, Lindenthal engaged Henry Hornbostel to design the architectural features of the Manhattan and Queensboro Bridges. Lindenthal also worked to improve Buck's design for the Williamsburg Bridge, which was already underway when he took office.

A thorough inspection of city bridges convinced Commissioner Lindenthal that many structures were in bad condition or otherwise inadequate. He requested funding for replacement bridges at many locations in the city. He was able to continue the bridge-building efforts begun with the establishment of the Department of Bridges. The Williamsburg, Manhattan, and Queensboro Bridges were built nearly simultaneously across the East River, serving as a symbol of the unification of the city of New York's boroughs. Until then, only the Brooklyn Bridge joined any two boroughs.[174]

The East River Bridge Commission, which had been established in 1895 to construct the Williamsburg Bridge, wanted a structure that was as impressive as the Brooklyn Bridge but lower in cost and quicker to construct. The commission's direction resulted in the choice of ungalvanized wires for its cables. As Commissioner of Bridges, Lindenthal disapproved of its heavy design but the bridge had progressed too far by the time he took office in 1902. He maintained that the bridge lacked architectural beauty and did not reflect the progress that had been made in bridge construction, except in its strength. With the assistance of a consulting architect, he was able to affect design changes to the bridge's anchorages and tower tops.[175]

The Manhattan Bridge, which was the third to cross the East River, suffered from following both the acclaimed Brooklyn Bridge and the criticized Williamsburg Bridge. With its thin Warren truss supporting the deck and sleek steel towers, the Manhattan Bridge was perceived as too modern by some critics. Its design was thoroughly debated with the resulting bridge incorporating a classical arch and colonnade, designed by Carrère & Hastings, as the gateway to the modern steel suspension span. Lindenthal was replaced as Commissioner of Bridges during this debate, likely as a final means to dismiss his proposal for an eyebar-chain suspension design. Ultimately wire was used, though traces of Lindenthal's ideas survived in the rigid tower design.[176]

The Queensboro Bridge provided a link to Manhattan, facilitating the development of the borough of Queens. When completed in 1909, the success of the Queensboro Bridge was noted worldwide since its type – the continuous cantilever – had fallen into disrepute after the collapse of the Quebec Bridge in 1907. Unlike the Manhattan Bridge, the Queensboro Bridge was built essentially as it had been designed when Lindenthal left his office as commissioner. Lindenthal's later design for the Hell Gate Bridge, a steel arch railroad bridge, capped his reputation of concern for a structure's visual appearance.[177]

C. Introduction of Standardization (1908-29)

(1) New Era of State Involvement Begins in 1908

The Highway Law of 1908 marked the beginning of a new era of state involvement in bridge construction, initiating a movement for better, more permanent bridges. It also established the New York State Department of Highways, which was mandated to supervise bridge projects funded by the state. The 1908 act revised and codified all general laws relating to the construction and maintenance of highways and bridges, including raising and expending funds for bridge projects. The state was still generally prohibited from undertaking bridge projects, but was in a better position to assist local governments. For the first time, a state commission was created to aid, supervise, and direct the local administration of public roadways. The state also began a program of inspecting town bridges. New York's newly centralized bridge-building program gradually led to greater standardization in bridge design.[178]

The 1908 Highway Law stipulated the role of counties in participating financially in bridge projects. An article of the Highway Law made counties liable for the costs of bridges across waters forming a boundary line. Bridges between the counties of Westchester and New York were excluded from this article. In addition, a special provision of the law allowed Westchester County to present claims against the city of New York for county bridges. Statewide, counties retained the option of relieving towns of burdensome costs incurred in bridge construction.[179]

Towns continued to build most bridges, but now could apply to the state for financial assistance to supplement funds raised from local and county taxes. The new office of town superintendents was established to direct the construction and repair of public free bridges. When bridges were erected between towns or between a town and a third-class city, expenses were divided equitably. No more than $1,500 could be raised for construction or repair of a single bridge within any tax year without adoption of a proposition at a town meeting. Towns were no longer able to substitute the work of their residents for payment of taxes, and instead had to contribute money.[180]

If towns could not receive assistance from a county superintendent who was a civil engineer, they were encouraged to seek help from the state commissioners of highways in preparing plans and specifications. The state's offer to furnish plans for new bridges was quickly accepted by town and county officials with 47 plans supplied in 1910, increasing to 84 in 1912.[181] For smaller crossings, town or county superintendents were encouraged to use available standard plans instead of paying for plans. When a manufacturer furnished plans, the state offered any needed advice to the county superintendent.[182] The state did not review many plans in the years immediately following the Department of Highways' formation. Bridge and culvert plans were reviewed at a fluctuating rate of eight to 28 a year between 1909 and 1914.[183]

(2) Guidance on Bridges Issued by the State

In 1910 the state of New York issued directions to county and town superintendents regarding the erection of bridges, including suggestions on type and material. The Department of Highways noted that stone arch bridges were still constructed at a reasonable cost in parts of the state where suitable material was available. Cast and wrought iron were acknowledged as having been displaced by steel. However, concrete was clearly becoming favored by the state. Noting that the design of bridges is now "more carefully understood," the department recommended materials for bridges of different lengths as follows:

> "Culverts and short-span bridges, having a span of less than thirty feet, generally, can be constructed more economically by the use of concrete and reinforced concrete in conjunction with the use of I-beams to hold the concrete slabs. Longer spans should, perhaps, be constructed with steel superstructure and concrete bottoms or concrete flooring."[184]

The Department of Highways dismissed timber bridges as temporary, saying that they were unlikely to last more than 10 years. Plank floors were also said to "wear out in from two to four years."[185] Despite their disfavor, the department still offered standard plans in its 1913 annual report for wood pony trusses up to 72 feet and any length of wood trestle. However, it was noted that these plans were primarily for temporary use, such as in the event of a flood.[186]

The department cited stone and concrete arches as the "most durable" of all crossings.[187] A 65-foot-span arch bridge in Waterburg, Tompkins County, built by the Groton Bridge Company in 1911, made use of durable reinforced concrete and was applauded as virtually maintenance free.[188] Twenty arch designs of various spans and widths were available from the state for use where local conditions were suitable.[189] One site deemed suitable for a concrete arch was Massena Springs, St. Lawrence County, where a two-span concrete arch bridge was constructed in 1911.[190]

Although the department's directions were generally positive about steel as a suitable material for bridge construction, they acknowledged that the life of a steel bridge was not yet well understood. To encourage good quality steel, the state required that bridge materials be inspected. For steel bridges, the need for painting and routine replacement of rivets was recognized as part of maintenance. The department also recommended that steel bridges be strong enough to support concrete floors.[191]

The Department of Highways' directions included aesthetic recommendations for towns. To receive approval from state and local authorities, a bridge had to possess certain qualities, including "good construction . . . good design and beauty." To achieve a beautiful design, the Department of Highways advocated "ornamental construction," rather than "constructed ornamentations" that may give "tawdry results." Concrete was commended for lending itself to molding into a "graceful outline."[192]

Truss or girder designs were prescribed for sites where soft soil could cause the abutments to move. By 1909 the state had prepared standard bridge plans for through trusses with 125- and 150-foot-spans, and pony trusses with spans ranging from 45 to

100 feet.[193] Standard designs for two Parker through trusses – one with a steel floor and the other with a concrete floor – were presented in the Department of Highway's Directions Prescribed by the Commission (1910). The department recommended a 16- to 18-foot clear width between trusses. Examples of truss bridges that were contemporary to these directives were found statewide.[194]

By 1910 the state had issued typical designs for a reinforced concrete box culvert, and I-beam and T-beam bridges.[195] Many steel I-beams encased in concrete were used along the Long Island Motor Parkway, which included 65 bridges when it was completed in 1911. The parkway also included a three-span reinforced concrete bridge and several plate girders, which carried it over main thoroughfares in Queens.[196]

(3) Department Reports Increased Construction Activity

The department's 1913 annual report stated that town superintendents had increased the pace of concrete construction and built 968 concrete bridges the previous year. The Department of Highways continued to expand its repertoire of standard plans, and was considering new plans for arch bridges, lift bridges, and draw spans. Standard plans for 216- and 235-foot truss bridges, with 21- and 20-foot clear widths, respectively, were added to the stock in 1913.[197] Other states and New York engineering schools often borrowed the department's standard plans.[198]

Since the 1908 Highway Law did not permit the state to build bridges without special permission, New York sought permission from the legislature to build needed structures. Two bridges authorized by special acts of the legislature were completed in 1914 – the steel girder over the Allegheny River in Cattaraugus County and the crossing of the South Bay of Lake Champlain, Washington County. Two other steel bridges, which had unusual designs due to difficult conditions, on the Storm King Highway (N.Y. 218) in Orange County were specially authorized in 1914 for future construction.[199]

Within the Department of Highways, the Bureau of Bridges grew to be one of the most important bureaus by 1915. Under the Highway Law of 1915, the bureau prepared plans and specifications at the request of local authorities. The Bureau of Bridges had no power to follow up on its plans to see that the towns had built structures properly. The department had jurisdiction over bridges in only those towns that had agreed to participate in the state's funding system.[200]

Despite the state's greater role in bridge building, towns still completed the majority of projects independent of state involvement. Truss bridges, erected by local bridge manufacturers, remained an economical solution for towns. For example, the Climax Road Machine Company of Marathon, New York, built a Pratt through truss over West

Canada Creek in Oneida County in 1913.[201] The Groton Bridge Company completed a Warren pony truss over the Oswegatchie River in St. Lawrence County in 1914.[202]

Bridge building slowed during World War I due to the scarcity of materials and labor.[203] In 1918, 402 town bridges were constructed in the state, down significantly from the numbers of a few years earlier.[204] The 1919 Report of the State Commissioner of Highways acknowledged that the state wanted towns to build concrete bridges for the purpose of saving taxpayers' money.[205] A multiple-span concrete arch bridge, built in 1918 in the town of Massena, St. Lawrence County, followed this recommendation.[206]

Despite this slowdown in bridge-building activity, New York State had 33,800 bridges by the early 1920s. Ninety percent of these bridges were on township or unimproved county roads, and only 10 percent stood on state or improved county roads. Two-thirds of these bridges had spans less than 20 feet and were sometimes categorized as culverts. More than 8,000 of New York's bridges were between 20 and 50 feet in span length. Only about 3,000 had span lengths over 50 feet.[207]

(4) Bridge Work Intensifies Following World War I

As automobiles became more prevalent after World War I, the state worked to update highways and river crossings to meet the demands of increased tourism throughout New York. Construction projects that had been slowed by the war gradually resumed.[208] Federal aid restrictions made money available to the state for highway construction only if the bridges on the affected highways were adequate. This requirement increased the work of the bridge department, which sought to replace bridges that were unacceptably small or skewed. By upgrading bridges, the state became eligible for federal funds for highway construction.

New bridges completed by the state's bridge department in 1922 are listed in Table 3.

Table 3
Bridge Projects for 1922

Type	Special Designs	Standard Plans
Slab	11	3
I-beam	16	19
Girder	18	2
Concrete (not arch)	2	0
Total	*47*	*24*

In addition, the department reviewed 42 plans that year and developed a new I-beam standard plan for spans of 10 to 46 feet.[209]

In the 1920s new parkways catered to increasing tourism. Since at-grade crossings would obstruct the free flow of automobiles, the parkways used grade separations for intersecting roads. Between 1922 and 1930, 74 grade-separated highway crossings were constructed on New York's arterial parkway system in Westchester County. Most of these crossings were rigid frame concrete arch bridges faced with stone. County engineer Arthur G. Hayden used the rigid frame, which had been recently introduced in concrete construction, because it was economical. The parkway bridges spanned 19 to 99 feet and were developed from a standard form with minor variations for skew and curving alignments.[210]

On the Bronx River Parkway, built between 1906-25, the bridges were described as "major architectural elements . . . significant in terms of engineering for their innovative designs and are almost all reinforced concrete structures with a stone-facing of native granite ashlar."[211] Because existing roads crossing the parkway were kept at-grade, a reinforced concrete, flat arch bridge was specially designed to maximize headroom while minimizing excavation costs. This allowed sufficient headroom for automobiles while keeping the parkway above the level of the adjacent river.[212] The bridges along the Taconic State Parkway, begun after 1925, were stone-faced to complement the landscaping. The parkway's single- and double-span bridges used the rigid frame, concrete arch, and steel girder types.[213]

During his tenure as head of the Long Island Parkway Commission beginning in 1924, Robert Moses influenced bridge design on parkways built by the commission. He purposefully kept overpasses low to keep out buses and sought variety in their design.[214] Not only were the bridges to be designed to harmonize with the landscape and to be stone-faced, but every bridge on every parkway on Long Island was to be different from any other bridge. Since iron would not blend in with a rustic setting, Moses had guardrails, which were reinforced with steel cable, and light poles made of wood.[215]

Increased numbers of automobiles created the need for a highway bridge over the Hudson River where valley residents had long used ferries. Construction of a bridge would have to avoid obstructing the Hudson River, which served as an important commercial waterway from New York City to Albany. The 1924 Bear Mountain Bridge – a long suspension span – met the needs of both motorists and commercial ship traffic. Built as a toll bridge by a private company, the Bear Mountain Bridge relied on the willingness of motorists to pay tolls to return the investment.[216]

(5) New State Agency Takes the Lead in Bridge Construction

The establishment of the Department of Public Works initiated broader state involvement in bridge building. Bridge projects placed under contract by the department from 1926-40 are described in Table 4. The figures include bridges on the state highway system, on parkways within municipalities, on farm to market highways, on town or county roads, and on a limited number of highways not on the state system; excluded are highway-railroad grade separations. The department recorded projects where bridges were constructed, reconstructed, widened, or permanently repaired.[217] This table presents lower annual totals than the text because it excludes bridges less than 20 feet in length, and two undefined bridge types – extensions and miscellaneous.

Although the department was formed under state law in 1923, enabling legislation was not passed until 1926.[218] As of January 1, 1926, the state assumed responsibility for the reconstruction of condemned bridges and construction of bridges on new roads. The new law responded to the inability of towns to keep up with the demand for new bridges that met modern requirements. The department considered 514 bridges across the state to be unsafe and recommended they be rebuilt immediately. The department's building campaign was somewhat slowed by the Attorney General's ruling that bridges condemned before January 1, 1926, could not be rebuilt at state expense.[219]

The Department of Public Works made ample use of its standardized plans. For bridges up to 125 feet, standard plans were on hand and only abutments needed to be designed on an individual basis. "Separate study and design" was anticipated for bridges over 125 feet.[220] The state considered simple slab, I-beam and plate girder structures to be most economical for bridges up to 100 feet. In 1926, 75 percent of the department's bridge projects were one of these three types. New standard designs were completed for concrete T-beam and I-beam bridges up to 45 feet, at various skews, and for square plate girders up to 90 feet.[221]

In 1926 the Department of Public Works recorded 179 bridge projects with spans over 5 feet in length. Although the state was more involved, towns continued to complete projects independently and, by law, retained the burden of rebuilding bridges condemned before 1926. Despite the restriction on state funding for previously condemned bridges, the legislature appropriated a special sum for reconstruction of the Columbiaville Bridge on Albany Post Road in Columbia County.[222]

Table 4
Contracts From 1926-40*

Type	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	Total
Slab	87	134	132	129	126	164	82	43	52	43	80	21	26	13	16	*1,148*
I-beam	37	55	52	35	40	44	41	42	32	28	76	30	39	46	37	*634*
T-beam	5	10	17	22	22	25	16	11	7	10	2	1	4	0	0	*152*
Through girder	0	21	37	32	40	36	30	13	18	18	30	13	10	13	3	*314*
Deck girder	11	0	2	4	0	7	5	8	2	0	4	2	4	5	2	*56*
Pony truss	0	5	4	13	16	25	12	11	18	8	6	3	3	1	3	*128*
Through truss	8	10	10	8	16	18	17	17	5	10	13	4	12	14	13	*175*
Deck truss	0	1	0	0	3	2	3	1	0	1	1	0	1	0	1	*14*
Rigid frame	0	1	4	2	2	16	16	12	20	8	14	19	5	6	10	*135*
Concrete arch	2	6	11	13	14	7	12	19	18	5	4	12	3	2	3	*131*
Steel arch	0	2	1	3	0	0	1	0	0	1	0	1	0	0	0	*9*
Timber trestle	1	0	1	1	2	0	3	1	6	32	32	2	5	2	3	*91*
Movable	0	1	1	1	0	0	0	0	0	0	1	0	0	0	0	*4*
Total	*151*	*246*	*272*	*263*	*281*	*344*	*238*	*178*	*178*	*164*	*263*	*108*	*112*	*102*	*91*	*2,991*

* *Compiled from New York State Department of Public Works, Annual Report of the Superintendent, for the available years between 1926-40. Culverts – distinguished by the department as structures with spans less than 20 feet in length – were excluded from this table. "Extensions" and "miscellaneous" – types distinguished by the department but not defined – were also excluded.*

The legislature also made the state responsible for maintenance of the 300 canal bridges, which had previously been cared for by local communities. The following year, 1927, the Department of Public Works undertook an effort to replace deteriorated canal bridges, removing or rebuilding 34 that year alone. In 1928, 60 canal bridge projects were completed.[223]

The Department of Public Works recorded 296 bridge projects – for spans greater than 5 feet – in 1927. Of these, 70 percent were slab, I-beam, or girder type bridges. The department also built two steel arches in this year. Another steel arch bridge, the Peace Bridge, was built in 1927 without state assistance by the Buffalo and Fort Erie Public Bridge Company, an international organization that had raised funds for the bridge's construction. In addition to its five steel plate girder arches, the Peace Bridge had one Pennsylvania through truss span.[224]

The Department of Public Works constructed or reconstructed 361 bridges – for spans greater than 5 feet – in 1928. Slab, I-beam, and girder type structures represented 62 percent of bridges. The department prepared 20 new standard sheets for slab, I-beam, and concrete beam bridges to accommodate a revised roadway width. The Chateaugay viaduct in Franklin County was called out in the department's annual report as an unusual project, consisting of three main spans of the three-hinged plate girder arch type. The state had also let contracts for the three bridges – two of which were "reinforced concrete trestle type" over 500 feet in length – to improve access to Long Island's popular Jones Beach State Park.[225]

Local governments had the option of cooperating with the state in bridge projects. By 1928 counties, towns, and villages made $3 million in voluntary contributions to reconstruction contracts. The local contribution was 17 times greater than it was in 1919, which relieved the department's financial obligations. Nineteen counties participated in projects with the state in 1928 as compared with only three in 1919. Town superintendents still had control over expenditures on local projects, though the department hoped to see the legislature transfer this responsibility to county superintendents. The state highway commissioner noted: "The supervision by the State Superintendent of Public Works of fifty-seven county superintendents can be much more efficiently carried out than can the supervision of 933 town superintendents."[226]

The state's imposition of a gasoline tax in 1929 provided more funds for road and bridge construction.[227] The 266-foot steel arch bridge across the Salmon Creek gorge between Ludlowville and Myers in Tompkins County, located on the new road to Kings Ferry, may have benefitted from this increase in funding. Begun in 1929, the arch span was designed by Roscoe C. Beebe of the American Bridge Company.[228] New York State shared costs with Vermont for the bridge across Lake Champlain at Crown Point, New

York – a cantilever through truss with three continuous spans – completed in 1929.[229] The department contracted for 404 bridge projects with spans over 5 feet in 1929.

(6) Bridge Building in New York City

After a lull in bridge building during the 1910s, the New York City's Department of Public Works completed many movable spans in the 1920s. Bascule type bridges were built at 233rd Street over East Chester Creek, Bronx (1922); Cross Bay Boulevard over the North Channel, Queens (1925); Nolins Avenue over the Shell Bank Basin, Queens (1925); Roosevelt Avenue over the Flushing River, Queens (1927); and Greenpoint Avenue over Newtown Creek, Brooklyn and Queens (1929). In 1929 a swing span was built at Stillwell Avenue over Coney Island Creek in Brooklyn.[230]

Following World War I, ferry boats shuttled 12 million vehicles annually between Manhattan and New Jersey.[231] To expedite the movement of people and goods through this harbor, legislation in the states of New York and New Jersey created the Port Authority of New York in 1925. The Port Authority became the principle sponsor of major bridge projects in the city. The first vehicle crossings constructed by the Port Authority were the 1928 Goethals Bridge, connecting Elizabeth, New Jersey, to Staten Island, and the 1928 Outerbridge Crossing, linking Perth Amboy, New Jersey, and Staten Island. Both bridges used steel truss cantilevers designed by the consulting engineering firm of Waddell & Hardesty.[232]

Soon after its creation, the authority began planning its most substantial project, the George Washington Bridge over the Hudson River.[233] The Port Authority of New York would continue to undertake major transportation projects in the succeeding decades.

D. Depression Era Bridge Construction (1930-40)

(1) Activity of the Department of Public Works

Despite the economic slowdown caused by the Depression, the Department of Public Works witnessed its peak number of bridge projects in 1931. Though the number of projects fell off after that year, a healthy number of bridges were still constructed until 1936. In the final years of the decade, bridge projects contracted by the department declined more sharply. Federal funding remained available for bridge building, and was especially used to finance programs for unemployed workers. Bridges constructed from 1930-40 met the increasing demands of the traveling public. Parkway construction, including associated bridges and overpasses, continued. Other new bridges linked popular tourist destinations with their principle source of visitors.

The effects of the Depression led to a reduction in state appropriations and an associated decline in the number of bridge-building projects. The number of bridge and culvert projects contracted by the department fell from 522 in 1931 to 154 in 1940. As a result of smaller appropriations, the department's staff size shrank during the 1930s. Starting in 1932, some department staff was eliminated, while other engineers were moved to a staggered employment system whereby they worked 1 month with pay and then were laid off for 1 month without pay.[234]

With funding limited, the department's priority was to replace or strengthen load-restricted bridges located on Class A highways (where the traffic count exceeded 2,500 per year).[235] Economical beams, slabs, and girders were the structures of choice, representing from 59 to 81 percent of bridges contracted in a single year during this frugal decade. Slabs were the most common type for much of the decade, but by 1939 I-beams represented up to 45 percent of bridges contracted by the department. When used in typical situations, I-beam bridges utilized the standard plan that the department had updated in 1932.[236]

In the 1930s the department continued to design truss bridges with this type representing from 6 to 19 percent of bridges contracted in a year. Examples included two Pratt trusses built in Tioga County in the late 1930s.[237] Concrete arches were built in smaller numbers, with a decade high of 19 built in 1933. A contemporary example was the single-span concrete arch bridge that carried a county road over Payne Brook in Madison County.[238] Timber trestles surged in use in 1935 and 1936, with 32 built each of these years.

During this period, the department undertook large bridge projects as special assignments from the legislature. In 1932 two special projects were completed: a five-span, filled spandrel, reinforced concrete arch over Catskill Creek at Catskill-West Coxsackie in Greene County; and a composite bridge at the Plattsburg-Ausable Chasm in Essex and Clinton Counties, with a 222-foot steel-plate, deck girder arch main span and two 52-foot, filled spandrel, reinforced concrete arch secondary spans.[239] A few years later, the department began construction of a nine-span, deck plate girder, viaduct at Callicoon-Long Eddy in Sullivan County.[240]

An unusually expensive bridge, completed in Rochester in 1932, contradicted the trend toward restricted funding. The Veterans Memorial Bridge was an open spandrel, reinforced concrete, ribbed arch. Tremendous cost was added by the bridge's granite facing, which gave it the appearance of a solid arch with project ribs. The bridge was criticized as uneconomical since it fit uncomfortably into this decade of cost-consciousness.[241]

Two large movable bridges over the Hudson River near Albany were constructed as state projects. The department described the Albany-Rensselaer Bridge, which opened to traffic in 1933, as having "the largest and heaviest" lift span in the world. The total weight of this span – designed by consulting engineers Waddell & Hardesty – was 3,000 tons. The bridge also included cantilever truss spans. The Troy-Menands Bridge, planned with an identical lift span, was also under construction in the early 1930s.[242]

As the state budget declined, the percentage of federal appropriations for bridge construction increased through the 1930s. By 1937 federal funds accounted for 20 percent of the total cost of the department's bridge projects.[243] In 1940, 45 percent of the cost for bridge projects was financed through federal appropriations with the state contributing the remainder.[244] Although the state and federal governments provided funding, the vast majority of bridges on the state highway system were built under private contract. According to Department of Public Works records, less than 5 percent were built "by department forces."[245]

(2) Tourism Traffic Served

Numerous bridges built during the 1930s served increased tourism traffic and linked main highways. As automobile traffic in the Hudson River Valley grew, two new bridges were built across the Hudson River. Constructed by the American Bridge Company, the Mid-Hudson Bridge at Poughkeepsie was completed in 1930. Its steel towers supported suspension cables in a design by Ralph Modjeski and Daniel Moran.[246] In 1932 the state legislature established the New York State Bridge Authority for purposes of constructing, operating, and maintaining bridges across the Hudson River.[247] The 1935 Rip Van Winkle Bridge at Catskill, which was part continuous steel trusses and part cantilever in type, was the authority's first construction project. Together with the 1924 Bear Mountain Bridge – still privately owned – and the 1931 George Washington Bridge built by the Port Authority of New York, highway bridges spanned the Hudson River from New York City to Albany at approximately 35 mile intervals.[248]

The Roosevelt International Bridge, a rebuilt railroad crossing that connected Cornwall, Ontario, to Massena, New York, opened for automobile use in 1934. Though not the most direct route between New York City and Ottawa, the bridge carried the bulk of long-distance tourist traffic, providing an alternative to automobile ferry services at Prescott and Brockville. Residents near the western end of the St. Lawrence River received their first international bridge crossing when the Thousand Islands Bridge opened in 1938. Composed of five individual bridges, this crossing linked Ivy Lea, Ontario, and Collins Landing, New York.[249]

A pair of bridges designed by Waddell & Hardesty spanned the Niagara River, linking Grand Island and the city of Buffalo to the south, and Grand Island and the city of Niagara Falls to the north. Completed in 1935, the North Bridge was a series of cantilevers, while the South Bridge combined cantilever spans with a tied arch.[250] Construction was supervised by the state's Department of Public Works. The bridges later became part of the thruway system.[251]

Parkway bridge construction continued during the Depression era. Use of the rigid frame bridge, which was especially popular on parkways, peaked during the mid-1930s. Of the 16 parkway structures the state placed under contract in 1936, nine were rigid frame bridges, four were culverts, and one each were arch, I-beam, and girder bridges.[252] The next year, the state contracted for 27 parkway bridges, 44 percent of which were rigid frame structures.[253] A larger and specially designed parkway bridge was the 1931 Taconic Parkway Bridge over the Croton Reservoir, a 750-foot steel, three-hinged arch. Its abutments were squared off with Art Moderne style pylons that flanked each approach to the bridge.[254]

To ease the flow of traffic, the state engaged in bridge projects to separate the grades between parkways and intersecting roads. In 1939 the Department of Public Works completed four highway grade separations on the Southern Parkway, 13 on the Cross Island Parkway, and three on the Shore Parkway.[255]

(3) New York City Bridges

In the 1930s New York City began a program to upgrade its transportation system. Much of this work was undertaken by Moses' Triborough Bridge Authority, which originally formed for the purpose of building the Triborough Bridge, but soon took on broader responsibilities. Two other authorities were formed to build individual bridges – the Henry Hudson Parkway Authority and the Marine Parkway Authority, and were later absorbed into the Triborough Bridge Authority. The previously established Port Authority of New York completed its biggest bridge, the George Washington Bridge, early in this decade.

The federal government's first public works program, the Reconstruction Finance Corporation, helped finance the Triborough Bridge.[256] Between August 1935 and June 1937, the Works Progress Administration expended $7.3 million on behalf of the Department of Plants and Structures, which was responsible for new bridge construction. This figure represented less than 2 percent of the administration's work-relief expenditures in New York City.[257]

The newly formed New York City Department of Public Works assumed responsibility for the construction of the city's bridges – excluding authority-sponsored structures – in 1938. This city department worked closely with Moses' Triborough Bridge Authority. The New York State Department of Public Works continued its role in New York City bridge building by completing grade separation structures on parkways.

(a) Moses's Building Campaign

Described as the "greatest builder in American history," Moses' tremendous influence over public works projects in the city and state of New York began in the 1930s.[258] Under Moses' direction, New York City witnessed a boom in land bridge building from 1935-65, during which time nearly 1,000 land bridges were built as part of the limited access highway system.[259]

Under Moses's firm guidance, the Triborough Bridge Authority became responsible for financing, constructing, maintaining, and operating toll bridges within the limits of New York City. First as chief executive officer and later as chairman of the authority, Moses initiated an aggressive bridge-building campaign to link Manhattan with the outer boroughs and surrounding suburbs. During the 1930s, he oversaw the construction of five major bridge projects: the Triborough Bridge (1936), Henry Hudson Bridge (1936), Marine Parkway Bridge (1937), Bronx-Whitestone Bridge (1939), and Cross Bay Parkway Bridge (reconstructed in 1939).[260] Othmar Hermann Ammann, a leading twentieth century bridge designer, collaborated with Moses, serving as his principle structural engineer.

The Triborough Bridge opened to traffic in 1936, connecting Queens, the Bronx, and Manhattan with a 3½-mile bridge and 14 miles of approaches. The 1,380-foot main suspension span and the 310-foot vertical lift span over the Harlem River were both designed by Ammann. When the Triborough Bridge Authority constructed the bridge, it also built connections to integrate the structure into the highway system.[261]

As chairman of the Henry Hudson Parkway Authority, Moses also oversaw construction of the Henry Hudson Bridge. Completed in 1936, this 800-foot steel, hingeless arch crossed the Harlem River and connected the Bronx with the Henry Hudson Parkway in Manhattan. To meet the demands of heavy traffic, a second deck was added to the bridge just 2 years later.[262] The Henry Hudson Parkway Authority was absorbed into Triborough Bridge Authority in 1940.

The 1937 Marine Parkway Bridge's 540-foot vertical lift span – part of a 4,022-foot structure connecting Brooklyn and the Queens – was described as the longest for a highway bridge. The bridge, which led to a popular recreation area, carried a high volume of seasonal traffic.[263] It was constructed by the Marine Parkway Authority, which became part of the Triborough Bridge Authority by 1940.

Connecting the boroughs of Queens and the Bronx over the East River, the 1939 Bronx-Whitestone Bridge – with a main suspension span – provided the gateway to that year's World's Fair. The bridge used solid plate girders as stiffening members for its 2,300-foot suspension span. The Triborough Bridge Authority built the Whitestone Parkway in Queens, including a double-leaf bascule bridge over the Flushing River, and the Hutchison Parkway in the Bronx in connection with the Bronx-Whitestone Bridge Project.[264]

In 1939 the New York City Parkway Authority reconstructed and widened Queens' Cross Bay Parkway Bridge, originally built in 1925, to provide a six-lane, double-leaf bascule span. The approaches were also improved. This authority was later consolidated under the Triborough Bridge Authority.[265]

(b) Port Authority of New York

To facilitate travel over the Hudson River between New York City and New Jersey, the Port Authority of New York opened the George Washington Bridge in 1931. This two-deck suspension bridge, designed by Ammann, almost doubled the maximum span length that had been previously achieved. Cass Gilbert, a designer of early skyscrapers, served as consulting architect.[266] Esteemed for both his technological virtuosity and aesthetic sensibility, Ammann originally intended to clad his steel towers with masonry, but the economic effects of the Depression led the Port Authority to abandon this plan as too expensive.[267] However, the George Washington Bridge still represented one of Ammann's greatest accomplishments.

Also completed by the Port Authority in 1931 was the Bayonne Bridge over the Kill van Kull between Bayonne, New Jersey, and Staten Island, New York. The bridge had a 150-foot mid-span clearance that allowed ocean-going vessels to pass without interference. The Bayonne Bridge's two-hinged, through steel arch spanned 1,675 feet from center-to-center of the arch bearings. Its lower chords used carbon-manganese steel for the first time in bridge construction. The bridge was designed by Ammann, assisted by Leon S. Moisseiff and others. Gilbert again served as a consulting architect.[268]

(c) New York City Department of Public Works

In 1938 New York City's Department of Plant and Structures, which had jurisdiction over bridges, was renamed the Department of Public Works. Moses served as New York City's construction coordinator, overseeing the city's federally-funded projects.[269] The city undertook improvements of deficient movable structures. In 1937-38 two bascule bridges were completed in New York City that replaced turn-of-the-century retractile structures.[270] The city opened the Westchester Avenue Bridge, a bascule span over the Bronx River, in 1938; a similar structure was completed at Northern Boulevard over the Flushing River, Queens, in 1939.[271]

(d) New York State Department of Public Works

During the 1930s, the New York State Department of Public Works prepared and reviewed highway grade separation structures located on parkways in New York City and adjoining counties. In 1936 the state reviewed plans for grade separation structures to be constructed in Queens County in association with the World's Fair; three contracts were awarded in 1936-37. Under the department's direction, construction began on four highway grade separation structures on the Henry Hudson Parkway.[272] In 1937 the New York State Department of Public Works widened the existing reinforced concrete, deck arch bridge over the Kenseco Reservoir, Westchester County, which had been built by New York City in 1910.[273]

E. Modern Bridge Building (1941-60)

Completed in October 1941, just prior to the United State's entry in World War II, the Rainbow Bridge over the Niagara Gorge was one of the last major bridge projects until the war ended. Efforts to replace the Falls River Bridge were begun as early as 1937 due to the safety of the existing structure. Built under the auspices of the Niagara Falls Bridge Commission, the new steel arch bridge catered to the tourist traffic at Niagara Falls. Designed by the New York engineering firm of Waddell & Hardesty, sections of the hingeless steel arch were constructed from each shore and linked at the center.[274]

(1) War Ends Bridge-building Activity

During World War II, bridge construction was almost halted due to the unavailability of steel and the use of labor for the war effort. Gas rationing also slowed tourism traffic, evidenced by a decline in tolls collected at Hudson River crossings.[275] The Department of Public Work's 1942 annual report noted that it had been operating on "a war basis . . . at the disposal of various war agencies of the Federal government."[276] During this time, many technical employees took leaves of absence to engage in defense-related work in the private sector, while others joined the Armed Forces. Some technical employees were able to earn "two to four times as much in private industry." The department had a difficult time maintaining staff in its Bureaus of Bridges and Grade Crossings and struggled to keep up with necessary maintenance projects and project planning activities.

Citing the department's difficulties, the 1943 annual report noted that "steel fabrication has been stopped" and "competent structural engineers are not obtainable."[277]

During the war, contracts for bridges were only let for those that were part of roadway systems necessary for the national defense. In 1942 only 12 bridge projects met this criterion.[278] In 1943 military-related contracts were let for nine bridges that provided access to military camps or airports, and in 1944 contracts were awarded for six bridges.[279]

Despite the limited construction of bridges, the Department of Public Works continued to complete plans and had 23 bridge projects awaiting contract in 1941; 54 in 1942; 57 in 1943; and 56 in 1944. Types of bridges represented in these numbers are shown in Table 5.

Table 5*
Bridge Plans Completed by the Department of Public Works, 1941-44

Type	1941	1942	1943	1944	Total
Slab	1	8	8	12	17
I-beam	9	16	22	28	47
T-beam	1	1	3		5
Through girder	5	1	2	1	8
Deck girder	3	2		2	5
Cantilever deck girder			1	2	1
Pony truss		1	2		3
Through truss		2	5	5	7
Deck truss			1		1
Rigid frame	4	20	10	5	34
Concrete arch		3	1	1	4
Concrete closed box			2		2
Total	*23*	*54*	*57*	*56*	*134*

* *Compiled from New York State Department of Public Works, Annual Report of the Superintendent For the Year 1944. Culverts – distinguished by the department as structures with spans less than 20 feet in length – were excluded from this table. "Extensions" and "miscellaneous" – types distinguished by the department but not defined – were also excluded.*

The Department of Public Works also continued to prepare standard plans for post-war bridge building. Standard plans for slab and concrete T-beam short-span bridges were prepared in 1942.[280] In 1944 the department revised its designs for composite beam bridges to reflect new federal requirements. Standard sheets, which were made available to district offices, were prepared for I-beam bridges under 65 feet and slab bridges up to 40 feet.[281] Some of the revisions were made to conform to the newly required, increased pavement widths.[282]

In 1941 and 1946 the state legislature appropriated funds for the elimination of specified highway-railroad grade crossings. However, the completion of these projects was delayed by labor and material shortages.[283] While difficulties in obtaining materials, especially steel, and labor remained in 1946, the department was able to award contracts for the construction of 163 structures. The vast majority of these bridges were concrete, with slab, I-beam, and rigid frame being the primary types used.[284]

Despite limited construction, the Department kept planning at a rapid pace, preparing plans for additional bridges to be let when circumstances permitted. Projects included highway-railroad grade separations, replacement of deficient structures, and new bridges carrying highways over streams, canals, and parkways.[285] In 1942 highway-parkway grade separations were designed for the Bronx River Parkway, Southern State Parkway, Taconic State Parkway, and Northern State Parkway.[286] In 1944 such structures were designed for the Bronx River Parkway and Cross-County Parkway, and extensions of the Saw Mill River Parkway and Southern State Parkway.[287]

Beginning in 1945, the department was engaged in preparing plans for structures in connection with the New York State Thruway. Contract plans and estimates were completed for 27 such bridges in 1946. For bridges carrying highways over the thruway, a minimum width of 24 feet was established.[288]

(2) Post-war Bridge-building Activity

When construction of bridges resumed following the war, the Department of Public Works had a heightened role in statewide bridge construction. The number of bridges – for spans over 5 feet in length – constructed grew slowly with 3 completed in 1944, 20 in 1945; 84 in 1946; and 35 in 1947.[289] In 1946 the Department planned a new, larger structure on the Erie Thruway across Cattaraugus Creek, 30 miles southwest of Buffalo. With three lanes in each direction, the thruway bridge consisted of five 132-foot deck girder spans. The structure was described as having a “pleasing appearance resulting from the simplicity of design” and would be painted gray-green to blend with its surroundings.[290]

Bridge construction on parkways resumed after the war. In 1946 the Department of Public Works was advancing plans for many stream and highway grade separation structures on parkways in Westchester County. Consulting engineering firms in New York City were preparing plans for bridges on other parkways, including the Palisades Interstate Parkway, to be reviewed by the department.[291]

The Department of Public Work's 1947 annual report reflected upon the significant changes in bridge building since the turn-of-the-century:

> "Forty years ago [building a bridge] would have been the culmination of a long, vigorous campaign in which nearly every individual in the community had been in some way involved. Features such as exact location, type, methods of construction, costs, who would get the job, prospects of employment on it, and others, would have been subjects of many an argument . . . And certainly the new bridge would have been prominent in local politics, perhaps for a period of several years."[292]

Since 1900 the bridge-building process had changed dramatically to meet the needs of the automobile age and growth of the state highway system. By the 1940s the Department of Public Works was responsible for designing and constructing most of the highway bridges in the state and had assembled "one of the largest engineering forces in the nation" to complete this task. The department's ten district offices met the need for a new or reconstructed bridge in a routine manner. Unlike a generation before, the department acted to replace bridges with little or no involvement from the neighboring community. Department engineers were said to "go about their various tasks efficiently and with little notice from the public." Though bridges were still described as "a symbol of man's triumph over natural obstacles," their design and construction had become so routine that "No one in the department gets excited about building any bridge."[293]

In further discussion, the 1947 annual report highlighted the 1,290-foot viaduct at Eden Valley, Erie County, as a case history of "how a modern bridge comes into being." Though larger than the average bridge, the structure was considered to be "by no means unusual." The skewed alignment and sharply turning approaches of the existing bridge presented a condition that was incompatible with plans to modernize the highway. The department decided that a high level viaduct would suit the site. Reconstruction of the accompanying highway had been completed in 1931. After much consideration, and an intervening depression and war, the high viaduct was built in 1947 to remove the remaining "weak link" in the highway system. Designed during the years of World War II, the 11-span, steel, deck plate girder bridge rested on simply ornamented piers with a cast recess and horizontal shadow bands. The horizontal lines created by the tubular railing and deck girders were said to enhance the bridge's "pleasing appearance."[294]

Scarcity of materials and labor continued to plague the department in 1947. The reserve of bridge plans ready for contract award stood at 300.[295] Contract plans were progressing for many parkway structures in Westchester, Rockland, and Suffolk Counties.[296] Though bridge building was at a standstill during the war, long-term planning activities continued. Consulting engineer David Barnard Steinman completed a report in 1948 that evaluated the need for a new crossing, known as the Kingston-Rhinecliff Bridge, over the Hudson River.[297] Ferry service, operated privately at this site since 1752, had been abandoned in 1942.[298] He selected a suspension bridge for its "pleasing and graceful appearance" and ease of construction, and for the economy of maintaining this bridge type.[299] However, ten continuous truss spans were ultimately selected for this crossing, which was completed in 1957.[300]

Even though high construction costs continued, the department placed 184 bridges under contract in 1948, representing an increase in construction of 136 percent over the previous year. The department established a temporary Bureau of Municipal Postwar Planning to assist counties, cities, towns, and villages by reviewing their bridge plans. An unusual and costly project undertaken in 1948 was the construction of the Meeker Avenue Viaduct on the Brooklyn-Queens Expressway, which had a steel superstructure.[301]

In 1950 the New York State Thruway Authority was established by the state legislature for the purpose of building, operating, and maintaining a major state thruway, including bridges. The original system was developed during the 1950s and completed in 1960. Much of the department's functional design approach was first adopted for thruway bridges.

The Department of Public Work's 1950 annual report concluded that: "The post war years have witnessed record achievements in the rehabilitation of the State Highway System."[302] Reflecting upon its recent accomplishments, the department presented its philosophy for present-day bridge design, including its approach to aesthetics. Progress made in designing thruway bridges illustrated the "effectiveness of their functional design." Dispelling the notion that a bridge must carry stone facing or decorative adornment, the department had "taken the attitude that the environment and purpose of a bridge are the basis for functional design." The report noted that massive pylons and railings, and heavy copings were rejected as "purely decorative and not functional." Lightness was described as "more agreeable" in horizontal, rather than vertical, members. Substructures should be designed without veneers or decoration to avoid the visual impression of weighing down the superstructure.[303]

Functional qualities desired by the department included the ability of the structure to flow traffic without restriction, provide for unrestricted vision, and avoid the appearance of physical or mental “hazards.” For the thruway system, the four-span beam bridge was identified as being the most flexible type of structure. The open type or column bent pier helped achieve a design that allowed traffic to move without restriction.[304]

To maintain the United States’s readiness for war, the Defense Production Act of 1950 established controls over all types of construction materials.[305] The federal government drastically reduced its allocations of steel in 1951, forcing the department to revise its construction program. Many bridge projects were delayed with both rolled steel and reinforcing bars unavailable. During 1951, seven highway grade separations were completed on the thruway and other projects included 60 new bridges, five bridge widenings, 65 culverts, and five culvert extensions. Steel beam and girder bridges were popular bridge types after 1950. An increasing volume of work was completed by contract engineers, as the department’s work force dwindled.[306]

In 1953 the department still had a shortage of engineers, yet it “maintained an efficient and economical production of bridge designs.” An increasing number of state engineers were assigned to the review of plans prepared by contracting engineers. In this year, contracts were awarded for the construction of 503 bridges designed by the department.[307]

In 1954 the department witnessed increased activity as the state initiated a new fiscal program for highway construction, including the building of bridges. Work began on 54 bridges and nine grade separation structures that were associated with the reconstruction of 277 miles of highway, and 176 bridges were completed as individual contracts. The state increased recruitment, raised salaries, and waived its residency requirements in an attempt to attract more engineers.[308]

In 1955, 143 bridges were constructed by the department as separate projects; others were built for grade separation purposes. Noting the tremendous increase in automobile traffic since World War II, especially in cities, the department recognized the need to modernize and expand its arterial highways. Many bridges and grade separations were required to facilitate the flow of urban traffic. Since engineers were still in short supply, many state employees were assigned to the review of consultants’ designs.[309]

In response to the planned construction of the New York State Thruway through the region, the Tappan Zee Bridge was completed in 1955. The Tappan Zee Bridge crossed one of the widest parts of the Hudson River, connecting Westchester and Rockland Counties at a point that had been previously served by a ferry. For more than half of its crossing, the Tappan Zee Bridge was an extended viaduct of deck truss spans. A cantilever truss span crossed the shipping channel.[310]

The state completed 245 individual bridges in 1956; others were built in conjunction with grade separation projects, some associated with the thruway. The department endeavored to keep up with the need for modern highways and bridges to accommodate increased traffic.[311] In 1957 the department awarded contracts for the reconstruction of 90 bridges and construction of 225 new bridges.[312] The department awarded contracts for 323 bridges in 1958 and 293 in 1959.[313]

When realigned shipping channels through Cornwall doomed the south span of the Roosevelt Bridge in the 1950s, Canadian and American officials investigated a new crossing between Massena and Cornwall. The south channel span, which crosses the St. Lawrence Seaway, opened in 1958, followed by the north channel span in July 1962.[314]

In 1959 the department began construction of the "longest post-tensioned concrete bridge in the country," a 320-foot structure carrying Interstate 81 – also known as the Binghamton-to-Canada Expressway – over the Oneida River in Onondaga County. This same year, the department began experiments with using aluminum in bridges to determine whether maintenance and construction costs might be lower with this material. The department started the construction of a bridge with rolled aluminum sections to carry the Long Island Expressway over Jericho Turnpike in Nassau County.[315]

In 1960 the state launched a program to accelerate construction of highway projects by exclusively using state funds. To increase the department's design capacity, it was readying an electronic bridge design computation program for use early in 1961. As part of its ongoing efforts "to develop more effective and economic methods and types of construction," the department awarded contracts for four bridges over the Sunrise Highway Extension on Long Island in 1960: two aluminum highway bridges of "semi-monocoque design;" a "conventional" steel and concrete highway bridge; and a steel railroad bridge that used a high strength, tempered constructional alloy. The results of these experiments were planned as guides for the department's future use of special materials.[316]

By 1960 one new international bridge had been completed and a second was underway. Ogdensburg-Prescott International Bridge, a suspension bridge designed by Modjeski & Masters, was completed in 1960 to provide American tourists easy access to Ontario. To enhance the thruway, Moses, in his role as president of the New York Power Authority, proposed replacing the old Lewiston and Queenston Suspension Bridge (1899) with a high-level, superhighway bridge in 1956. He envisioned this bridge as the final link in a New York to Toronto expressway connecting the New York State Thruway to Ontario's road system speeding the flow of long-distance highway traffic between the U.S. and

Canada. The Niagara Falls Bridge Commission financed construction of the steel arch bridge, which began in November 1960.[317]

During this period, the department received awards for their bridge designs. The department received honorable mention in the 1954 competition of the American Institute of Steel Construction for two bridge designs: the West Henrietta Road Bridge over the Thruway in Monroe County; and the New York State Thruway Bridge over the Onondaga Lake Outlet in Onondaga County.[318] The department also received an honorable mention in the American Institute of Steel Construction's 1960 "most beautiful bridge" contest for the Interstate 87 (Northway) Bridge over the Mohawk River near Dunsbach Ferry. Designed by consulting engineers Frankland and Lienhard, the bridge consisted of twin parallel structures, each 813 feet long, with steel arch center spans.[319]

Bridge building in New York City in the 1950s included plans for future crossings and replacement of bridges. In 1956 the New York State Bridge Authority began studies for a new Hudson River crossing to replace the ferry at Newburgh-Beacon.[320] Retractile bridges, used in New York City as early as c. 1861, were still built as late as the 1950s. Completed in 1958, the Bayview Avenue Bridge, Staten Island, replaced an earlier retractile bridge.[321] Other movable bridges completed in New York City in the 1950s included two bascule bridges – the 1953 Unionport Bridge over Westchester Creek and the 1953 Eastern Boulevard (Ludlow Avenue) Bridge over the Bronx River – and the 1955 Welfare Island Lift Bridge in Queens.[322]

F. Bridge Designers and Planners

This section of the contextual study lists designers and planners who were involved in major bridge projects within New York and/or who have contributed significantly to the development of bridge design. The list was compiled from references to designers and planners found in the New York State Historic Preservation Office, the New York City Landmark Preservation Commission files, and the other noted sources. A short biography of each person, as well as his activities within the state, is included. The bold area includes the designer's or planner's name, place of birth, date of birth, and date of death. Some designers and planners are listed without a location or birth/death dates, when conclusive information has not been found.

The following list will aid in determinations of eligibility for bridges by recognizing those designers or planners who have influenced bridge building in New York. A bridge may be eligible under Criterion C if it represents the work of a master. A master is defined in *National Register Bulletin 15* as "a figure of generally recognized greatness in a field." The "work of a master" refers to the technical or aesthetic achievements of an architect or craftsman. To be eligible under Criterion C as the work of a master, the bridge must display a distinct phase in the designer's career, an aspect of his work, or a particular idea in his craft. In rare instances, a bridge may be eligible under Criterion B if it is associated with an individual who made specific contributions to history. To qualify, a bridge must illustrate a person's important achievements.

(1) Ammann, Othmar Hermann – Schaffhausen, Switzerland 1879-1965

Ammann began his studies at the Federal Polytechnic Institute of Zurich, earning an engineering degree in 1902. In 1904 he traveled to America and immediately began working in John Mayer's New York office assisting the consulting engineer. Ammann was then hired by Frederic C. Kunz of the Pennsylvania Steel Company to do engineering calculations for the Queensboro Bridge in New York City. Also part of this job was the technical writing for Kunz's book, *Design of Steel Bridges*, which became the standard in its field. Ammann left Kunz and began assisting Charles Conrad Schneider in the analysis of the Quebec Bridge collapse in 1907. He then became second-in-command to Gustav Lindenthal in the Hell Gate Bridge project. A few years later, Lindenthal and Ammann vied for the Henry Hudson Bridge project, which was awarded to Ammann.[323]

Robert Moses appointed Ammann chief engineer of the Port of New York Authority, while Ammann's design for the George Washington Bridge was being constructed. Completed in 1931, the George Washington Bridge returned the distinction of having the longest suspension span to New York City. Considered one of the twentieth century's leading bridge engineers, Ammann went on to design five other major bridges in New York City: the Bayonne Bridge (1931); the Triborough Bridge (1936); the Bronx-Whitestone Bridge (1939); the Throgs Neck Bridge (1961); and the Verrazano-Narrows Bridge (1964).[324]

(2) Baird, Howard C.

Baird designed the Bear Mountain Bridge, a suspension span completed in 1924 in Peekskill, New York. Holton Duncan Robinson and David Barnard Steinman were also consulting engineers on the project. Baird also designed the steel arch 1931 Taconic Parkway Bridge over the Croton Reservoir with C.F. Lloyd for the Westchester County Park Commission.[325]

(3) Boller, Alfred Pancoast – Philadelphia, Pennsylvania 1840-1912

Boller was an agent for the Phoenix Iron Company from 1866 until 1870. He was the vice president and engineer for Phillisburg Manufacturing Company, building and designing iron bridges and other structures for 2 years. Boller opened an independent office in New York City in 1874. He wrote the treatise, Practical Treatise on the Construction of Iron Highway Bridges for the use of Town Committees, in between bridge building. In 1882 he became the chief engineer of the Albany & Greenbush Bridge Company. For the year of 1883 Boller acted as consulting engineer for the Department of Public Works, New York City.[326] Boller partnered with another engineer named McGaw, mainly producing gasholder tanks and designing one bridge – the

Metropolitan Avenue Bridge over Newtown Creek in Brooklyn. Boller designed the third Macombs Dam Bridge (Central Bridge) and 155th Street Viaduct over the Harlem River in New York City, acting in consultation with William Hubert Burr and George W. Birdsall, in 1894. Boller designed the substructure of the Arthur Kill Bridge in 1898. The following year Boller acted as consulting engineer for the Melrose Avenue Viaduct in the Bronx and for the 96th Street Viaduct for Riverside Drive in Manhattan. Boller designed and built the University Heights Bridge (1895), 145th Street Bridge (1905), and the Madison Avenue Bridge (1910).[327]

(4) Buck, Leffert Lefferts – Canton, New York 1837-1909

Buck, a native of Upstate New York, attended the Rensselaer Polytechnic Institute and graduated in 1868. While at the Institute, he was selected to assist Washington Augustus Roebling in building the Brooklyn Bridge.[328] He was hired by the Croton Aqueduct Department of New York City as assistant engineer from 1868 until 1871. Buck then traveled to South America to design an unusually high railroad. From 1877 until 1886 Buck rebuilt parts of John Augustus Roebling's 1855 railroad suspension bridge at Niagara Falls. Buck reinforced anchorages, replaced cables, and substituted wood suspended superstructure and stone towers with steel. During this time, Buck formed a partnership with George McNulty. Together they designed and constructed the Driving Park Avenue Bridge, which is the first spandrel braced arch in the United States, and the Platte Street Bridge in Rochester, New York in 1889. Buck submitted designs and became consulting engineer for the Williamsburg Bridge construction. Buck was the consulting engineer of the Lewiston and Queenston Suspension Bridge across Niagara River (1899), and consulting engineer for the Department of Bridges in New York City in 1903.[329]

(5) Burr, Theodore – Torringford, Connecticut 1771-1822

Burr, educated and apprenticed in the building trades, settled in Oxford, New York, in the Chenango Valley. Burr began operating a saw-and-grist mill, building his first bridge because of his customer's need to cross the Chenango River. This first design was a simple stringer bridge; however, Burrs' fame eventually developed to the point that toll-bridge companies all over New York State were requesting his services. Burr designed the Union Bridge, also known as the Waterford Union Bridge, in Waterford, New York, in 1804. The bridge, which crossed the Hudson River, used what would later become the patented Burr arch-truss, and was considered Burr's masterpiece. The Burr arch-truss superimposes an arch on a king post truss, resulting in the greater rigidity. Burr's arch-truss, most suited for long-span timber bridges, was used to a great extent in the eastern United States for turnpike bridges.[330] In 1809 Burr built a bridge over the Mohawk River at Schenectady in a new design: a wood suspension bridge, which was a conglomeration of "mammoth supporting beams and long laminated cables of built-up flat plank from which hung the floor timbers."[331] After Burr's death, his carpenters became bridge contractors and constructed many bridges throughout New York using his design.[332]

(6) Burr, William Hubert – Watertown, Connecticut 1851-1934

Burr began his education at the Rensselaer Polytechnic Institute, graduating in 1872. He then went to work for the Phillipsburg Manufacturing Company, constructing wrought-iron bridges over the next 2 years. From 1875 until 1884 Burr acted as professor at Rensselaer before leaving to become superintendent of construction for a number of bridges built by the Phoenix Bridge Company. In 1893 he took a position as civil engineering professor at Columbia University, which lasted for many years. As a consulting engineer, Burr supervised the construction of many bridge projects within New York City in the 1890s. This continued into the 1900s, when he acted as consulting engineer to Othmar Hermann Ammann during the George Washington Bridge Project of 1931. He was a part of the investigations into the collapse of the Quebec Bridge. Burr was also the author of many publications and engineering books.[333]

(7) Cooper, Theodore – Cooper's Plain, New York 1839-1919

Cooper joined the U.S. Navy at the age of 22, serving as an engineer before resigning in 1872. Cooper was then hired by James Eads as an inspector for the Midvale Steel Works and the Keystone Bridge Company. During this time, Cooper acted as Eads' superintendent on the St. Louis Bridge Project. Cooper then succeeded Eads as engineer of the Bridge and Tunnel Company. In 1875 Cooper began working for various companies around the country as superintendent. During this time, he designed the 2nd Avenue Bridge over the Harlem River, after which he was appointed by President Cleveland to a five man commission of engineers to determine the span for the Hudson River Bridge. As Cooper's last project, he acted as consulting engineer for the Quebec Bridge from 1905 until the collapse in 1907.[334]

(8) Ellet, Charles – Bristol, Pennsylvania 1810-62

Ellet began his engineering career at the age of 17, serving as rodman for the Susquehanna Branch Canal. In 1830 he traveled to France to enroll at the Ecole des Ponts et Chaussees, graduating and returning to America 2 years later. Ellet then resumed surveying for railroad companies and occasionally submitted bridge designs. Ellet was awarded his first bridge-building job in 1838. The bridge, the Fairmount Park Bridge over the Schuylkill River, was America's "first successful wire suspension bridge." Ellet then was awarded the Wheeling and Belmont Bridge of Wheeling, Ohio, in 1849. This suspension bridge was destroyed by a windstorm in 1854 and Ellet had to rebuild it later that year.[335] A designer of early suspension bridges, Ellet conceived the first such structure across Niagara Falls. His suspension span, built in 1848, served as a carriage bridge until it was replaced in 1854.[336]

(9) Embury, Aymar II – New York, New York 1880-?

After receiving a degree from Princeton University, Embury entered an apprenticeship to acquire his architectural training in New York City. In 1905 he won first and second prize in a contest held by the Garden City Company for his designs of country homes. This commission, considered to be his "big break," led to many other country home designs in the New York region. In the 1920s Embury began receiving commissions in North Carolina, Alabama, and Michigan, as well as New York. During the Great Depression, Embury shifted employment, becoming chief and consulting architect to the Port Authority of New York, the Triborough Bridge and Tunnel Authority, and the New York City Parks Department. Within this capacity, Embury aided in the construction of the Henry Hudson Bridge in 1938.[337] Working for the Triborough Bridge and Tunnel Authority, Embury assisted Othmar Hermann Ammann in the design of the Triborough Bridge (1936) and the Bronx-Whitestone Bridge (1939). Embury went on to design the New York City building for the 1939 World's Fair and the Hofstra University campus in Hempstead.[338] Acting as a consulting architect, along with A. Gordon Lorimer, John B. Peterkin, and Theodore J. Young, Embury assisted with the Throgs Neck Bridge Project (1961).[339]

(10) King, Zenas – Upstate New York 1818-1892

King moved west after high school to Milan, Ohio. In Milan, King began a carpentry and construction business. At the age of 40, he decided to change careers, becoming a sales agent for Thomas Moseley. Four years later, King founded a partnership with Peter Frees to build bridges and boilers. King retained the bridge portion of the business when the partnership dissolved a few years later. Twenty-two years after forming his own company, King concentrated on bridge building and changed the company name to the King Bridge Company. King obtained the patents for the tripod pier and the swing bridge – results of collaborations with engineers Theodore Mills and Cyrus Force. King died in 1892; however, his company prospered for another 30 years.[340]

(11) Lindenthal, Gustav – Brunn, Moravia 1850-1935

Lindenthal began his engineering education in Europe, attending the Polytechnic Institute of Vienna. He worked for awhile as the assistant for Austrian Empress Elizabeth Railway and as a bridge surveyor for the Swiss National Railway. He arrived in America in 1874 and became a consulting engineer for the Centennial Exposition at Philadelphia for 3 years. Lindenthal continued his engineering career in Pittsburgh, working for Andrew Carnegie's bridge-building firm, the Keystone Bridge Company. After that time, he worked for 13 years as bridge engineer for the Western Pennsylvania Railroad. He opened a private practice in 1881, designing both suspension and truss bridges. In the late 1890s he came to New York forming his own bridge-building company called the North River Bridge Company, of which he was chief engineer. In 1902 he was appointed commissioner of bridges. Lindenthal, acting as commissioner, hired Henry Hornbostel, a

New York City architect, to design the aesthetic features of the Manhattan and Williamsburg Bridges. In 1917 Lindenthal designed a steel arch railroad bridge over the East River, known as the Hell Gate Bridge.[341] Lindenthal's chief assistants for this sizable project were Othmar Hermann Ammann and then David Barnard Steinman. Lindenthal's last role in a bridge-building project was as special design advisor on the George Washington Bridge Project of 1931 – he was over 80 years old.[342]

(12) Lupfer, Edward P.

Lupfer made a name for himself as a railway contractor before accepting a commission as chief engineer for the Peace Bridge Project. Completed in 1927, the design consisted of five steel arches to span the Niagara River and an additional truss spanning the adjacent Black Rock Canal. Lupfer went on to build the Rainbow Bridge at Niagara Falls, assist the Defense Plant Corps and the Reconstruction Finance Corporation during World War II, and design other bridges in the Buffalo area.[343]

(13) MacDonald, Charles — 1837-?

MacDonald graduated from Rensselaer Polytechnic Institute as a civil engineer. In 1871 MacDonald built the first suspension bridge (not extant) across the Hudson River, which linked the towns of Johnsburg and Chester with cables purchased from Roebling & Sons Company. With a span of 230 feet, this bridge was described as using "the pattern of Roebling's bridges." He opened an office at 80 Broadway in New York City in 1868 and practiced for the next 4 years. He was elected president of the American Society of Civil Engineers in 1908.[344]

(14) Maillart, Robert – Switzerland — 1872-1940

Maillart began his career in the Zurich Polytechnical Institute, graduating in 1894. He became the first major designer in reinforced concrete to shed the vestiges of masonry construction. Flat-slab construction, Maillart's invention of 1900, was designed to meet the increasing load demands without increasing the size of structural members. The Maillart system was cost effective because it eliminated all but functional material and the concrete slab became an active bearing surface.[345] Maillart designed with three ideals in mind: efficiency, economy, and elegance. Efficiency meant using as little material as possible in order to achieve a lighter structure; economy was translated into competitive costs and minimal future maintenance; and elegance was expressed through the visual possibilities of reinforced concrete. He designed reinforced concrete bridges for 40 years throughout the world. Maillart's ideals of integration, slenderness in form, and artistic form influenced many modern structures. A 1947 exhibit of his work at the Museum of Modern Art in New York was the first show devoted to a single engineer to be mounted at an art museum.[346]

(15) McAlpine, William Jarvis – Upstate New York 1812-90

McAlpine designed, built, consulted, wrote papers on, and discussed bridges for 63 years. He was the third president of the American Society of Civil Engineers and the first American to be accepted into the French Society of Engineers and the Institute of Civil Engineers in England. He served as both the state engineer and the state railroad commissioner in New York. His achievements include laying out the Riverside Drive and Riverside Park, chief engineer on the Erie Canal, and completion of the U.S. Navy Yard in Brooklyn. He designed the Third Avenue Bridge in 1860 and began the Washington Bridge as chief engineer. McAlpine and civil engineer, Theodore Cooper, revised the designs of the Washington Bridge, adding decorative elements when it was decided that a more ornamental structure was favored.[347]

(16) Melan, Josef 1853-1941

Melan began in the engineering field as a professor at the Technical University of Vienna, later becoming head of the bridge department at the Technical Institute in Prague. Melan developed the first scientific methods for designing reinforced concrete arches by analyzing the material's behavior. Melan's designs were introduced in America when patented by Fritz von Emperger in 1893.[348] The Melan Arch Construction Company of New York, in conjunction with Emperger, held all Melan patents in the United States. Melan's design is said to "combine the beauty and permanence of the stone arch with the low cost and adaptability to local conditions of the steel bridge . . ."[349] The Melan system of reinforcement can be found throughout the United States. Bridges using this method were generally built from 1892 until the 1920s as the technique was adopted by engineers, corporations, and municipalities. Engineers began using prestressed concrete in the 1930s to accommodate the increase in live loads and Melan's system declined in use.[350]

(17) Modjeski, Ralph – Cracow, Poland 1861-1940

Modjeski moved with his family to the United States in 1876 and eventually continued his engineering education at the Ecole des Ponts et Chaussees in Paris, graduating in 1885. Returning to his family in America, he opened an office in Chicago in 1893, specializing in bridge design. Early in his career he worked with George Shattuck Morison and, in 1924, he formed a partnership with Frank M. Masters. Modjeski & Masters joined with P.L. Pratley to design the Ogdensburg-Prescott International Bridge (1960) – a suspension bridge over the St. Lawrence River.[351] Modjeski & Masters prepared designs for the Newburgh-Beacon Bridge in 1956. In 1930 Modjeski partnered with Daniel Moran to design the Mid-Hudson Bridge in Poughkeepsie – a suspension bridge built by the New York State Department of Public Works. Alone or in partnership with others, Modjeski designed many of the country's finest major bridges.[352]

(18) Moisseiff, Leon S. 1872-1943

Moisseiff consulted on many of the twentieth century's important bridge projects, including the George Washington Bridge and Manhattan Bridge in New York. Through his work on the Manhattan Bridge, he established a deflection theory that allowed lighter decks to be used in bridge building.[353] Moisseiff also acted as consulting engineer on the 1940 Tacoma Narrows Bridge. This was the first project he directed; however the collapse of the bridge less than 6 months after it was completed put an end to his career.[354]

(19) Morison, George Shattuck – New Bedford, Massachusetts 1842-1903

Morison began his education at the Phillips Exeter Academy before continuing on to Harvard. He was admitted to the New York State Bar and was associated with a law firm in New York City in 1866. Morison assisted Octave Chanute in the construction of a bridge over the Missouri River in 1867. He acted as chief engineer of the Detroit, Eel River & Illinois Railroad from 1871 until 1873. Morison moved to New York City in 1875, erecting the replacement for the Portage Bridge in 6 weeks. He then resigned from the railroad and formed Morison, Field, and Company, bridge contractors. Morison was a part of this firm for 5 years before moving on to build bridges on his own. From 1894 to 1903, Morison was a member of a variety of influential boards in New York City: the Board of Engineers for New York and New Jersey Bridge Authority (1894), Board on Improvement of Waterfront of New York City (1895-97), Board on Barge Canal (1900-01), and Commission on Plans for Manhattan Bridge across East River (1903). This final commission was an appointment by Mayor Low, on which Morison served with Mansfield Merriman, Henry S. Hodge, Theodore Cooper, and Charles Conrad Schneider. They were a panel of expert engineers assigned to report on the Manhattan Bridge's revised plans. The commission accepted Gustav Lindenthal and Henry Hornbostel's plans for the bridge and the construction commenced. Morison was also a member of the American Society for Civil Engineers from 1875 and president in 1895.[355]

(20) Moses, Robert – New York, New York 1888-1981

Moses was born in New Haven, Connecticut, in 1888, and received degrees from Yale University, Oxford University, and Columbia University by 1914. Beginning his career in 1913 at the Training School for Public Service of the Bureau of Municipal Research, he was made assistant to the commissioner of the Civil Service Commission a year later.[356] In a career spanning many decades, Moses became the head of park, transportation, and power agencies in New York State. Moses held the title of chairman in many offices, including: State Emergency Public Works Commission (1933); Jones Beach State Parkway Authority (1933-63); Bethpage Park Authority (1933-63); New York City Planning Commission (1940-60); Triborough Bridge and New York City Tunnel Authority (1946-68); and New York Power Authority (1954-63). He also was the New York Secretary of State (1927-37); the New York City Park Commissioner

(1934-60); the sole member of both the Henry Hudson Parkway Authority and the Marine Parkway Authority (1934-38); and the founder and chairman of the Triborough Bridge Authority (1936-46).

Moses was instrumental in the construction of many bridges, roadways, buildings, tunnels, housing projects, power facilities, state parks, and city parks in New York. The bridges built during his tenure included: the Henry Hudson (1936); Triborough (1936); Marine Parkway (1937); Bronx-Whitestone (1939); Cross Bay (1939); Throgs Neck (1961); and Verrazano Narrows (1964). In addition to serving in public offices, Moses gave lectures, acted as consultant to many governmental organizations and private corporations, wrote books, and served on the Board of Trustees of Hofstra College. He was the recipient of numerous awards and medals.[357]

(21) Mueser, William – Germany 1872-1950

Mueser emigrated to the United States in 1893, and 2 years later began designing for the Melan Arch Construction Company. Eventually he became the owner of the company until 1900. In these years, Mueser is credited with designing the first reinforced concrete arch bridges in New York, New Jersey, Pennsylvania, and the District of Columbia. He formed the Concrete-Steel Engineering Company in 1900 with Edwin Thacher, who also specialized in reinforced concrete designs. Mueser dissolved the company and entered into employment with the Federal Civil Works Administration as a regional director in 1933. In the last 16 years of his life, Mueser obtained 50 patents relating to reinforced concrete construction.[358]

(22) Nichols, Othniel Foster – Newport, Long Island 1845-1908[359]

Nichols, an 1868 graduate of the Rensselaer Polytechnical Institute, became assistant engineer with Cooper & Hewitt in 1870. In 1888 Nichols began what would be many years as a public servant. He became chief engineer of the Brooklyn Elevated Railroad Company for 7 years, then assistant engineer in charge of the Williamsburg Bridge from 1895 until 1902, and finally principal assistant engineer in the Department of Bridges for the next year. He was appointed chief engineer of New York’s Department of Bridges in 1904. In this position he supervised the redesign of the Manhattan Bridge after Gustav Lindenthal’s departure as commissioner. Nichols also was responsible for the construction of the University Heights Bridge during his tenure.[360]

(23) Robinson, Holton Duncan – Massena, New York 1863-1945

Robinson began his career working in the office of his uncle, George W. McNulty, who was in partnership with Leffert Lefferts Buck. Robinson began by conducting surveys and studying engineering at night. He eventually gained enough experience to become chief draftsman under Buck. Robinson was the assistant engineer, in charge of cable construction, on the Williamsburg Bridge Project. In 1904 he worked for Buck again on the Manhattan Bridge Project, in charge of design and construction. He built a suspension bridge in his hometown of Massena soon after, and then occupied himself with a variety of bridge, tunnel, and navy war projects. He briefly was employed by the Keystone State Construction Company designing cables. In 1920 he was approached by David Barnard Steinman to enter into a partnership. Robinson agreed and the two remained partners for a quarter of a century.[361]

(24) Roebling, John Augustus – Muhlhausen, Germany 1806-69

Roebling began his education at the Royal Polytechnic School in Berlin, graduating in 1826. He was the engineer for the Prussian government for 3 years before emigrating to America. Settling in Germania, now called Saxonburg, Pennsylvania, Roebling planned on becoming a farmer, but soon became involved in canal work. Roebling manufactured the first "transversely wrapped wire cable" in the United States in 1841, and he was responsible for the first suspension bridge to carry a highway over the Monongehela River at Pittsburgh in 1846. Roebling moved his factory – Roebling and Sons – to Trenton, New Jersey, in 1848. Roebling then began designing and building aqueducts, railroad bridges, and highway bridges. From 1858 until 1860, he and his son, Washington, were busy building a bridge over the Allegheny River at Pittsburgh, Pennsylvania. Roebling was the designer of the 1854 Niagara Falls suspension bridge – an early railroad and carriage suspension bridge. His last and best known achievement was the design of the Brooklyn Bridge.[362]

(25) Roebling, Washington Augustus – Saxonburg, Pennsylvania 1837-1926

Washington earned an engineering degree at Rensselaer Polytechnic Institute and began working in his father's wire mill at the age of 20. One year later, he began assisting his father in the bridge-building aspect of the business. Washington then entered the army in 1861. He participated in various campaigns and also built two suspension bridges for the army's use. He resigned his commission in 1865 and assisted his father in completing the Cincinnati and Covington Bridge in 1867. Washington then traveled to Europe to analyze pneumatic foundations for a year, before returning home and succeeding his father as chief engineer of the Brooklyn Bridge in 1869. He completed his career as the vice president of the John A. Roebling's Sons Company in Trenton, New Jersey.[363]

(26) Schneider, Charles Conrad – Saxony 1843-?

Schneider trained and practiced as a mechanical engineer in his homeland before traveling to America in 1867. Like many other engineers, he began his career as a draftsman. Schneider eventually was hired by the Erie Railroad and given the responsibility of checking bridge plans that were submitted by bridge companies.[364]

Schneider's first known bridge design was a cantilever bridge over the Niagara River in 1883. Schneider's career expanded when his design plans were accepted for the Harlem River Bridge, which had become known as the Washington Bridge by the time of its completion in 1889. Schneider and Wilhelm Hildenbrand's designs were combined into one less expensive plan by the Union Bridge Company, which was accepted, but later revised by John McAlpine.[365] Schneider became the chief engineer for the American Bridge Company in the early 1900s. Part of that job included the investigation into the collapse of the Quebec Bridge in 1907, while under construction. He was also one of five men appointed by Mayor Low to act a commission of expert engineers to report on revised plans for the Manhattan Bridge Project.[366]

(27) Steinman, David Barnard – New York, New York 1886-1960

In 1906 Steinman graduated *summa cum laude* with a bachelor-of-science degree from the City College of New York. He continued his education at Columbia University, attaining master of arts and civil engineering degrees in 1909. A year later Steinman became the youngest professor of civil engineering in the country, at the University of Idaho. While teaching, he earned his doctorate from Columbia University and translated Josef Melan's *Theory of Arches and Suspension Bridges* and *Plain and Reinforced Concrete Arches*.[367]

Steinman's engineering career included designing bridges throughout the United States and in many other countries. Steinman was the designer of the 1936 steel arch Henry Hudson Bridge in New York City. A year later he added a second deck to the popular bridge. The same year Steinman's Marine Parkway Bridge opened. In 1948 Steinman designed braces to be added over the traffic lanes of the Brooklyn Bridge, giving it greater strength.[368] He served as design engineer for the 1957 Kingston-Rhinecliff Bridge, which consisted of ten continuous truss spans.[369] Steinman authored the biography on John and Washington Roebling and *Suspension Bridges and Cantilevers: Their Economic Proportions and Limiting Spans* (1911). Steinman was also one of the designers for two international crossings between New York and Canada: the Thousand Islands Bridge (1938), which consisted of five bridges of four types; and the Seaway International Bridge (1962), with a main suspension span.[370]

(28) Thacher, Edwin – De Kalb, New York 1839-1920

Thacher, graduate of the Rensselaer Polytechnic Institute, began by working for a variety of railroad companies. In 1868 Thacher began his bridge-building career as assistant engineer for the Louisville Bridge Company. In 1897 Thacher built a bridge spanning the Kansas River in Topeka, which was credited as the "first large multi-span concrete bridge."[371] By 1900 he had gained experience within bridge companies, originated the multi-scale cylindrical slide-rule, and invented a metal truss bearing his name.[372] Another Thacher bridge was built in Paterson, New Jersey, carrying Main Street over the Passaic

River. Thacher partnered with William Mueser, who also specialized in reinforced concrete designs, to form the Concrete-Steel Engineering Company in 1900. Thacher retired from the bridge-building company in 1912.[373]

(29) Waddell and Hardesty

Waddell, John Alexander Low – Port Hope, Ontario **1854-1938**[374]

Hardesty, Shortridge **Unknown**

Waddell began his career after earning a civil engineering degree from the Rensselaer Polytechnic Institute in 1875. He worked briefly as a draftsman and engineer in Canada before becoming an assistant professor at Rensselaer. In 1882 he attained both his bachelor's and master's degree at McGill University. After spending four years as a professor of civil engineering in Tokyo, Waddell returned to the United States. Joining the Phoenix Bridge Company, he opened an office in Kansas City to serve as both an agent of the company and as a consulting engineer in his own right. Hardesty's educational background was not found.[375]

The prolific New York City firm of Waddell and Hardesty practiced for only 11 years from 1927 until 1945.[376] Waddell and Hardesty designed two similar cantilever structures in New York City – the 1928 Goethals Bridge connecting Staten Island to Elizabeth, New Jersey, and the 1928 Outerbridge Crossing of the Arthur Kill, connecting Staten Island to Perth Amboy, New Jersey. In 1933 the firm acted as consulting engineers on the lift span of the Hudson River Bridge, connecting the cities of Albany and Rensselaer. The North and South Bridges over the Niagara River Grand Island, New York, both using cantilever spans – were completed by this duo in 1935. Waddell and Hardesty acted as consulting engineers in the construction of the 1936 Henry Hudson Bridge.[377] The duo also designed the 1930s lift span of the Troy-Menands Bridge over the Hudson River and the 1941 steel arch Rainbow Bridge at Niagara Falls.[378]

(30) Whipple, Squire – Hardwick, Massachusetts **1804-88**

Whipple moved to Otsego County, New York, at a young age. In 1830 he began his career as a rodman and leveler for the Baltimore & Ohio Railroad. He then assisted with surveys for the enlargement of the Erie Canal and surveys of railroads and canal routes. His railroad experience spurred his interest in bridge building. He patented an early iron highway bridge, the bowstring arch-truss, in 1841. Using his design, Whipple began building iron bridges over the Erie Canal and at other sites in the state. Two examples of Whipple's patented truss within New York are the Whipple bowstring arch-truss of Chili Mills, New York, built in 1851, and the Whipple bowstring arch-truss built in 1867 with Simon DeGraff on a private road near Albany. In 1847, Whipple invented another truss type, this one with a trapezoidal form that featured diagonals that crossed two panels and sloped downwards in opposite directions from end to center.[379] His 1847 book, *A Work on Bridge Building . . . and Practical Details for Iron and Wooden Bridges*, influenced other practitioners. Whipple has been called "the father of American bridge building" and "father of iron bridges."[380]

G. Bridge-building Companies

This section of the contextual study lists bridge companies known to have been active within New York. The list was compiled from references to bridge companies found in Victor Darnell's A Directory of American Bridge-Building Companies 1840-1900, the New York State Historic Preservation Office files, and other footnoted sources. Unless otherwise footnoted, information presented is from Darnell's directory. The frequency with which the company's name appeared in these sources helped to determine the extent of its presence in the state. Based on this research, this section has been divided into two parts: (1) companies that built widely in the state; and (2) other companies that seem to have had a less significant presence within New York. The history of each company and its activities within the state are included. The bold area includes the company's name, location, and length of operation.

The following list will aid in determinations of eligibility for bridges by recognizing bridge-building companies that were active historically within New York. Criterion C states that properties may be eligible for the National Register of Historic Places if they express the distinctive characteristics of a construction practice. These characteristics are defined in *National Register Bulletin 15* as "the physical features or traits that commonly recur in individual types, periods, or methods of construction." Distinctive characteristics can be "general, referring to ideas of design and construction such as basic plan or form, or they can be specific, referring to precise ways of combining particular kinds of materials." Specific characteristics of the work of a bridge-building company might include patents held by the company or innovations incorporated into a bridge.

(1) American Bridge Company (Chicago) – Chicago, Illinois 1870-78; 1891-1900
This company's contracts ranged from Texas, across the Midwest, and to New England. The company was organized by Lucius B. Boomer in 1870 with colleagues from a previous business, including his brother-in-law Andros B. Stone; general agent L.C. Boyington; H.A. Rust as vice president; and general superintendent Moritz Lassig. Failed designs and troubles with contracts and general business conditions led to the American Bridge Company's liquidation in 1878. The Chicago Forge and Bolt Company leased the plant in 1885 and bought it shortly after. In 1891 the American Bridge Company reappeared as the American Bridge Works and began leasing the shop from Chicago Forge. Four years later the American Bridge Works bought the plant and began its business. This only lasted for 5 years, when in 1900, the company was bought out by J.P. Morgan's newly organized American Bridge Company.

(2) American Bridge Company (New York) – New York, New York1900-c. 1955

This company was formally organized by J.P. Morgan and Company on April 14, 1900. It operated as an independent business for only a year before its stocks were bought by United States Steel Corporation. The bridge company became a subsidiary in April 1901; however, this did not affect its corporate administration. Headquarters began in New York City, then were moved to Philadelphia in 1904, and finally settled in Pittsburgh. As described by Victor Darnell, the American Bridge Company was an amalgamate of many smaller firms: "twenty-four companies, fifty percent of the nation's fabricating capacity, were purchased the first year." The companies acquired in 1900 within New York were: the Buffalo Bridge and Iron Works; Elmira Bridge Company Ltd.; Groton Bridge and Manufacturing Company; Hilton Bridge Construction Company; Horseheads Bridge Company; Post and McCord; Rochester Bridge and Iron Works; and Union Bridge Company. Companies acquired within New York State became part of the subsidiary – the Empire Bridge Company. Other prominent companies that built numerous bridges within New York and were also acquired in 1900 were: the American Bridge Works of Chicago, Illinois; Berlin Iron Bridge Company of Berlin, Connecticut; King Bridge Company of Cleveland, Ohio; Youngstown Bridge Company of Youngstown, Ohio; and the Wrought Iron Bridge Company of Canton, Ohio.[381]

The American Bridge Company headquarters in New York was responsible for contracts, construction, and sales until at least 1913. The company's chief engineer was C.C. Schneider, who assisted in the design of the Washington Bridge of New York City in 1886. Generally, shop drawings were made at one office and were distributed to the shops for fabricating, thereby maintaining a central control. The American Bridge Company remained the largest structural fabricator and continued to manufacture steel bridges into the early twentieth century. The Mid-Hudson Bridge, Poughkeepsie, superstructure contract was awarded to this company on March 11, 1927.[382]

(3) Berlin Iron Bridge Company – East Berlin, Connecticut 1880-1900

Corrugated Metal Company – East Berlin, Connecticut c. 1875-83

The Berlin Iron Bridge Company began as the Corrugated Metal Company producing roof trusses c. 1875. The Corrugated Metal Company built bridges in the state of New York in the early 1880s. The company began designing bridges around 1879, and in 1883, changed its name to the Berlin Iron Bridge Company, operating for 17 years. The Berlin Iron Bridge Company manufactured many prefabricated iron vehicular bridges between 1880 and 1900 throughout New York and New England. William O. Douglas of Binghamton, New York, patented the lenticular or parabolic truss in 1878. In 1885 he allotted these patents to the Berlin Iron Bridge Company and became an agent for this leading iron bridge fabricating firm during the 1880s. Manufacturers of the lenticular truss spans in through, deck, and semi-deck versions, the Berlin Iron Bridge Company became one of the most industrious firms of the late 1800s. In 1900 the company was acquired by the American Bridge Company.[383]

(4) Canton Bridge Company – Canton, Ohio 1876-1929

The first 15 years of business, this company manufactured and built bridges only within its immediate area; however, an infusion of working capital in 1891 helped the bridge builders to expand. The company is known to have built bridges within New York State around the turn-of-the-century, including two in Chenango County. The Canton Bridge Company operated successfully for the next 34 years, before being bought out by the Massillon Steel Joist Company in 1925. The two companies functioned independently from the other and business continued for another 4 years. In 1929 the two merged and became MaComber Steel Company.[384]

(5) Clark, Reeves and Company (*see Phoenix Bridge Company)*

(6) Concrete-Steel Engineering Company – New York, New York 1900-33

William Mueser formed the Concrete-Steel Engineering Company in 1900 with Edwin Thacher, both specialists in reinforced concrete designs. Thacher retired in 1912, so Mueser became the sole owner for the next 21 years. This company fabricated bridges within New York in the 1900s, including the Court Street Bridge (1921), a reinforced concrete arch in Watertown.[385]

(7) Corrugated Metal Company (*see Berlin Iron Bridge Company)*

(8) Empire Bridge Company – New York, New York 1900-1914[386]

This company was formed by the American Bridge Company as a subsidiary with the sole purpose of operating all American Bridge Company's shops within New York State.

(9) Groton Bridge and Manufacturing Company (*see Groton Iron Bridge Company)*

(10) Groton Bridge Company *(see Groton Iron Bridge Company)*

(11) Groton Iron Bridge Company – Groton, New York 1877-87
Groton Bridge and Manufacturing Company – Groton, New York 1887-99
Groton Bridge Company – Groton, New York 1902-20

The Groton Iron Bridge Company was a result of a merger between an agricultural machine manufacturing company (Groton Separator Works) with an iron foundry (Groton Iron Works). Groton Separator Works, founded by Daniel Spencer in 1847, operated in partnership with William Perrigo after 1859. Groton Iron Works was founded by Charles and Lyman Perrigo in 1849. Soon after, the merger between the brothers occurred and the two companies organized under the new name Groton Iron Bridge Company.[387] From 1877 to 1882, the company produced an average of 25 bridges a year, including many simple Pratt trusses in Upstate New York. Awarded bridge contracts in 27 states around the country, the following years proved even more productive for the company.[388] The company went through another reorganization in 1887, becoming the Groton Bridge and Manufacturing Company. In 1899 the American Bridge Company absorbed the Groton Bridge and Manufacturing Company. The Groton shop continued for 1 year and then in 1901, the plant was closed and dismantled. The former proprietors repurchased the plant in 1902, and with new equipment, began their business under the name Groton Bridge Company. By 1920 the business of bridge building had diminished to the point that the Groton Bridge Company sold its equipment to the American Bridge Company and went out of business.[389]

(12) King Bridge Company – Cleveland, Ohio 1871-1922

The King Bridge Company began as the King Iron Bridge and Manufacturing Company and was incorporated by Zenas King in 1871. The King Bridge Company has examples of its work throughout the country; however, most are concentrated within New York, Kansas, and Illinois. The company prospered into the 1890s, when the Sherman Act crippled the business. By 1922 the company had been formally disbanded.

(13) Morse Bridge Company – Youngstown, Ohio 1878-c. 1889

This bridge company was founded in 1878, operating for about 13 years before changing its name to Youngstown Bridge Company. One of the many bridges the Morse Bridge Company built was the Spangler Bridge in Columbia County, New York, in 1880.[390]

(14) Ohio Bridge Company – Cleveland, Ohio 1869-74

The Ohio Bridge Company was begun by Rezner, Stone and Company, which may have functioned under its own name before this undertaking. One of the bridges the Ohio Bridge Company built in the late 1800s was the Tioronda Bridge in Dutchess County, New York.[391]

(15) Passaic Rolling Mill Company – Paterson, New Jersey 1867-1903

The company was founded in 1867 and added mills and shops 3 years later. This firm designed, manufactured, and contracted for all types of structural steel and high-grade ironwork for bridges and railroads. Passaic maintained offices in New York City and Boston, and furnished the steel for the Washington Bridge and for many of the elevated railroads of New York City. This company was awarded the construction of the Macomb’s Dam Bridge and the approach in 1892.[392]

(16) Phoenix Bridge Company – Phoenixville, Pennsylvania[393] 1884-1901
Clark, Reeves and Company – Philadelphia, Pennsylvania 1870-84

The Clark, Reeves and Company business was organized by Thomas C. Clarke and the Reeves family in 1870. The Reeves family commanded the Phoenix Iron Company in Philadelphia, while Clarke, Reeves and Company operated a plant in Phoenixville, known as the Phoenixville Bridge Works. In 1883 Clarke left the firm for independent work, so the company regrouped the next year as the Phoenix Bridge Company. This company operated in conjunction with the other Reeves' business – the Phoenix Iron Company. The resulting company operated until 1901.

(17) Union Bridge Company – New York, New York 1884-1900

The Union Bridge Company was a result of the merging of the Central Bridge Company of Buffalo with Kellogg and Maurice, of Athens, Pennsylvania, in 1884. The company's main office was situated in New York and the shop was in Buffalo. The Union Bridge Company submitted designs for the Washington Bridge in the 1880s. The company's plans combined the designs of Schneider and Wilhelm Hildenbrand at a less expensive price. Around 1890 the shop closed, and in 1900 the company was bought out by the American Bridge Company.[394]

(18) Wrought Iron Bridge Company – Canton, Ohio 1840-

This company began as a small foundry and evolved into a major bridge-building company in 26 years. The company manufactured all kinds of truss, arch swing, and plate bridge and iron piers. It built bridges throughout the United States and Canada. In 1899 the Wrought Iron Bridge Company was acquired by the American Bridge Company and became one of 35 plants. This company is known to have been fabricating bridges in New York State in the late 1800s.[395]

H. Other Known Bridge-building Companies

This section includes bridge builders that built with less frequency within New York State. The bold area includes the company's name, location, and length of operation. The companies with only the bold information were listed in Victor Darnell's A Directory of American Bridge-Building Companies 1840-1900. Some companies were listed without any dates of operation, and further research has not resulted in anything conclusive. Therefore, these companies are listed without this information. Unless otherwise footnoted, information presented is from Darnell's directory.

(1) Albany Bridge and Iron Works – Albany, New York 1885

(2) Albany Iron and Machine Works – Albany, New York 1866-82

This company functioned under three owners within its lifetime: Jones, Haskell and Company 1866-67; Haskell and Orchard 1868-71; and Henry C. Haskell 1872-82. This company advertised as "Manufacturers of Rezner Patent Improved Wrought Iron Tubular Arch Truss Bridge." No information concerning the patent was found.

(3) Albany Iron Works – Albany, New York 1849

This company built the iron bridge over the Erie Canal basin in Albany, New York, in 1849.

(4) Alden and Lassig Bridge Works – Rochester, New York 1881-86
Rochester Bridge and Iron Works – Rochester, New York 1886-1900

This company was formed through a partnership between John Alden, chief engineer of Leighton Bridge of Rochester, New York, and Moritz Lassig of Chicago. The company operated the Chicago plant, while leasing Leighton's New York plant, which operated as Alden and Lassig Bridge Works. In 1884 they purchased Leighton's plant; however, 2 years later the partnership dissolved. Lassig assumed control of the Chicago part with Alden taking over the Rochester section. Alden soon reorganized the company and called it the Rochester Bridge and Iron Works. This company operated for only 4 years before being acquired by the American Bridge Company.

(5) Alexander Iron Works – Syracuse, New York 1899-1901

(6) Architectural Iron Works – New York, New York 1865

This company's 1865 catalogue showed many bridges, but does not state where any were constructed.

(7) Atlantic Bridge Works – New York, New York 1863

This company was "prepared to erect Post bridges of iron and of wood and iron." The owners were Post, McCallum and Company.

(8) Atlas Iron Construction Company – New York, New York 1891-96

(9) Buffalo Bridge and Iron Works – Buffalo, New York 1891-1900

This bridge-building company was founded in 1891 and acquired by the American Bridge Building Company in 1900.

(10) Buffalo Engineering Company – Buffalo, New York 1898-1901

(11) Buffalo Structural Steel Works – Buffalo, New York 1899-1901

(12) Central Bridge Company – Buffalo, New York 1876-84

The company organized in 1876, and 5 years later purchased the Kellogg Bridge Company. The Union Bridge Company of New York acquired the Central Bridge Company in 1884. Its shop was closed about 6 years later.

(13) Cleveland and Sons Company – Brockport, New York

This company constructed the Locust Street Bridge in Waterloo, New York, as part of the Cayuga and Seneca Canal improvement and enlargement plan of 1915. The bridge design was a filled spandrel, reinforced concrete, with multiple arches and a concrete balustrade utilizing Josef Melan's system of "longitudinal reinforcement."[396]

(14) Climax Road Machinery Company – Marathon, New York 1887-

This company primarily fabricated and sold the Climax Road Machine, which was a patented road grading machine. Although the extent of the company's bridge building is not known, four examples were found within New York: the Partridge Bridge (1913), a steel stringer bridge in Keene; the Jersey Bridge (1913), a Pratt through truss in Au Sable Forks; the Lamb's Corners Bridge (1909), a Pratt truss in Columbus; and a Pratt pony truss (1913) in Trenton.[397]

(15) Corrugated Bridge Company – New Berlin, Connecticut

An example of this company's work was the Hakes Bridge in Otsego County.[398]

(16) Croton Bridge Builders

This company built the Woolen Mill Bridge in Warren County.[399]

(17) Elmira Bridge Company, Limited – Elmira, New York 1889-1900

This company was begun by Charles Kellogg and operated for only 1 year before being sold to the American Bridge Company.

(18) Empire Construction Company – New York, New York 1899

(19) Fort Pitt Bridge Works – Canonsburg, Pennsylvania

This bridge company manufactured and built the Quantuck Canal Bridge, spanning the Quantuck Canal, in 1935. This bridge in Southampton, New York, is a double-leaf, Strauss-style trunnion bascule bridge with reinforced concrete girder approach spans.[400]

(20) Good Roads Machinery Company – Marathon, New York

This company constructed a bridge for the hamlet of North Chatham in Columbia County, New York, in 1915.[401]

(21) Green and Wicks, Company

The Lincoln Parkway Bridge of Erie County was an example of this company's work.[402]

(22) Hilton Bridge Construction Company – Albany, New York 1880-1900

Charles Hilton, the chief engineer of Hilton Bridge Construction Company, began by working for the New York Central Railroad and then the Leighton Bridge Company. An advertisement for the Hilton Company states that it built "Wrought Iron & Steel Bridges, Roofs, Trestles & Turn Tables, Riveted Girders, Tanks, Beams, Pillars & c." This company was bought out by the American Bridge Company in 1900.

(23) Horseheads Bridge Company – Horseheads, New York 1890-1900

This company was organized in 1890 and bought by the American Bridge Company in 1900. The Horseheads Bridge Company built the1893 Pratt through truss bridge in North Elba, New York.[403]

(24) Hudson River Bridge Works – Hudson, New York 1881-88

The proprietors of this company were Whitbeck and Power in 1881.

(25) Jackson Architectural Iron Works – New York, New York 1896-1901

This company provided the balustrades for the construction of the Washington Bridge over the Harlem River in 1888.

(26) Kellogg Bridge Company – Buffalo, New York 1870-81

Founded by Charles H. Kellogg (the elder) in 1870, the shop was bought by the Central Bridge Company in 1881.

(27) Kellogg Iron Bridge Works – Buffalo, New York 1894

Finding that this company was only listed in the American Iron and Steel Association for 1 year, Darnell suggests this was perhaps an unsuccessful attempt to use the Union Bridge Company's shop.

(28) Kellogg Iron Works – Buffalo, New York 1891-1901

This company's name changed from Kellogg Iron Works to Kellogg Steel and Iron Company, sporadically. This business was directed by Charles H. Kellogg, son of the proprietor of Kellogg Bridge Company.

(29) Lane Bridge Works – Painted Post, New York c. 1890-1901

This company was organized by D.F. Lane. It fabricated bridges that "used rails for the chords and compression members, as well as the usual types of trusses."

(30) Leighton Bridge and Iron Works – Rochester, New York 1870-81

This bridge-building company was formed by Thomas Leighton when his partnership with Fowler ended. He leased the plant to John Alden and Moritz Lassig in 1881, and eventually sold it to them.

(31) Madison Construction

This company manufactured and erected the New York State Route 9N Bridge in Upper Jay in 1954.[404]

(32) McClintic Marshall Construction Company – Pottstown, Pennsylvania

This company constructed the Hinmansville Bridge (1915), a Pratt truss connecting the towns of Schroeppel and Granby, New York.[405]

(33) Mosely Iron Bridge and Roof Company – New York, New York 1867-1901

This company periodically built under the name of the Mosely Iron Bridge and Corrugated Roof Company.

(34) Murray, Dougal and Company – Milton, Pennsylvania 1864-c. 1900

This firm was organized by Samuel W. Murray, William P. Dougal, Charles D. McCormick, and John McCleery to build railroad freight cars of all types. The company, which also went by the name of Milton Car Works, was a leading producer of tank cars for the new petroleum industry. In the 1860s Murray received the first U.S. patent for a railroad tank car, and was considered a pioneer in his field. The next decade brought the added business of iron bridge building and fabricating. For example, this company built the Upper Bridge (1878), a Pratt truss in Keeseville. Murray, Dougal and Company continued building bridges for a decade, when a fire in 1888, destroyed the entire bridge shop. The company decided not to rebuild and continued until the 1900s building railroad tank cars.[406]

(35) National Bridge & Iron Works – Boston, Massachusetts

This bridge-building company erected the c. 1870 Parker truss bridge designed by Charles H. Parker in St. Lawrence County.[407]

(36) New Jersey Bridge Company – Manasquan, New Jersey

This company manufactured the North Church Bridge (1904), a lattice truss in Mexico, New York.[408]

(37) New Jersey Steel and Iron Company – New York, New York 1836-

The New Jersey Steel and Iron Company, a Cooper, Hewitt, and Company subsidiary, specialized in the manufacturing of bridges and viaducts. The Cooper, Hewitt, and Company was "one of the foremost nineteenth century American firms responsible for the production of iron and steel." This company assisted in many advances in the production of iron and steel. The subsidiary, the New Jersey Steel and Iron Company, manufactured the superstructure of the Carroll Street Bridge in Brooklyn, New York, in 1889.[409]

(38) New York Bridge Company – New York, New York 1877

This bridge-building company was managed by J.W. Shipman and J.D. Hutchinson.

(39) New York Iron Bridge Company – New York, New York 1850-53
Rider Iron Bridge Company – New York, New York 1848-50

This company was formed to carry on the work begun by the Rider Iron Bridge Company, which operated from around 1848 until 1850. The Rider Iron Bridge Company was organized by Nathaniel Rider, and his death, occurring around the same time, is perhaps the cause of the name changing to New York Iron Bridge Company.

(40) Niagara Bridge Works – Buffalo, New York 1873-96

(41) Owego Bridge Company – Owego, New York 1891-1901

This company was founded in 1892 by Ellery Colby. A year earlier, Colby sold his interest in the Groton Bridge Company and moved to Owego, New York, to begin on his own. Two years into the business, this bridge-building company constructed the longest single-span highway truss at Mount Morris, New York. The Owego Bridge Company also constructed the Hegeman-Hill Bridge, spanning Batten Kill in Easton, New York, in 1901. The company dissolved in 1901.[410]

(42) Penn Bridge Company – Beaver Falls, Pennsylvania

The Penn Bridge Company, organized by Timothy S. White & Son, began building wood bridges. However, in 1868 it began manufacturing iron structures. This company built the Stillwater Bridge (1913), a Pratt through truss in Orwell, New York.[411]

(43) Pennsylvania Steel Company

The Queensboro Bridge, designed by C.M. Ingersoll, was constructed by the Pennsylvania Steel Company in 1909. The company also built two single-span truss bridges and a side-by-side pair of Warren through trusses in Oneida County – all in 1911.[412]

(44) Post and McCord – New York, New York 1877-1900

Post and McCord owned a shop at Greenpoint, Long Island City, New York. The company was bought out by the American Bridge Company in 1900.

(45) C.O. Richards and Company – New York, New York 1885-88

(46) Rider Iron Bridge Company (*see New York Iron Bridge Company*)

(47) Rochester Bridge and Construction Company (*see W.H. Shepard and Sons Bridge Company)*

(48) Rochester Bridge and Iron Works (*see Alden and Lassig Bridge Works*)

(49) Roebling and Sons – Trenton, New Jersey

This company, organized by John Augustus and Washington Augustus Roebling, erected the Manhattan Bridge in 1903. Roebling and Sons was then awarded the steel cable contract for the Williamsburg Bridge completed in 1908.[413]

(50) W.H. Shepard and Sons Bridge Company – Havana, New York 1891-96

Havana Bridge Works – Montour Falls (formerly Havana), New York 1896-1901
Rochester Bridge and Construction Company 1900s-

This company began with William H. Shepard and his sons, William H. Jr., and James A., purchasing a part of the Novelty Foundry in Havana, New York. After 2 years of producing farm implements, the Shepards gained complete control of the foundry and renamed the business W.H. Shepard & Sons. By 1892 the Shepards reorganized as W.H. Shepard and Sons Bridge Company and began manufacturing "fixed truss iron and steel railroad and highway bridges, turntables, iron columns, and girders, standpipes, tanks, and boilers."[414] The Shepards regrouped as Havana Bridge Works 5 years later. The early 1900s brought more business and the final change into the Rochester Bridge and Construction Company.[415] This company built several pony trusses in Oneida County.[416]

(51) J. Shipman and Company – Van Hornesville, New York 1856

This company organized and built its shop in 1856 for the fabrication of iron bridges and axles. Shipman eventually moved on, working for other companies and submitting designs independently. Shipman was a nephew of Squire Whipple, the well-known designer and builder of iron bridges.

(52) Sooysmith & Company 1887-

William Sooy Smith – Buffalo, New York 1830-1916
Charles Sooysmith – Buffalo, New York 1856-1916

Charles Sooysmith, the son of celebrated engineer William Sooy Smith, was educated at the Rensselaer Polytechnic Institute and continued on to study at the Polytechnic Institute in Dresden, Germany. Smith had been credited with the "first American use of the pneumatic process in 1859 . . . and the first pneumatic caisson in 1867." Sooysmith and his father organized a contracting firm, Sooy Smith & Son, in 1881. Sooysmith then opened his own firm of Sooysmith & Company in 1887, which specialized in the construction of pneumatic foundations for bridges in the New York area. These included the Washington Bridge (1886) and the Macomb's Dam Bridge (1895). Two years later, Sooysmith became a consulting engineer in New York City.[417]

(53) Stone & Boomer – Massachusetts

Stone & Boomer was initiated by Amasa Stone after acquiring the patent for the Howe Truss from William Howe in 1841.[418]

(54) Terry & Tench Company

The Kingston-Port Ewen Suspension Bridge in Ulster County, built in 1921, was an example of this company's bridge building.[419]

(55) Weedsport Construction Company – Weedsport, New York 1900-14

This company was founded by cousins Charles E. Whitman and Wayne Whitman. The company manufactured windmill frames, as well as bridges. The cousins entered into bridge building when a flood washed away many of the bridges within Sullivan County. The Weedsport Construction Company built and installed many of the replacement bridges. By 1914 the cousins pursued differing businesses. Charles E. Whitman joined with Charles Caywood, Thomas Osborn, and Jay Wood to manufacture the Whitwood truck. Wayne Whitman went on to pursue the concrete silo business. The Weedsport Construction Company built two lattice truss bridge in New York.[420]

4. Development of New York's Transportation Networks

A. Introduction

From historical and archaeological studies of Native American trails to tomes describing the political and socioeconomic genesis of the superhighways of the Eisenhower era, an immense volume of information could be gathered on the development of transportation networks in New York State. This chapter of the contextual study is intended to focus on the aspects of historic transportation development that are most related to the roadway bridges that will be surveyed in a later phase of this project.

The material presented below is intended to be useful in assessing the National Register eligibility of the surveyed bridges. Specifically, it should facilitate the application of Criterion A to bridges that played a vital role in New York's settlement or transportation development. To be eligible under Criterion A, a bridge must be associated with one or more events important within a defined historic context. This chapter provides the historic context for the development of transportation networks in the state.

Chapter 4 is presented in four sections: *4B – Overview* links road evolution and historical or political themes or events; *4C – Statewide Transportation Development* considers statewide development, including state transportation agencies, other transportation networks, and international/interstate development; *4D – Regional Transportation Development* discusses regional development; and *4E – Transportation Development in Major Urban Areas* focuses on the major urban areas of the state beginning with New York City.

The overview is arranged chronologically so that national events occurring at roughly the same time and influencing each other – whether they were political events or economic competition that spurred transportation innovations, or breakthroughs in one type of transportation that influenced others – can be discussed together. The time periods coincide with road evolution from early roads to the interstate system.

Next, statewide development is discussed in three subsections: transportation agencies in chronological order; other transportation networks – ferries, canals, and railroads; and international and interstate development with Canada followed by bordering states.

The third section discusses transportation development in four major regions: the Hudson River Valley, Long Island, the area north of Albany, and western New York. Networks are presented chronologically in each region.

Finally, the fourth section discusses urban transportation networks in five major urban areas: New York City, which is the largest city in New York, followed by major cities to the north and then west, including Albany, Syracuse, Rochester, and Buffalo. Again, the development of transportation networks in these cities is presented chronologically.

B. Overview

(1) Early Transportation Routes

The earliest transportation networks consisted of waterways and Native American trails. Arriving European traders and then settlers made use of both. The Hudson River was the natural highway of what was to become New York State. In the 1620s the Dutch established New Amsterdam (present day New York City) at its mouth and built Fort Orange at the mouth of the Mohawk River, its principal tributary. In between New Amsterdam and Fort Orange, they established trading posts and claimed the surrounding area as their province of New Netherland. Then in 1664, the King of England issued letters of patent granting the territory between Connecticut and Delaware to his brother, the Duke of York. British warships arrived in New York Harbor shortly thereafter, and New Netherland became the province of New York in the same year.

(2) Post Roads and King's Highways (1669-1700s)

In the colony of New York, communication with other British settlements and with England itself was important. Colonel Francis Lovelace, the second British governor of New York, began the first postal service in America between Boston and New York in order to receive news from abroad through Boston as quickly as possible. In 1673 the first postman rode up Broadway to Harlem and across a bridge on the Bronx River that was built by Lovelace. This bridge was located in an area that is today near Broadway and 229th Street.[421] Today, the Boston Post Road still runs through the Bronx and Westchester County (and along the Connecticut coastline). Although it is now U.S. 1, it still known, and labeled on maps, as the Boston Post Road.

The British established postal service from New York City to Albany on a road running up the east side of the Hudson River between New York City and Albany in 1692. (A 6.6-mile dirt-and-paved section of this route in what is now Putnam County is listed on the State and National Registers of Historic Places.) Postal service to Philadelphia was established about a year later.[422]

Other than the post roads, significant road building did not begin in the colonies until about 1720.[423] As populations increased and farmland adjacent to navigable waters was taken up, colonists began to move inland. At first they followed Native American trails, but soon they cleared new roads. Roads were often called king's highways. The term was applied not only to royal and military roads, but eventually to all public highways.[424] Patterned on English laws, colonial laws made road building and repair the responsibility of local governments. Elected town officers, including the surveyor of highways, were charged with the maintenance of roads and bridges. The public was required to help. Nevertheless, many roads remained impassable in winter or during spring thaws.[425]

(3) Turnpikes (1792-1840s)

By the end of the eighteenth century, a shift to inland travel was beginning. However, roads in the United States were not sufficient, wide, or well-maintained enough to support the expanding population and economy and the demand for travel and shipping.

When neither local nor state governments had funds to construct or maintain roads, the states began to charter private turnpike companies. They provided improved roads in return for the payment of tolls. The success of Pennsylvania's Lancaster Turnpike (1792) spurred interest in toll roads. Toll roads increased competition among Baltimore, Philadelphia, and New York City to capture the east-west trade route.

Turnpikes also shifted the financial burden of maintenance from the local inhabitants to the users of the roads. Turnpikes stimulated the agricultural production of many regions, allowed the transportation of manufactured goods, and brought settlers into sparsely settled regions of the interior. Farmers and people who drove animals like cows or sheep along the road were the most frequent users of turnpikes.[426] Tolls were often too high for farmers or merchants to afford, so some resorted to using shunpikes, or detours around tollgates.[427]

Turnpikes reached their peak in 1830. Then increasing competition from canals and railroads, along with the cost of maintenance, brought an end to the turnpike era in about 1845.[428]

(4) Plank Roads (1846-60s)

Although sand and clay roads were built, the only serious alternative to stone for rural roads was timber (usually cut from the abundant adjacent forests). Corduroy roads, consisting of logs lain transversely along the course of travel, were a bumpy but popular road type. Plank roads appeared as another option for rural roads by the 1840s. After 1846 some turnpikes were surfaced with wood planks and became plank roads.[429]

Constructed as private ventures, plank roads were developed in Toronto (in the British territory of Upper Canada) in 1835 and were first used in the United States in Syracuse, New York, in 1846. Dubbed the "farmer's railroad," plank roads consisted of flat planks nailed onto a foundation of longitudinally sawn logs lain flat side up. Because plank roads were made of wood, they were not durable and rarely lasted more than 10 years, contributing to their demise.[430]

(5) Advances in Paving (1800s)

Consecutive advances in stone surfacing by Thomas Telford and John McAdam, both Englishmen, led to the emergence of better road conditions in New York. Telford, nicknamed the "Colossus of Roads," built on the advances of the Frenchman Pierre-Marie Jérôme Trésaguet who first paved roads with uniformly laid large stones in the 1770s in France. Telford's innovation was to meticulously shape the blocks of stone so their angular edges would fit more closely, thus distributing the pressure of traffic more equally. These larger blocks were surfaced with a smaller layer of stones to increase smoothness. John McAdam, working in England in the 1810s, eliminated the larger stones entirely, demonstrating successfully that a carefully built layer of small broken stones could effectively handle traffic loads. McAdam's broken stones would compact into an interlocking mass that did not deteriorate as rapidly as smooth stones or gravel.[431] McAdam or "macadam" paving increased road reliability and encouraged increased travel and shipment of goods, which in turn precipitated further road and bridge construction in New York State.

In urban areas, markedly increased traffic loads demanded better (and more expensive) solutions. Asphalt paving, or stone aggregate combined with bitumen or tar to form a consistently strong and smooth surface, was first used in the United States in Philadelphia in 1838. Traditional street-building methods using cobblestones, flat-faced stone paving blocks, or even creosote-soaked timber blocks continued to be used throughout the nineteenth century.[432]

(6) Parkways (1860s-1960)

Parkways were first designed and built in this country by Frederick Law Olmsted, later known as the father of landscape architecture. Olmsted traveled to France in the 1850s, saw the grand tree-lined boulevards of Paris, and brought this idea home to be used in his park designs for Brooklyn (1868-74) and Buffalo (1868-1915). Parkways were the links between his parks or from his parks to the urban neighborhoods that surrounded them. Parkways were very wide avenues with traffic divided by trees. On the outside, there were service roads in front of the houses; the lanes for through traffic were in the center. Between the service roads and the central traffic lanes were shaded pedestrian malls.

In the age of the automobile, more city dwellers could escape to the countryside. Early twentieth century parkways were designed to provide a pleasant experience for recreational driving. They were "designed landscapes (or parks) that are experienced by the act of moving through them." Placed in the landscape, they followed the natural topography and took advantage of scenic views. Parkways followed indirect routes chosen for recreational or conservation purposes – they were not intended to facilitate the most efficient travel.[433] In general, parkways had wide park-like right-of-ways, limited access, and no at-grade crossings. Landscaping was provided to protect parkway surfaces from erosion, as well as for aesthetic reasons. High standards of architectural excellence were specified for related structures, including bridges.[434] Later, parkways became little more than limited access highways with narrow open spaces along their edges.

(7) Good Roads Movement (1890s-1916)

The widespread desire of people to travel, combined with the development influenced by the Industrial Revolution, led to the invention of bicycles and then automobiles in the late nineteenth century.[435] Bicycling became so popular in this country that its fans created the League of American Wheelmen in 1880. The league produced the first modern road maps, founded many of today's automobile clubs, and was the first organized protagonist for better roads. The National League for Good Roads was founded at a national conference in 1892 by the League of American Wheelmen and the National Grange of the Patrons of Husbandry. Farmers joined the league to gain support for improved farm-to-market access and upgraded rural mail delivery. The league also published the Good Roads Magazine to promote its ideas.[436]

The league's efforts led to a federal bill to create a national highway commission. Although the bill was not enacted, an appropriation was made to the Department of Agriculture to investigate road construction and management in 1894. Within the Department of Agriculture, the Office of Road Inquiry (later renamed the Office of Public Road Inquiries [1899] and then the Office of Public Roads [1905]) was established in 1893. Its purpose was to gather and disseminate technical information to locals about the best methods of improving roads. As part of this effort, the Office of Road Inquiry built examples of good roads throughout the country.[437] The Office of Road Inquiry and its nineteenth century successors are the predecessors of the Federal Highway Administration.

In 1901 large-scale car manufacturing began in Detroit, Michigan, and, in 1908, Henry Ford introduced the low-priced Model T – a car the average person could afford.[438] Increasing numbers of drivers from the city were damaging the macadam and gravel rural roads, calling attention to the need for rural road improvement – mostly for those roads connecting farms with towns and railroad stations. The Good Roads Movement, started in the nineteenth century, led to new organizations: the American Automobile Association (1902), the American Association for Highway Improvement (1910), and the American Association of State Highway Officials (1914). Road improvement was recognized as a federal and state concern rather than just a local problem.[439]

(8) Pre-Depression Era Federal Aid Programs (1916-20s)

The federal government became actively involved in road improvement with the 1916 Federal Aid Road (or Shackleford or Good Roads) Act. This act initiated the federal-aid highway program, providing for postal and general rural road improvements.[440] Seventy-five million dollars was appropriated over 5 years. The federal share of highway projects was 50 percent, and all improved roads had to be free and maintained by the state. The states were required to submit their projects to the Secretary of Agriculture for approval. Any state that received aid had to have a state highway agency.[441] This led to the development of state highway departments headed by professional engineers, which took control of construction and maintenance of roads and bridges on major highways. Standards for highway construction projects were developed by the Bureau of Public Roads (a successor to the Office of Road Inquiry).[442]

World War I slowed the expenditure of federal funds for transportation, as manpower and materials were in short supply. As railroads failed to keep up with national demands, people turned back to roads for commerce and travel needs. Freight was increasingly carried by trucks, and heavy truck traffic also damaged roads.[443] After World War I, many roads began to fail within a very short time. This created a demand for load limits and higher truck taxes. The truck industry responded with the slogan "Build the Roads to Carry the Loads." These pressures led to the creation of the Highway Research Board.[444]

Due to the increased attention roads were receiving, the highway construction business and the manufacturing of road machinery witnessed a tremendous expansion between 1919 and 1920.[445] After 1920 highway transportation assumed a dominant role in the United States.[446] The 1920s became known as the golden age for road building as highway agencies focused primarily on developing a network of good rural roads.[447] In 1921 congress initiated a new program that:

> "concentrated the expenditure of federal funds on roads each state decided would be part of the interconnected nationwide system. The complicated funding formula was known as the 7 percent system because each state could designate up to 7 percent of its total mileage as routes that would qualify for federal aid. It was not until 1933 that Federal aid was again extended to non-federal aid system roads."[448]

Three-sevenths of the roads in the system had to be interstate roads.[449] By the mid-1920s urban roads became congested. In response, lanes were added to existing highways, and divided highways were created.[450]

Before the United States Congress developed a plan for consistent numbering of all major roads in 1926, drivers faced a bewildering array of names and signage. Organizations, community leaders, and business groups named and promoted different routes that were designated as auto trails. These trails, often named after historical leaders, nearby towns, or local landmarks, ranged from little-known combinations of county roads to cross-country routes that achieved international fame. The Lincoln Highway, America's first transcontinental highway, extended from Times Square in New York City to San Francisco. Other major auto trails included the Theodore Roosevelt International Highway which connected Portland, Maine, to Portland, Oregon, and the Yellowstone Trail, which joined Boston to Seattle. The "construction" of auto trails usually meant little more than the erection of colorful, easy-to-follow signage, although the existence of a popular trail through town often prompted local businesses or governments to undertake road and infrastructure improvements.[451]

(9) Depression Era Programs (1930s)

The highway boom of the 1920s continued in the 1930s despite the Depression. While the Depression forced states to reduce road-building programs, large federal aid appropriations and a variety of federal relief programs for the jobless increased road-building activity overall. In 1930 President Herbert Hoover began authorizing large sums for highway projects.[452] The road and bridge-building boom continued through the 1930s under President Franklin Delano Roosevelt's New Deal efforts. Highways became the largest public works program undertaken by the federal government. Between 35 and 45 percent of all workers on federal relief during the 1930s, mostly through the Works Progress Administration, were involved with building roads.[453] By 1935 cross-country travel by automobile in practically any direction was practicable, although many roads were already obsolete due to larger vehicles and increasing traffic.[454]

Pressure for the development of transcontinental superhighways began to build in the late 1930s. The Federal Aid Highway Act of 1938 directed the Bureau of Public Roads to study the possibility of a toll network of superhighways. The Bureau of Public Roads did not find enough transcontinental traffic to support a network of toll superhighways and suggested a non-toll interregional highway network.[455]

(10) Interstate System (1941-60)

Highway improvement was limited during World War II – manpower and materials were used for the war effort. Even though military interest in road development had begun in the 1920s when roads of prime military importance began to be identified, it was not until 1941 that a defense act was passed that provided specific funds for constructing such roads, including freeways.[456] In that year, President Roosevelt appointed the National Interregional Highway Committee to study the manpower and industrial capacity that would be available at the end of the war.[457] In 1944 the committee recommended the establishment of the National System of Interstate and Defense Highways. Construction of interstate highways was initially justified as a defense system for moving military vehicles and evacuating civilians. Defense requirements called for the interstate system's geometry and structures to accommodate and aid the movement of large military equipment.[458] The system of highways was to connect principal metropolitan areas, cities, and industrial centers by direct routes and to connect with routes of continental importance in Canada and Mexico. States submitted recommendations of routes to be included in the interstate system. However, construction moved slowly due to high standards and limited federal aid.[459]

After the war, the population increased and the economic situation of the country improved. Automobiles became economically feasible for the middle and working class. Commuters, then businesses, moved out from cities and the suburban growth that followed again spurred highway development. During this period, superhighway plans were also seen as an integral part of urban planning. In the 1950s the flight to the suburbs had left city centers run down. Some envisioned highways not only bringing residents and shoppers back to the city, but also acting as buffers between residential and industrial areas.

The modern era of the freeway began in the early 1950s as lobby groups began to encourage a political vision of a nationwide road network.[460] In 1952 the Federal Aid Highway Act "was the first authorized federal funds specifically for interstate construction. The Federal share of interstate construction increased from 50 to 60 percent with the passage of the Federal Aid Highway Act of 1954."[461]

President Eisenhower, recognizing the importance of a national highway system for defense, appointed a committee to study American highway needs in 1954 at the height of the Cold War. The committee advised Eisenhower that an interstate system was needed. New York's "master builder," Robert Moses, was also involved in the development of the system; he had pushed for the large scope of the project through consultations with Eisenhower assistant Sherman Adams and with General Lucius D. Clay, chairman of a key presidential committee studying highways.[462] The system was initiated in 1956 by the

Federal Aid Highway Act, which got the interstate program underway, and the Highway Revenue Act, which provided the funding for the program. The acts required that the system be designed for traffic projected for 1975, and initial funding was authorized for 12 years, from 1957-69. The federal government would pay 90 percent of the cost from an increased gasoline tax and other highway user tax changes, and states would pay 10 percent. Fifty billion dollars was made available to construct 41,000 miles of interstate highways during the act's first decade, c. 1955-65. In 1956 the Bureau of Public Roads became the Federal Highway Administration.[463]

A superhighway or freeway, such as the New York State Thruway, had distinct design intents. These roads had direct routes, wide lanes and shoulders, and straight roadways, which allowed fast and efficient travel.[464] Freeways had separated roadways for travel in each direction, no access from abutting properties, and grade-separated intersections. They were designed for movement and commercial travel, in direct opposition to parkways, which were designed for beauty, recreation, and private travel. Another feature of the freeway as it developed during this period was that it represented a new road or new route. The freeway required new alignments that enabled efficient, high-speed, and safe travel. Old roads could not accommodate these requirements.[465]

C. Statewide Transportation Development

(1) State Transportation Agencies

(a) Office of the Surveyor General (1642-1846)

Although the Dutch were traders and not major road builders, the origins of the Department of Transportation can be traced to the Dutch office of surveyor general, which was established in 1642 to survey the lands of the province of New Netherland. When the English captured New Amsterdam and renamed it New York in 1664, the office of surveyor general was continued under the British colonial government.[466] However, road development continued to be slow until after the Revolution.[467]

After 1781 the new state legislature began passing laws that would lead to the development of roads across the state. The office of surveyor general was reestablished in the same year.[468] In 1784 the legislature passed an act creating a road commission and authorizing it to lay out, improve, and regulate all public and private roads. The public was to be taxed for the upkeep of highways. In 1787 a new law was passed to provide even better roads. By 1797 demand for roads and bridges throughout the state was so great that the legislature created a board of superintendents in most counties. These officials gave directions for building roads and bridges and keeping them repaired and authorized state money for roads and bridges. The law also regulated road standards such as the width of roads and the types of vehicle that could be used on highways.[469]

In spite of the laws of the late eighteenth century relating to the development of highways, roads were often ruts through forests that were muddy in wet weather.[470] Unable to provide ample public funds for the improvement of roadways and in the face of constant demands from both western farmers and Hudson River towns for adequate transportation facilities, the legislature chartered turnpike and bridge companies. Sixty-seven turnpike companies, capitalized at over $5 million, were chartered before 1807 to build 3,071 miles of turnpike roads and 21 companies were chartered to build toll bridges. By 1808 New Yorkers had invested more money in road company stock than any other state. By 1812 New York had a well-developed turnpike system extending from the Massachusetts border to Lake Erie. In addition to providing improved transportation routes, many turnpike companies in New York were controlled by large landowners more interested in selling land than providing transportation.[471]

(b) Office of the State Engineer and Surveyor (1846-1908)

The office of the surveyor general, begun in colonial times, was continued until 1846, when the New York State Constitution established the office of state engineer and surveyor. This new office took over the duties of the abolished surveyor general and was responsible for engineering and survey work.[472] The state engineer and surveyor was also a member of several commissions and boards, including the canal board, and for the first time, was required to be a practicing engineer.[473]

Throughout the late 1800s, public roads continued to be financed almost entirely by local property taxes. Not a single act had been passed by the legislature nor one dollar of state money appropriated for its 81,000 miles of public highways. The growing influence of the Good Roads Movement at the end of the century gradually changed that. In 1898 the Higbie-Armstrong and Fuller-Plank Acts were passed. The Higbie-Armstrong Act provided for the construction of improved roads at the joint expense of state, county, and town, in the ratio of 50, 35, and 15 percent. The Fuller-Plank or Money System Act was

> "designed not only to aid financially in maintenance of the great network of earth roads throughout the state, but also to encourage the abandonment of the antiquated system of working out the highway tax, which has been the most potent factor in the deterioration of our public highways. The initiative under these laws was left entirely with the local authorities. The money was paid over to the local highway officials and expended as they saw fit."[474]

Counties and towns were slow to accept the new system and did not participate fully for many decades.

The end of the nineteenth century witnessed growing political support for better roads as public complaints increased in volume. It was a time when two formerly opposed groups, the city gentry who toured on bicycles and the rural folk who relied on farm-to-market roads, combined to create genuine political interest in a comprehensive statewide road building program. Counties in and around major cities such as New York, Albany, and Buffalo built the state's first hard-surfaced roads of bituminous macadam (asphalt). Little effort was made to eliminate curves, widen right-of-ways, or reshape hillsides to accommodate roads. At the turn of the twentieth century, an "improved" road was merely a traditional road with a hard surface.[475] Road building began in earnest during the reform administration of Governor Benjamin B. Ordell, Jr., in about 1901.[476]

(c) New York State Department of Highways (1908-23)

The Highway Law of 1908, establishing the New York State Department of Highways, evolved from the 1898 Fuller-Plank or Money System Act. It consolidated the entire system of public highways and bridges in the state (except New York City) under the new department's direct supervision. The 2,800 miles of state highways were to be improved solely at the expense of the state. County highways, which included a system of main market roads, were to be improved at the joint expense of the state, county, and town in the manner provided by the Higbie-Armstrong Act. Town roads were to be maintained and repaired as earth roads at the expense of the town, with the help of aid donated by the state under the Money System Act.[477] Highway improvements that occurred at this time included the widening of narrow roads, the straightening of sharp curves, and the reduction of steep grades.[478] The superintendent of highways, the state engineer and surveyor, and the superintendent of public works were designated as highway commissioners in 1911. In 1913 these three commissioners were replaced by a single highway commissioner.[479] By 1914 most local roads had been widened.[480]

As the decade progressed, more road improvements were made, such as widening curves to avoid accidents, elevating the outside of curves to make steering easier, leveling and straightening (where possible) approaches to railroad crossings, increasing the thickness of pavements, and constructing new bridges in alignment with the roads.[481] During World War I, military truck routes were designated. In New York, the route was from New York City north to Albany and then west to Buffalo. These roads were open to other traffic and well-maintained. Due to the major increase of loads on highways from army trucks crossing the state during World War I, the law on the limitation of total weight of trucks on certain highways was revised.[482]

Three classes of improved roads were built wholly or in part from state funds: state routes financed completely by the state and decided by legislative approval; state and county highways paid for jointly by both entities with routes suggested by the state engineer but open to changes by local authorities; and federal aid roads, which received federal subsidies in addition to state or state and county funds, depending on whether the route was a designated state route. By the end of the 1910s, this policy came under increasing criticism for its vulnerability to politically influenced amendments at the county level. Irrational changes had resulted in the construction of isolated, disconnected stretches of highway and the parallel duplication of existing highways in "practically every county in the State."[483] While the federal government was offering matching federal aid funds for state highway construction, New York did not participate in this program significantly until 1921.[484]

Due to the redirection of government resources during World War I, road construction in New York State slowed dramatically with practically no construction or reconstruction during 1917 and 1918. Postponed contracts would not be completed until 1922. Harsh winters at the end of the 1910s had been exceptionally destructive to the existing outmoded highway pavements. In addition, the expanding use of bigger and heavier motor trucks had decimated the relatively delicate macadam surfaces and foundations. In 1920 the state dispatched its first truck-weighing motor squad to try and protect the roads from truck overloading.[485] Rampant favoritism to individuals or communities in road-building decisions at the local level was another factor limiting progressive road building. Circumstances resulted in an inadequate statewide road system at the advent of increased demand in the 1920s.

Understanding these various problems, Highway Commissioner Frederick Stuart Greene recommended in 1920 that a definite course be established for a state-financed system of roads. Correspondingly, the highway commission prepared a map that designated through state routes and important county routes for construction and continued maintenance, which it submitted to the legislature for approval. This map, "showing a connected and completed system for the state," was prepared through consolidating the recommendations of the nine state highway geographic divisions and was based on a map prepared for the federal government in 1917 as required by its federal aid program for designated highways.[486] The state legislature debated the map and proposed a number of changes, which were considered in a revised version of the state map issued by the commission in 1920.[487]

The legislature created a joint committee chaired by Senator Charles J. Hewitt to approve the new state map. The committee's mandate, decided in 1920, was to "investigate the State highway system and determine what highways shall be included therein for construction and improvement as State highways or State and county highways, so that together with those improved by Federal aid, there shall be established a system of connected State highways . . . [and] that such committee shall prepare a map and plan for such system of highways."[488]

The committee's work, approved by the state legislature in 1921, resulted in a total of about 11,000 miles constituting the ultimate highway system of the state, of which 2,000 miles remained to be built. The chosen routes included eight complete and continuous east-west arteries and 21 state routes running north-south from the southern tier counties to the Mohawk River Valley. Additionally, 60 connections with adjoining states and Canada were designated, to allow the motorist "to enter the State on any one of these sixty highways and leave it on any other of these connections without traveling on a single mile of unimproved highways."[489] The Hewitt Report's plan, based on Greene's work, was to be completed in 6 years.[490]

That same year, the state legislature passed a law allowing counties to participate directly in the Federal Aid Road Act programs for construction not on designated state routes. This encouraged increased road development at local levels. This legislation was augmented by another state initiative, the Lowman Act, which allowed the counties to seek matching road-building funds from the state if such funds were raised by tax or bonds in an equal amount. Town and county roads demanded attention because the usefulness of the improved state roads was diminished due to the deplorable condition of feeder routes by farmers to bring produce to cities.[491]

(d) New York State Department of Public Works (1923-67)

New York State's road-building program benefitted from the progressive reforms and responsible government instituted by Governor Alfred E. Smith, who served from 1918 through 1928 (with one 2-year break). Smith's "conduct of the government made New York a model for every other state in the Union and served as an outstanding example of the continuing strength of progressivism in an age of conservatism."[492] Significant state government involvement and reorganization involving the construction and maintenance of new highways made New York a leader in transportation development.

In 1923 the New York State Department of Public Works was established with Greene as its first superintendent. The department consolidated the offices of superintendent of public works, superintendent and trustees of public buildings, department of highways, interstate bridge commission, and commission on boundary waters between the United States and Canada.[493]

The department went through several changes and many road improvements were made in the period between 1923 and the 1950s. In 1924 a program was initiated to widen all main roads to a minimum width of 18 feet. The office of state engineer and surveyor was abolished in 1925 and its duties were reassigned to the department. The enabling legislation that reorganized the state government in 1926 established five divisions within the department – canals and waterways, highways, public buildings, engineering, and architecture. The legislature also mandated that, starting in 1926, New York State be responsible for the reconstruction of condemned bridges on state or county highways.[494] In 1943 the department was again reorganized, this time into three divisions: administration, construction, and operation and maintenance.[495]

In concert with Smith's critical analysis of the state's budgetary and political priorities, the Department of Public Works in 1923 submitted a revised highway map to the legislature for approval. Determined that the map be free of implied political dealing, the plan was submitted to an advisory committee composed of non-partisan representatives from the County Superintendents Association, the Dairymen's League Cooperative Association, the Farm Bureau, the Motor Truck Association of America, the New York State Association of Real Estate Boards, the New York State Automobile Association, the New York State Grange, and the New York State Motor Federation. This diverse committee, representing both the rural truck farmer and the urban automobile enthusiast, discussed the proposed state-level roads county by county, and adopted the map through general agreement.[496]

Another important development in the rationalization of the state's official road network was a unified numbering system. The growing importance of roads for long-distance travel and commerce by automobile had prompted various independent and creative efforts by gas companies, map-makers, and local governments to label roads. These multiple road-labeling systems were made obsolete by a 1924 Department of Public Works initiative to devise a simple system of numbering the routes. The department numbered "all important routes" and then painted the numbers on poles along the routes.[497] Key maps were also prepared and distributed to automobile clubs and other organizations. This comprehensive state effort effectively ended the era of private route numbering and was "met with instant approval" by New York's various driving constituencies.[498] The Department of Public Works immediately proceeded to expand the numbering process to include routes of lesser importance.[499]

During the 1920s recreational driving became increasingly popular. This led to the creation of auto trails. New York boasted several popular auto trails which crisscrossed the state, most of which have disappeared from today's maps but survive as segments of various modern-day routes. Major auto trails designated by business groups and civic interests in the state include the Theodore Roosevelt International Highway (which wound through Niagara Falls, Albion, Rochester, Oswego, Mexico, Watertown, Alexandria Bay, Ogdensburg, Moira, Lake Placid, Keeseville, and Plattsburg), the Yellowstone Trail (which followed today's U.S. 20 and N.Y. 5 from the Pennsylvania state line to Buffalo and then across the state to Albany), the Gap Way (now U.S. 209 from Port Jervis to Kingston), the Southern Tier Route (now N.Y. 17 across the southern section of the state), the Thousand Islands Parkway (which ran north-south from Binghamton to Watertown on today's U.S. 11), the Susquehannah Valley Route (today's N.Y. 7 from Binghamton to Albany), the Buffalo-Pittsburgh Highway (U.S. 219 south of Buffalo) and the Lincoln Highway (several blocks of which existed in New York City on 42nd Street between Times Square and the Hudson River).[500]

At this time, the major advances in road-building machinery and organization were the greatest factor leading to an increase in road construction. As an industry, road building had taken enormous strides since 1925. The majority of roads were constructed with reinforced concrete pavement, but the policy of constructing heavy bituminous macadam pavement on the secondary system, particularly those roads in the Catskills and Adirondacks, continued.[501]

Before 1929 financing of a highway was both the state's and the county's responsibility. The law required that the county pay 35 percent of the cost of construction and furnish the right-of-way. This continued until the gasoline tax in 1929, after which the state paid the full cost of construction. In the 1930s regional roads and town roads were pulled into the federal highway system, as state and federal money flowed into every locality across the state. It was not until 1944 that the counties were relieved of furnishing the right-of-ways.[502]

During World War II, there was little road-building activity in the state. Contracts were certified only for the construction and reconstruction of highways by the Army or Navy as necessary in national defense.[503] The state began to plan for post-war construction by studying the possibility of a superhighway system through the entire state from New Jersey to Lake Erie. In 1941 legislation was passed to create independent authorities to sell bonds and build toll roads.[504] After the war, the Department of Public Works began to create a state system of superhighways. As of 1948 nearly 13,000 miles of the more important routes throughout the state constituted the state system. At this time, town and county highway organizations still constructed and maintained about 70,000 miles of highways within their jurisdictions, but the greater part of the burden of providing highway bridges was carried by the state.[505]

In the late 1950s the department was inundated with work after the passage of the Federal Aid Highway (Interstate) Act of 1956 and a $500,000,000 statewide highway bond issue. It struggled to handle the growth of the state's superhighway construction program, which had created a significant increase in the workload of the office. All construction plans for highways, parkways, thruways, bridges, grade separations and structures, canals, waterways, and flood control devices were to be approved by the office of chief engineer.[506] The office of transportation was established in the state's executive department in 1959 to advise the governor on transportation policy. Beginning in the 1959-60 fiscal year the state highway program exceeded $1 billion annually. Factors that led to peak work levels in the department in 1960 included "the launching of a substantial program for construction of highway projects with 100 percent state funds; a record $20 million program for resurfacing of older roads; acceleration of construction in labor surplus areas; and continuing large-scale interstate, primary, secondary, and urban highway programs."[507] The New York State Department of Public Works was abolished in 1967 and its responsibilities – transportation planning, construction, and operation – were transferred to the new, New York State Department of Transportation.[508]

(e) State Council on Parks (1924-Present)

The State Council on Parks, chaired by Robert Moses, was established in 1924 to create a comprehensive statewide system of parks and parkways. The new state parks were to be accessible primarily by the private automobile and the system was to be unified by connections between parks, their visitors, and their service areas. The council's enabling legislation specified development of parks and parkways. The Taconic State Park Commission was a result of the state parks plan (see 4.D[1]).[509]

(f) New York State Thruway Authority (1950-Present)

The thruway, envisioned as an American version of Germany's Autobahn, was conceived by the Department of Public Works in the late 1930s. Construction was set to begin under Governor Herbert Lehman in 1942, but was delayed by World War II.[510] Ground was finally broken for the thruway by Governor Thomas E. Dewey in the Rochester area in 1946.[511] The New York State Thruway Authority, an independent public corporation, was created in 1950 by the New York State Legislature to build, operate, and maintain the thruway system. Bertram D. Tallamy, an early protégé of Moses and a prominent civil engineer, was selected to head the authority. His success in building the thruway led to his appointment by Eisenhower as the first Federal Highway Administrator in charge of the interstate system in 1956.[512]

The first 115-mile section of the New York State Thruway opened between Lowell (Onondaga County) and Rochester in June of 1954. By August 1954, the thruway reached Buffalo; in December 1955 it was to Yonkers; and in August 1956 it reached New York City. These and other extensions throughout the 1950s increased the thruway's total mileage to 559 by the end of 1960, when the original thruway was completed. The Thruway Authority Act of 1950 provided geographical names for each of the thruway's sections, including Southern Westchester, Hudson, Catskill, Mohawk, Ontario, Erie, Berkshire, New England, and Niagara. Subsequent legislation also named these sections for old Indian trails. These comprise the Iroquois Trail between New York City and Buffalo; the Erie Path between Buffalo and the Pennsylvania border; the Mohican Path for the New England Section in the Bronx and in Westchester County; the Algonquin Path for the Berkshire Section in Albany, Rensselaer, and Columbia Counties; and the Tuscarora Path for the Niagara Section in Erie and Niagara Counties.[513]

Today, the thruway is the longest toll superhighway system – consisting of 641 miles – in the United States. The thruway's 426-mile mainline connects New York City and Buffalo, the state's two largest cities. Other thruway sections make direct connections with the Connecticut and Massachusetts Turnpikes, New Jersey's Garden State Parkway and Interstate 287, and other major expressways that lead to New England, Canada, the Midwest, and the South.

The thruway now includes Interstate 87 from New York City to Albany; Interstate 95 from New York City to Connecticut; Interstate 287 connecting Interstate 87 with Interstate 95; Interstate 84 connecting Pennsylvania and Connecticut through Newburgh; Interstate 90 – both the Berkshire Spur, which connects Interstate 87 with the Massachusetts Turnpike, and the mainline thruway, which runs from Albany to the Pennsylvania border through Syracuse and Buffalo; and Interstate 190 connecting Buffalo with Niagara Falls.[514]

(2) Other Transportation Networks

Ferries, canals, and railroads have all been important to the development of transportation in New York State. Ferries were developed almost immediately upon the arrival of Europeans on Manhattan and Long Island. Over the years, the ferry locations often became the sites of major bridges from the Brooklyn Bridge to the Verrazano Bridge. In some places, such as Lake Champlain, and in New York City between Manhattan and Staten Island, ferries still operate.

Canals and railroads dominated transportation development in the eras of turnpikes and plank roads. Good transportation access was not only an important means of getting goods to market (usually New York City), but was a major factor in the value of land in different parts of the state. As the roads were often built to connect to or compete with the canals and railroads, both these forms of transportation influenced road and bridge building. It was also necessary that roads cross over the canals and in some places the railroads. The bridges of the Erie Canal are included in its listing on State and National Registers of Historic Places.

(a) Ferries

Until the mid-1800s ferries were the primary mode of transportation across large streams, rivers, and lakes. Many ferries were private and operated for a fee. The right to operate a ferry was obtained from the colonial legislature or county by a grant or contract.[515] As early as 1642, a ferry from Manhattan to the tip of Long Island, approximately where the Brooklyn Bridge stands today, was established by Cornelius Dircksen.

The first ferry service from New Jersey to Manhattan, across the Hudson River, was established in 1661 at Paulus Hook, now Jersey City.[516] It was a crucial link in the route between New York and Philadelphia.

In addition to the Paulus Hook ferry, there were ferries at New Brunswick, Amboy, Woodbridge, Weehawken, Hoboken, and Elizabethtown. New York City merchants interested in improving connections to their wharves often provided the financial backing. Tides and wind made the crossing difficult, and after 1760 the routes with a minimum of water travel were favored.[517] The Hell Gate Ferry linked Manhattan to Long Island during the 1760s and 1770s.[518] Military and civilian traffic during the Revolutionary War was constant on the ferry and induced the establishment of the first regular ferry service from Astoria to New York in 1782.[519] In Putnam County, a ferry was set up in 1821 to travel across to West Point.[520] Ferries remained the only mode of travel across the Hudson River to Manhattan until construction of the railroad tunnel into Pennsylvania Station in 1910.

(b) Canals

When the state and the nation were first being settled, transportation between the Hudson River and western New York was difficult. Rivers provided the easiest method of travel, but still did not provide efficient access to the Great Lakes or the lands and markets of the West. Interest in building a navigable waterway through the state began in the late 1700s. Two private canal companies that the state subsidized – the Western and Northern Inland Lock Navigation Companies – were formed in 1792 to improve river travel by building short bypass canals around major obstructions. The western company completed a number of improvements on the route between the Hudson River and Lake Ontario. By 1796 the Western Inland Lock Navigation Company had made the rivers between

Schenectady and Seneca Lake passable for small boats without portages. However, this was very costly, so the state stopped aid and the company began to levy tolls.[521] Virtually nothing was accomplished by the northern company on the route between the Hudson River and Lake Champlain, since resources were devoted mostly to the western company. Other small private companies, particularly the Seneca Lock Navigation Company, also made some progress.[522]

In 1810 the legislature appointed canal commissions to study the possibilities for inland navigation, and in 1817 Governor DeWitt Clinton convinced the legislature to authorize $7 million for the construction of the Erie Canal. The canal took 7 years to build and cut through miles of wilderness between the Hudson River and Lake Erie.[523] The entire canal was opened in 1825.

Although the canal only ran through the northern and western portions of the state, it influenced development statewide and beyond through its connection to the Hudson River. The Erie Canal appears in American history books because "it spurred the first great westward migration of American settlers, opened the only trade route west of the Appalachians, and helped make New York the preeminent commercial city in the United States."[524] The canal created the "first effective means of interstate commerce in the United States."[525] As a result of the increase in trade and traffic, cities developed in New York west of Albany, including Syracuse, Rochester, and Buffalo.

Other canals were also built in New York State, some to connect to the Erie Canal and others to try to compete with the Erie Canal. Between 1823 and 1828 construction began on several lateral canals, including the Champlain, the Oswego, and the Cayuga-Seneca. The Champlain Canal from Troy to Whitehall, at the southern end of Lake Champlain, was a major impetus for the development of northern New York State.[526] Canals were also constructed between New York and Pennsylvania. The Delaware and Hudson Canal, which traveled between Kingston, New York, and Honesdale, Pennsylvania, was constructed from 1826-28.[527]

Improvements were made to canals during the later half of the nineteenth century. The Erie, Oswego, Cayuga, and Seneca Canals were enlarged and the Champlain Canal was deepened. However, interest in canals waned as the railroads grew. As the canals lost business, their revenues decreased and the state began abandoning some canals. Increasing competition in commercial trade renewed interest in improving the canals again in the 1890s, and in 1896 the second enlargement of the Erie Canal and its connecting canals began.[528]

Canals were not a major means of transportation in the twentieth century. However, the Barge Canal Law of 1903 directed improvements to the Erie, Champlain, and Oswego Canals.[529] The improved canal system – the New York State Barge Canal – was designed to accommodate 1,000-ton barges. To accomplish this, much of the original Erie was abandoned and the rivers the canal had been constructed to avoid, such as the Mohawk, Oswego, Seneca, Oneida, and Clyde Rivers, and Oneida Lake, were canalized.[530] The improved system, opened in 1918, generally ran parallel to the original canal route. Some abandoned canal sections were paved over as roads.[531]

Local communities did not maintain the approximately 300 bridges over the canal, and the bridges deteriorated rapidly. In 1926 when the state became responsible for them, almost all of the bridges were too weak for modern traffic and over 60 bridges were rebuilt or removed.[532] More bridges were subsequently raised. Traffic on the canal system slumped during World War II, but recovered to an all-time high in 1951. However, the canal's importance as a means of transportation greatly decreased over the course of the twentieth century due to the growing competition from railroads and highways, and the opening of the Saint Lawrence Seaway in 1959.[533]

(c) Railroads

Railroads and steam-powered locomotives also arrived about the same time as canals. The symbol of the industrial age, they minimized travel time and shipping costs. For topographic reasons, many railroads were located on lines parallel or close to turnpikes and canals and created direct competition. The first railroad company in New York State was chartered in 1826, within 6 months of the completion of the Erie Canal.[534] It was the Mohawk and Hudson, and it began operation between Albany and Schenectady in 1831.[535] The success of this railroad sparked a rail boom. Entrepreneurs and communities began requesting corporate charters from the legislature. Money flowed into lines that linked other Erie Canal towns, and within a decade through service was available from Albany to Buffalo.[536] The Harlem Line of the New York Central opened in 1837 and the Hudson River Line opened in 1851.

The Long Island Rail Road began operation in 1836, enabling those who worked in the city to live in the country.[537] It was also intended to foster the economic vitality of Kings, Queens, and Suffolk Counties and to speed travel between New York and Boston by connecting Jamaica with the harbor at Greenport.[538] The New York & New Haven Railroad opened in 1848 and linked New Haven and other ports in Connecticut with New York by 1849.

During the Civil War, the Mississippi River was closed to commercial traffic. As a result, passengers and freight increased on established east-west railroads, such as the Erie and New York Central. Demand also strengthened old lines like the Hudson River Railroad, and spurred the construction of new ones.[539] The New York Central Railroad was formed in 1853 from a number of smaller companies.[540] The Erie Railroad became the first through line to the Midwest and Great Lakes in 1861, with financial control of lines to Buffalo and Chicago.[541]

Railroads had proved their worth during the Civil War. Railroads became the dominant form of transportation in the country in the late 1800s, taking traffic off roads and causing roads to be neglected. Railroads provided an economical and efficient method of moving materials and products, and offered access to markets in the east and west and to major ports. On a smaller scale, railroads provided a link between urban centers and small surrounding towns.

After World War I, confidence in railroads was shaken. Exports doubled during the war, placing a tremendous strain on railroads traveling to the Port of New York. This brought New York's railroads, and consequently the nation's railroads, near the point of collapse. Since truckers could undercut railway rates, trucking became a viable economic alternative. Railroads continued to have a role in the region's transportation system, but emphasis was shifted to highways after World War I.

(3) International/Interstate Development

(a) Canada

The area that became Canada in 1867 was first settled by the French and known as New France. Extensive waterways, including Lake Ontario, Lake Erie, Lake Champlain, and the St. Lawrence River, provided water routes between New York and New France. However, the rivalry between the Dutch (and then British) and the French was not conducive to the establishment of permanent transportation connections. As early as 1690 the British began building forts along Lake Champlain. Building hostilities between the British and the French led to the Seven Years War. When the war was over, the British controlled the territory. The American Revolution again made this border a hostile frontier. The British hoped to crush the rebellion by gaining control of the Hudson River, in part by sending troops down Lake Champlain and Lake George to Albany. The lack of roads between Lake George and the Hudson River was one of the factors that hampered the British and led to their defeat at the Battle of Saratoga.

With the exception of ferries, there were few major transportation improvements between Canada and New York across the St. Lawrence River, Lake Ontario, or Lake Eric until the early 1900s. Transportation improvements between Canada and New York at this time first consisted primarily of bridge construction. The Commission on Boundary Waters between the United States and Canada was created in 1920 to study the possibility of building a bridge between the United States and Canada. The commission included the state engineer and surveyor, the superintendent of public works, and several other state officials. The commission was made part of the New York State Department of Public Works in 1923.[542]

The Buffalo and Fort Erie Public Bridge Authority, later known as the Buffalo and Fort Erie Public Bridge Company, was created in 1925 by legislation enacted in New York State and Canada. The company was mandated to construct the Peace Bridge between Buffalo, in Erie County, New York, and Fort Erie, Ontario, Canada, across the Niagara River.[543] The bridge was a vital link to long distance interstate travel and international trade.[544]

The Roosevelt International Bridge, originally a railroad crossing, opened for automobile use in 1934 between Cornwall, in Ontario, and Massena, in St. Lawrence County, New York. It provided an alternative to the ferry services at Prescott and Brockville in Canada.[545]

The Thousand Islands Bridge Authority was formed by the State Emergency Public Works Commission. This authority was chaired by Moses and funded by President Hoover's 1932 Reconstruction Finance Corporation, a federal agency designed to aid self-supporting public works projects. The Thousand Islands Bridge Authority constructed the International Bridge to Canada, which opened in 1938 to facilitate traffic between Jefferson County, New York, and Canada over the Thousand Islands.[546]

In 1941 the Niagara Falls Commission completed the construction of the Rainbow Bridge over the Niagara Gorge between Niagara Falls in Niagara County, New York, and Ontario. The bridge carried mostly tourist traffic to the falls.[547]

The popularity of the automobile began to cause congestion on main roads between Canada and New York State by the mid-1900s. New highways were built to relieve this congestion. In 1939 the Queen Elizabeth Way officially opened in Canada, connecting Buffalo, New York, with Toronto, Ontario.[548] In Quebec, most of the highway network was not built until the 1960s. In New York, construction of the New York State Thruway reached the Canadian border at Buffalo during the 1950s. Construction of the Adirondack Northway (Interstate 87) from Albany to the Canadian border near Lake Champlain began in 1957 and was finished in 1967. It was the first long-distance, toll-free interstate highway completed in the state.[549] By 1964 Interstate 81 was completed between Tully and Watertown, except for the section through Syracuse. Although its first segments were completed as early as 1957, Interstate 81 would not be fully operational between the Pennsylvania state line and the Thousand Islands International Bridge until 1970.[550]

The Ogdensburg-Prescott International Bridge was completed in 1960 to provide easy tourist access to Canada. The bridge carries N.Y. 812 over the St. Lawrence River between Ogdensburg in St. Lawrence County, New York, and Prescott, in Ontario.[551] In order to enhance the connection between the New York State Thruway and Canada's Toronto expressway, construction of another bridge began in 1960.

Creation of the St. Lawrence Seaway also began in the mid-1950s to improve travel between the Great Lakes and the Atlantic Ocean. In 1954 the Wiley-Dondero Act (the Seaway Act) was signed into law to create a joint United States-Canadian Seaway (what would become the St. Lawrence Seaway). The act established the St. Lawrence Seaway Development Corporation in the United States to work with Canada's St. Lawrence Seaway Authority in the construction, operation, maintenance, and development of the water route. From 1954 to 1959 most of the corporation's activities were concentrated on building the Seaway between Massena, New York, and Lake Erie. The seaway opened in 1959 and extended from Montreal, Quebec, to Lake Erie, linking the Atlantic Ocean and St. Lawrence River to the Great Lakes.[552] The seaway competed with the New York State Barge Canal system, aiding in its demise.

(b) Connecticut

For many years, the main transportation route between New York and Connecticut was the Boston Post Road, which ran through Connecticut. By the mid-1700s a regular stagecoach service existed on this road and during the Revolutionary War, it was a major transportation route.[553]

Turnpikes began to be built between New York and Connecticut by the 1800s. In 1800 the Susquehanna Turnpike Company was incorporated and built the Susquehanna Turnpike from Salisbury, Connecticut, to Wattles' Ferry (Unadilla), New York, on the Susquehanna River in the central part of New York State.

Most improvements in the 1900s were due to the increase in automobile traffic between New York and Connecticut. Traffic along the Boston Post Road, also known as U.S. 1, dramatically increased by 1920. This road was the primary link between the Port of New York and Connecticut's major industrial centers. It had been widened several times, but traffic was still congested. In response, a new east-west road was planned to connect with the parkway system in Westchester County, New York. In 1931 the Merritt Highway Commission was established to oversee the project. Construction began in 1934, and at the same time Westchester County announced plans to build a connector that would link the Hutchinson River Parkway in New York to the Merritt Parkway. The first section of the Merritt Parkway opened in 1938 from the New York State line to Norwalk, Connecticut.

Defense concerns also played a major role in highway planning in the 1940s. "In 1942 traffic authorities in Connecticut, New York, New Jersey, and the Metropolitan Defense Transport Committee of the City of New York designated a series of primary and secondary highways in each of the states as Civil Routes. These highways would provide alternative routes for civilian traffic between metropolitan New York and outlying areas when the Boston Post Road or Merritt Parkway were needed by the government or defense agencies."[554]

During the 1950s the primary focus was the construction of an interstate highway system in Connecticut that would connect to the New York Thruway. The Connecticut Turnpike (now Interstate 95) officially opened in 1958 along the south shore of Connecticut. The turnpike's Byram Bridge, connecting Connecticut with New York, was completed in 1959.[555]

(c) Massachusetts

For many years, the primary route between Massachusetts and New York was the Boston Post Road, which ran through Connecticut. New York's older road connections with Massachusetts, like the westward-bound route through Albany, were improved in the early 1900s. By the 1940s the highway joining Albany and Pittsfield, Massachusetts, was designated as U.S. 20.[556] In Massachusetts, the primary focus during the 1950s was the construction of an interstate highway system. Interstate 90 in Massachusetts – also known as the Massachusetts Turnpike – connected to the New York Thruway near Albany.

(d) New Jersey

Transportation between New York and New Jersey during colonial times and up to the early 1900s was either by road across New Jersey's northern border or by boat across the Hudson River (to Manhattan) or the Arthur Kill (to Staten Island).

The Old Mine Road was built between 1620 and 1650 to link copper mines in Warren and Sussex Counties in New Jersey with the port at Kingston, New York, on the Hudson River. It was 140 miles long and was in use as a road until 1940.[557] A king's highway existed from Shawangunk in Orange County, New York, through Montgomery to Goshen, then through Florida and Warwick to Sussex, New Jersey, where it intersected the king's highway to Fort Lee, New Jersey.[558] This was also used as a mail route. As early as 1750, a regular stagecoach service ran from Philadelphia to New York, through Trenton and Brunswick, New Jersey. The well-traveled route between New York and Philadelphia included a ferry trip across the Hudson. Turnpike construction then began in the 1800s. For example, in 1806 the Franklin Turnpike opened, connecting New York State with Hohokus, New Jersey.[559]

Extensive transportation improvements were made between New York and New Jersey beginning in the 1900s, including the construction of tunnels, bridges, parkways, and interstate highways as described below. State highways that crossed the New Jersey-New York state line were constructed by either improving and expanding old routes or by making new routes, mainly during the 1920s.

New York Interstate Bridge Commission

The New York Interstate Bridge Commission (later the New York State Bridge and Tunnel Commission) was created in 1906 to investigate the feasibility of a bridge over the Hudson River between New York City and New Jersey. In 1913 the commission was authorized to consider the possibilities of vehicular tunnel construction. During World War I, there was tremendous difficulty getting goods from New Jersey to shipping ports in Manhattan due to the limited capacity of the harbor crossings. Immediately after the war, the railroads did not move quickly to initiate capital improvements, giving government officials further reason to embrace highway bridges and tunnels spanning the Hudson River. In 1919 the legislature authorized the commission to proceed with construction, in cooperation with New Jersey, of a tunnel or tunnels between Canal Street in Manhattan and Jersey City, New Jersey, for pedestrians and vehicles not operated by public service corporations. The commission was given full authority to determine the site, size, type, and method of construction and to enter into a contract for joint construction, operation, and maintenance of such tunnel or tunnels. The commission chose Clifford M. Holland of Brooklyn as chief engineer.[560] However, this project was transferred to the Port of New York Authority for implementation.

Port of New York Authority

The New York and New Jersey State Legislatures created several intergovernmental bodies to oversee highway and harbor planning. The most important of these bodies was the Port of New York Authority (now the Port Authority of New York and New Jersey), created in 1921. It was charged with the development of terminals, transportation, and other facilities within the port district, which extends about 20 miles in all directions from the Statue of Liberty.[561] The Port Authority developed a comprehensive plan of highway improvements resulting in the construction of the Holland Tunnel (1920-27) between Jersey City, New Jersey, and lower Manhattan, the George Washington Bridge (1927-31), and the Lincoln Tunnel (1934-45) between Weehawken, New Jersey, and mid-Manhattan. These improvements greatly enhanced vehicular networks between New Jersey and New York City and promoted interstate trucking. However, the Port Authority was criticized because it paid more attention to vehicles than to the harbor.[562]

The George Washington Bridge – spanning the Hudson River between Fort Lee, New Jersey, and Manhattan and now carrying Interstate 95 – was the culmination of years of planning and unachieved dreams and plans. Its location posed challenges for the design of limited access, multi-lane approach highways that served both the needs of long-distance traffic traveling north and south along the East Coast or east and west (between New York City and New Jersey), and of local and commuter traffic crossing the Hudson River.[563]

Other Port Authority projects included the construction of bridges between Staten Island, New York, and New Jersey. The Goethals Bridge was completed in 1928 between Elizabeth, New Jersey, and Staten Island. (It now carries Interstate 278.) The Outerbridge Crossing, also completed in 1928, connected Perth Amboy, New Jersey, and Staten Island and carried N.Y. 440. These two bridges were the first constructed by the authority and represent an era of rapid expansion of New York's network of highways and bridges.[564] Both bridges primarily facilitated movement between New Jersey and Staten Island when they were built, and served as freight links between distribution centers in New Jersey and Staten Island as trucks grew in importance relative to rail movement.[565] The Bayonne Bridge was then built in 1931, which carried N.Y. 440 and linked Bayonne, New Jersey, and Staten Island.

The Lincoln Tunnel, designed by Ole Singstad, connected Weehawken, New Jersey, to 39th Street in Manhattan and was built by the Port Authority under the leadership of Moses. Moses obtained funding for the project from the Federal Reconstruction Finance Corporation.[566] Construction took more than two decades with the first tube opening in 1937 and the last in 1957.[567]

Palisades Interstate Parkway
Parkway development between New York and New Jersey began as a means of preserving the Hudson River Palisades, a natural cliff outcropping covered by forest extending north along the west side of the river. The Palisades Interstate Park Commission, a cooperative effort of New York and New Jersey, was established in 1900. However, development actually began in the 1920s under the guidance of John D. Rockefeller, Jr., who donated land and money, and facilitated the political process. In 1928 the Regional Plan Commission, fearing that suburban development would be unleashed by the imminent construction of the George Washington Bridge over the Hudson River, joined the cause with the Bronx River Parkway as its inspiration. The Palisades Interstate Park Commission agreed that a parkway on "top of the Palisades was the best way to preserve the cliffs" by controlling access to the 60,000 acres of the Palisades Interstate Park and limiting unregulated development and movement through the area. The parkway was "an important regional planning initiative, encouraging orderly suburban growth while directing development away from the most fragile and scenic areas."[568]

The Palisades Interstate Parkway extends 42 miles from the George Washington Bridge in Fort Lee, New Jersey, north to Bear Mountain, New York. Construction on the 30-mile New York section began in 1947 under the Department's Division of Highways. New Jersey began construction on its portion of the parkway shortly after. The Palisades Interstate Parkway Commission coordinated construction in pursuit of consistent design and construction standards. Today, all of the original interchanges and all but one of its original bridges survive, with only limited additions.[569] The Palisades Interstate Parkway from Fort Lee, New Jersey, to Bear Mountain, New York, is on the State and National Registers of Historic Places.

(e) Pennsylvania

While the main route between New York City and Philadelphia has always been through New Jersey, toll roads and bridges were constructed across the New York-Pennsylvania border to improve the movement of goods between adjacent parts of the two states in the 1800s. In 1810 the New York State Legislature granted a charter to the Narrowsburgh Bridge Company to build a bridge across the Delaware River at the Narrows (Big Eddy) in Sullivan County, and to collect tolls. It was the connecting link between the Mount Hope, New York, and Honesdale, Pennsylvania, roads. The bridge was rebuilt in 1832, destroyed in 1846, and rebuilt again in 1847. The bridge provided an outlet for Sullivan County's valuable timber, while bringing the agricultural products of the county toward the Hudson River to be exchanged for merchandise.[570]

Turnpike companies were chartered to improve transportation between Pennsylvania and New York. For example, the Mount Hope and Lumberland Turnpike was chartered in 1812. Work began on the turnpike to Narrowsburgh, Sullivan County, New York, in 1815. An act of the Pennsylvania Legislature extended the turnpike to Honesdale, Pennsylvania, in 1815.[571]

More transportation improvements were made in the early 1900s. State highways were constructed to connect at the border. The activities of the New York Interstate Bridge Commission were not restricted to those between New Jersey and New York. In 1925 the commission acquired six of the 11 toll bridges over the Delaware River between New York and Pennsylvania. The bridges were located in Delaware, Sullivan, and Orange Counties.[572]

In the 1950s interstate highway construction was of primary importance. Interstate 84 was constructed and connected northeastern Pennsylvania with Hudson River Valley of New York State. Interstate 81 connected eastern Pennsylvania with Binghamton, Syracuse, and Watertown, New York. Interstate 90 in New York was also constructed through the northwestern tip of Pennsylvania.

(f) Vermont

Until the early 1900s, most transportation between Vermont and New York was by boat across Lake Champlain, which formed a large part of the border between these states. Later transportation development mainly consisted of improving existing roads and building new bridges over Lake Champlain. A bridge over Lake Champlain on N.Y. 2 between Rouses Point, in Clinton County, New York, and Alburg, Vermont, was constructed in the late 1920s or early 1930s. This bridge completed a major transportation corridor between New York State, Vermont, New Hampshire, and Maine.[573] The Crown Point Bridge, located between Crown Point, in Essex County, New York, and Chimney Point, Vermont, was constructed in 1929 to carry N.Y. 17. Three ferry routes continued to be used for travel across Lake Champlain: Grand Isle, Vermont to Plattsburgh, New York; Burlington, Vermont, to Port Kent, New York; and Charlotte, Vermont, to Essex, New York.[574]

D. Regional Transportation Development

(1) Hudson River Valley

(a) Early Transportation Routes

The Albany Post Road between New York City and Albany, originally developed in the seventeenth century, continued to be improved throughout the eighteenth century. King's highways were built throughout the Hudson River Valley. For example, New Windsor, Newburgh, and Cornwall were important trading points in Orange County because of their positions as natural points for access to New York City, and so early roads tended in their direction. These roads included the king's highways from Kingston to New Paltz, New Windsor to Goshen, New Windsor to Wallkill, and Florida to Goshen (now N.Y. 17A).[575] In Putnam County, the first king's highways were laid out in the mid-1700s. Some extended to the Connecticut border.[576] In 1785 stagecoaches began to run on Albany Post Road. Another post road was created on the king's highway from Rhinebeck and Kingston to New Paltz, Goshen, and Warwick, and then to Sussex, New Jersey.[577] A road from Albany down the Hudson River's west bank reached as far as Catskill, where ferry service across the river made the connection with the post road on the east bank.

Turnpikes were built in the Hudson River Valley at the beginning of the 1800s. Stagecoaches conveyed passengers and freight wagons carried goods on these roads. The Susquehanna Turnpike from Wattles Ferry (Unadilla), New York to Salisbury, Connecticut, crossed the Hudson River Valley in 1800. In 1804 the part of the road east of the Hudson River was incorporated into a separate road called the Ancram Turnpike. West of the Hudson River, the Greene County section of the Susquehanna Turnpike then ran from Catskill northwest through the town of West Durham to the Schoharie County line. It provided the easiest method of travel through Greene County to the west during most of the nineteenth century. The road functioned, in part, as a toll road for more than 100 years and contributed to the economic and demographic growth of western New York. It follows Old State Route (now U.S.) 145 (the Mohican Trail) and then County Route (C.R.) 22 to C.R. 20.[578] The Susquehanna Turnpike from Catskill to the Schoharie County Line is on the State and National Registers of Historic Places.

Turnpikes shifted the commercial center of Orange County from New Windsor to Newburgh. The county's first turnpike, the Orange Turnpike, was built in 1800 and extended in 1806 from the town of Cheescocks (now Monroe) to New Jersey on the route to New York City and along the route to Albany. In 1801 the Newburgh and Cochecton Turnpike was constructed from Newburgh, on the Hudson River, to Cochecton, on the Delaware River. It ran 60 miles with substantial bridges. By 1808 the road was completed and brought mining to Sullivan County.[579] In 1805 the Newburgh and Chenango Turnpike linked Newburgh to Oxford, in Chenango in western New York. The object of this road was to open the area to settlement.[580] A mail route was also constructed from Newburgh to Ithaca via Monticello, Binghamton, and Oswego in 1810.[581]

In Putnam County, the first turnpike company was chartered in 1804. This company – the Highland Turnpike Company – built a road that ran through Philipstown. In 1806 it was extended from Fishkill to Rhinebeck to Hudson. The Highland Turnpike Company also controlled the lower section of the Albany Post Road in 1806 and widened and improved it. The Philipstown Turnpike Company was incorporated in 1815 and built a road from Cold Spring east to the Connecticut border.[582] In Columbia County, a direct road was constructed by the Chatham Turnpike Company in 1804 from Chatham to Canaan, and the Hillsdale and Chatham Turnpike was built from Hillsdale to the post road from Kinderhook to Albany in 1805.[583] The Hudson Branch Turnpike from Livingston to Hudson was improved in 1812 and the Farmer's Turnpike was improved from Hudson to Troy in 1813.[584]

In the 1850s plank roads were built in the Hudson River Valley. In Orange County, the New York and Ellenville Plank Road Company built a plank road to Ellenville in 1851. The Newburgh and Shawangunk Plank Road was completed in 1851, the Middletown and Bloomingburgh Plank Road was constructed in 1853, and the Middletown and Unionville Plank Road was constructed in 1853.[585]

(b) Parkways

A number of parkways were built in the first half of the 1900s in the Hudson Valley. They provided an essential connection between the overcrowded New York metropolitan area and the vast public parkland to the north."[586] In addition to the Palisades Interstate Parkway, they most notably included the Bronx River Parkway and the Taconic Parkway.

The Bronx River Parkway – the country's first public automobile parkway – runs from the Bronx in New York City north to Valhalla in Westchester County.[587] It was planned and built between 1906 and 1925, and is an early and outstanding example of a limited access automobile parkway. It was the first of the early twentieth century parkways to respond to new trends in conservation, transportation, recreation, and community development.[588] The parkway's development also grew out of the desire to reclaim the Bronx River Valley, which was threatened with heavy water pollution.[589] The parkway from its intersection with Sprain Brook Road to and including the Kensico Dam Plaza is on the State and National Registers of Historic Places.[590] In its final form, the 1,155 acres of the Bronx River Parkway Reservation included 28 parkway bridges, 10 crossing bridges for local roads, and 21 timber footbridges which carried paths across the Bronx River.

The Westchester County Parks Commission was established in 1922 due to the success of the Bronx River Parkway. In 10 years, the commission, operating as an agency of the state, developed more than 160 miles of recreational parkways throughout the county. It served as a model for planners around the country.[591]

The Bear Mountain State Parkway, originally called the Bronx Parkway Extension, was approved by the state legislature in 1923. It was foreseen as a scenic connector route between the Bronx River Parkway and the Bear Mountain Bridge, which was under construction at the time across the Hudson River. The parkway, while similar to other Westchester parkways in its combination of limited-access and at-grade construction, was unique in that it was an undivided, four-lane arterial highway. Two sections totaling about 5 miles in length were completed by the time construction halted in 1932.[592]

The Taconic State Parkway, a 105-mile-long "twentieth century limited-access scenic pleasure drive," extended from the northern end of the Bronx River Parkway at Kensico Dam in Westchester County north to Interstate 90 in Columbia County.[593] The Taconic State Park Commission, which was formed in 1925 and immediately began working towards the goals of the State Council on Parks, built the parkway. Franklin D. Roosevelt was the first chair of the commission and is credited with assisting the selection of the parkway's route, securing many large donations of land, and selecting park sites along the route.[594] The Taconic State Parkway was designed to link the Bronx River Parkway and the Westchester County Parkway System with the proposed Palisades Interstate Parkway via the Bear Mountain Bridge. It became "part of an enormous proposed interstate parkway and recreational system stretching from the tip of New Jersey to the Canadian border."[595] The Taconic State Parkway north of and including the Crompound Road Bridge in Westchester County has been determined eligible for the State and National Registers of Historic Places.

Other parkways built in the region during this period include the three built under the direction of Moses: the Saw Mill River Parkway from Katonah in Westchester County to New York City, where it connected to the Henry Hudson Parkway; the Sprain Brook Parkway, which connected the Bronx River Parkway at Bronxville, Westchester County, to the Taconic Parkway in Mount Pleasant, Westchester County; and the Hutchinson River Parkway (completed in 1941), which ran from the Bronx-Whitestone Bridge in Bronx County through Westchester County to the Connecticut border.

(c) State and U.S. Routes

Roads and bridges in the Hudson River Valley became heavily traveled at the beginning of the 1900s. With the shift from the railroad to the automobile and truck as a principal means of transportation, industries along the Hudson River Valley were no longer dependent on the river or the railroads. River communities that were once linked by the Hudson or the railroad became connected by highways.

The west side of the Hudson River between Albany and New York (including northern New Jersey) was among the most important and heavily traveled areas in the state. As early as 1919 this direct highway was labeled Route 3 by the highway commission. The earliest available automobile maps for the corridor note a "principal through auto route" traversing the distance on what would soon become Route 8. In the 1920s the highway was sometimes called the New York-Albany-Montreal Route. By 1925 Route 8 (now N.Y. 94 from Newburgh to Vails Gate, then N.Y. 32 and N.Y. 17) and Route 10 (now U.S. 9W) ran south to New Jersey and then crossed the Hudson at the 130th Street Ferry for passage into Manhattan.[596]

Storm King Highway (now N.Y. 218) in Orange County was developed at Storm King Mountain in combination with the Bear Mountain Bridge in 1924. Designed as a scenic approach route to the new bridge and blasted out of solid rock, the road's construction prompted the first major opposition to a road-building project and has been called the birthplace of the ecological movement in the United States. At its completion in 1922, the 4-mile-long scenic, winding highway along the Hudson River between Cornwall Landing and West Point was called "one of the most remarkable and picturesque roads in existence."[597] The 1924 Bear Mountain Bridge carried U.S. 6 and U.S. 202, connecting U.S. 9W and the Palisades Parkway in Orange County with U.S. 9D in Westchester County, north of Peekskill.[598]

In the 1950s construction of the New York State Thruway and expressways began in the Hudson River Valley. In response to the planned construction of the thruway, the construction of new bridges was required. In 1955 the Tappan Zee Bridge was completed. It was a key structure of the New York State Thruway carrying Interstate 287/87 and connected Tarrytown in Westchester County and Nyack in Rockland County over the Hudson River. Previously these counties had only been connected by ferry.[599] In Sullivan County, the Quickway was built over and along the existing N.Y. 17, transforming it into an expressway. Soon to be redesignated as Interstate 86, construction of the Quickway was underway in 1958.[600]

(d) New York State Bridge Authority

The New York State Bridge Authority was created by the legislature in 1932 and was given the exclusive right to construct, operate, and maintain crossings over the major part of the Hudson River between Albany and New York City. The initial function of the authority was to operate the 1930 Mid-Hudson Bridge and to secure financing for the Rip Van Winkle Bridge near Catskill.[601] The authority enabled the construction of bridges that linked communities that were previously separated by the Hudson River.

The 1935 Rip Van Winkle Bridge (also known as the Catskill-Hudson Bridge), connected Catskill in Greene County to Hudson in Columbia County.[602] It provided a direct connection between U.S. 9W on the west side of the Hudson River and N.Y. 9G on the east side of the river.[603]

The authority also built the 1947 Kingston-Rhinecliff Bridge, which spans the Hudson River between Kingston in Ulster County and Rhinecliff in Dutchess County.[604] It carries N.Y. 199 and connects N.Y. 9G on the east side of the Hudson River to U.S. 9W on the west side.

(2) Long Island

(a) Early Transportation Routes

Before and during the 1700s, most roads on Long Island were for local use and generally followed old Native American paths that settlers improved and widened. The main road that was developed leading east from the ferry landing (at what is now the foot of the Brooklyn Bridge in Brooklyn) was originally a principal trail that was widened into a wagon road and later called the Ferry Road. In 1704 it was improved as a king's highway. Three roads led from the Ferry Road, one to Jamaica, one to Flatbush, and one toward Gowanus.[605] A road called the Old Bowery Bay Road, also existed along the north shore line of Queens County. Parts of it still survive as 20th Road.[606] Native Americans and settlers also traveled from what is now Brooklyn to Jericho along the route now known as Jericho Turnpike.[607] In 1703 the General Assembly of New York appointed highway commissioners in Kings, Queens, and Suffolk Counties to lay out, clear, and preserve highways. The roads were to be about 18 feet wide.

The first cross-island routes spread east from Brooklyn, and by 1733 there were three well-traveled roads – North Country Road, Middle Country Road, and South Country Road. Parts of present Montauk Highway are still called South Country Road, and parts of present Jericho Turnpike are still called Middle Country Road. Present Route 25A follows much of the route of North Country Road. These three primary routes became more important after the first mail route was established.[608]

The establishment of regular ferry service between Manhattan and Long Island, and the construction of turnpikes and railroads in the 1800s enabled the development of Long Island. These modes of transportation made travel faster and made it possible for people to live on Long Island and commute to New York City to work.

Turnpikes were constructed all over the island to connect major settlements and facilitate the movement of traffic. Besides those on the western end of Long Island in Kings and Queens Counties, they included the Bull's Head Turnpike (now called the Bridgehampton-Sag Harbor Turnpike) constructed in 1840, and the East Hampton Turnpike (now called the East Hampton-Sag Harbor Turnpike) constructed between East Hampton and Sag Harbor in 1844 on the eastern end of Long Island.[609]

Plank roads were constructed in the 1850s and 1860s on Long Island. In 1852 Merrick Road, one of Long Island's longest highways, was developed from Jamaica, Queens, to Merrick in Nassau County as a plank road.[610] Merrick Road (Merrick Boulevard in Queens) still exists today from Jamaica to Merrick.

(b) Parkways

After Eastern and Ocean Parkways in Brooklyn, the Long Island Motor Parkway was the first road called a "parkway" to be built on Long Island. It did not connect parks, but was built for strictly recreational purposes. It was also the first highway designed only for automobiles, the first to use overpasses and bridges to eliminate intersections, and the first concrete highway in the United States. It was built by William K. Vanderbilt II as a private toll road that could be used as a racecourse. Construction on the road began in 1908 and used a new paving method of reinforced concrete. By 1910 it was 43 miles long and ran from Lakeville Road in Great Neck, Nassau County, to Ronkonkoma in Suffolk County. In 1911 it was extended west to Springfield Boulevard in Queens County. It had 65 bridges and 12 toll lodges. The toll lodges were designed by John Russell Pope. After 1920 the parkway was no longer used as a racetrack but was used as a testing ground for car and tire manufacturers like Packard and the U.S. Rubber Company. In 1926 Vanderbilt extended the roadway to Horace Harding Boulevard in Queens County and built a 2 mile spur to connect the road to the Jericho Turnpike in Commack. The opening of the Northern State Parkway in 1933 decreased traffic on the parkway so much it caused Vanderbilt to turn the road over to the state in lieu of back taxes. The Long Island Motor Parkway was closed to traffic in 1938. Today, only small stretches of concrete remain. Suffolk County has kept part of the road in use (13 miles), calling it the Vanderbilt Motor Parkway.[611]

Moses began building parkways during his tenure as head of the Long Island Parkway Commission from 1924 to 1963. The parkways built by Moses on Long Island were meant to move vehicular traffic between New York City and Long Island's state parks, which were concurrently being developed by Moses.[612] The Long Island Parkway plan was conceived as an integrated system of separated roadways. This was the earliest system of true "superhighways" and became a model for other states, this nation, and other nations.[613] These parkways increased recreational opportunities and expedited traffic in the region.[614]

Some of the parkways Moses built during this period include:

- The Southern State Parkway was located between the Queens/Nassau county line and Islip in Suffolk County. Right-of-way acquisition for the Southern State Parkway began in 1924, immediately after Moses became head of the Long Island Parks Commission. The parkway opened in 1929. By the 1950s traffic was so congested on this parkway that a new parkway was built next to the original with a wide median strip. New bridges over the westbound lanes were constructed next to the original bridges using stone from the same quarries.[615]

- The Wantagh Parkway opened in 1929 between Westbury and Wantagh in Nassau County.

- The Northern State Parkway was built between 1933 and 1952 from the Queens county line to Mineola in Nassau County.

- The Bethpage State Parkway ran between Bethpage State Park and the Southern State Parkway in Nassau County. It was built in 1934 by the Bethpage State Park Authority, one of the seven separate governmental agencies concerned with parks and major roads in the metropolitan area. The authority was largely formed and subsequently chaired by Moses in 1933-34.[616]

- The Meadowbrook Parkway, from the Northern State Parkway, through Eisenhower Park and Roosevelt Park, to Jones Beach State Park in Nassau County, opened in 1934. It was the first fully divided, limited access highway that would be the model for all future Long Island Parkway projects.[617]

- The Sagtikos Parkway opened in 1952 and ran north-south on Long Island, connecting the Northern and the Southern State Parkways in Suffolk County.

- The Sunken Meadow Parkway, which ran north-south and connects the Sunken Meadow State Park on Long Island Sound to the Northern State Parkway and the Sagtikos Parkway in Suffolk County, opened in 1957.

(c) State and U.S. Routes

Many highways were constructed on Long Island between 1900 and 1950. In 1922 Long Island's first divided "super highway," called Long Beach Road, opened in Nassau County.[618] In 1928 the department was constructing Wantagh Avenue from the northern end of the Jones Beach Causeway to the Southern State Parkway. The construction of three Jones Beach Causeway and Jones Beach Boulevard Bridges was also contracted in 1928. In 1929 the Sunrise Highway (N.Y. 27), which ran from the Brooklyn/Nassau county line to Shinnecock Hills in Suffolk County, opened and Conduit Boulevard was completed. Conduit Boulevard – a 24-mile-long highway from Brooklyn to the Nassau/Suffolk county line – was authorized as a special highway by the legislature and became the heaviest traveled road on Long Island.[619]

Construction of the Long Island Expressway (now Interstate 495) then began in 1955 under the direction of Moses. An extension of the Long Island Expressway from Patchogue to the North Country Road near Shinnecock Bay was built c. 1960.[620]

(3) North of Albany

(a) Early Transportation Routes

Northern New York was sparsely occupied through most of the 1700s. The rugged terrain of the Adirondacks, which occupies much of the area north of Albany, also discouraged early travel and road development. However, Lake George and Lake Champlain had historically served as a valuable water route to the east of the Adirondacks.[621]

In the mid-1790s, after a victory over the Native Americans at Fallen Timbers and the ratification of the Jay Treaty between the United States and Britain, tens of thousands of settlers began to occupy western frontier territories. They traveled along the Mohawk Valley and over the Adirondacks to the rich country below Lake Ontario. As a result, new transportation routes began to be developed in the northern and western regions of the state, particularly where water navigation was not possible. Bridges were sometimes also constructed. In northern New York, the AuSable River (or Sandy River) was not navigable, so early settlers in the surrounding area had to rely on land transportation in Clinton and Essex Counties.[622] In 1793 the state built a bridge over the AuSable Chasm to carry a road that would connect the towns and villages along the western side of Lake

Champlain.[623] By 1800 a road, which followed an old Native American trail to Canada, was opened from Albany north to Clinton County, facilitating settlement in the northern part of the state.[624]

While there was extensive road building in other portions of the state during the early 1800s, the Adirondack mountains, which fill the central part of this region, were still a substantial barrier to development. Most settlements continued to be located along the St. Lawrence River or Lake Champlain and Lake George, where travel was much easier. In St. Lawrence County, the first surveyed road started at the mouth of the Racquette River and continued along the St. Lawrence River, similar to what is now N.Y. 37.[625]

During the War of 1812, roads were constructed to carry military supplies through the region. What is now N.Y. 3 was built between 1812 and 1814 and ran between Fulton in Oswego County and Plattsburgh in Clinton County, passing through the northern edge of the Adirondack mountains. The road that is now U.S. 11 was built between 1813 and 1814 from the Canadian border near Lake Champlain to Syracuse and points south.[626]

Industrial companies built roads in the region to access resources or carry their products to markets. For example, the Peru Iron and Steel Company built a road from Clintonville, where its iron business was located, to their wharf in Port Douglas in Clinton County. The J. and J. Rogers Company, also located in Clinton County, built roads connecting AuSable Forks to forges in Black Brook and charcoal and wood supplies elsewhere.[627]

Some turnpikes were built in the region. The Port Kent and Hopkington Turnpike was one of the earliest roads in the AuSable Valley in Clinton and Essex Counties. It ran from Port Kent, followed the AuSable River to Au Sable Forks, and then went northwest into Franklin County.

Many of the other roads in the region were built by local governments during the nineteenth century and relied on volunteer labor, local expertise, and local resources for their construction.[628] Plank roads were built in St. Lawrence County in the late 1840s and early 1850s. In 1849 the Ogdensburg-Heuvelton plank road was opened. The Gouverneur-Somerville-Antwerp plank road and a plank road between Gouverneur and Canton opened in 1850. The Hammond-Rossie-Antwerp plank road was also completed in 1850. In 1851 the Canton, Morley, Madrid plank road was completed, and in 1852 the Norfolk-Raymondville-Massena plank road was built. The Western Plank Road was an early toll road. Fourteen miles long, it was built around 1850 between Black Brook in Clinton County, and Franklin Falls. As maintenance costs increased and the roads began to wear out, the companies went out of business and turned the roads over to the town commissioners.[629]

Unique to the region is the Adirondack State Forest Preserve, the first state forest preserve in the United States, which was established in 1885 to preserve several million acres of forest land. Its establishment limited the construction of roads in the preserve, and is the reason why there are few roads and bridges in certain counties.

(b) State and U.S. Routes

Many new roads were constructed in the region north of Albany as the popularity of automobiles increased. The new roads were either more direct routes that cut traveling distances or traveled through areas that were previously without roads.

In St. Lawrence County, the first state road in the county was built from Massena to Louisville in 1907. In 1908 the Office of the County Superintendent of Highways was created, but St. Lawrence County did not start building county roads until 1922.[630] In 1929, N.Y. 58 from Gouverneur to Fine, which continues as N.Y. 3 to Tupper Lake, was completed and open to traffic. Most of this road traveled through the Adirondack forest preserve.[631]

In Essex County, plans were underway in 1917 to construct the Whitehall-Dresden Road, an important link in the eastern part of the state from Whitehall to Lake Champlain. This road was expected to relieve dense traffic going north via Lake George and Elizabethtown.[632] In 1928 the highway between Elizabethtown and Keeseville, popularly known as the "Poko-Moonshine" road on the Albany-Montreal route – now U.S. 9 – was under construction. This highway cut the distance between the towns and eliminated the arduous journey by way of Jay and AuSable Forks.[633]

The Clifton Park to Round Lake section of U.S. 9 in Saratoga County was placed under contract in 1928. It cut the distance between Albany and Saratoga Springs by about 6 miles and eliminated Mechanicville from the route.[634]

In the northern part of Hamilton County, the Long Lake-Tupper Lake highway (N.Y. 30) was almost complete in 1928. Previously there was no road in this part of the Adirondacks. This route shortened the distance between the St. Lawrence River and Albany by 80 miles.[635] In 1929, N.Y. 28 through Old Forge, Blue Mountain Lake, and Long Lake in the Adirondacks was opened to traffic. It was considered one of the most scenic routes in the state.[636]

In the 1950s, Interstates 81 and 87 were begun through this part of the state, linking to the thruway on opposite sides of the Adirondacks.

(4) Western New York

(a) Early Transportation Routes

In western New York State, the Mohawk River provided access from the Hudson River to the Great Lakes and the Mississippi. The Iroquois/Mohawk Trail, a Native American path between Buffalo and Albany, followed the Mohawk River. The trail is now known as N.Y. 5.[637] Native American trails also existed around the Finger Lakes.[638]

The first roads through the region were constructed in the late 1770s, after the ratification of the Jay Treaty. One of the first roads constructed in Tompkins County was part of a longer route between Oxford in Chenango County to Ithaca. It was constructed in 1791-99, along an old Native American trail (now N.Y. 13).[639] In 1793 the first appropriation was made for improving this road from Old Fort Schuyler to Canandaigua. It became known as the Great Genesee Road and was later called the State Road. Opening of this road greatly stimulated immigration to the area.[640] In southern Seneca County, most new roads were laid out by the town board of Ovid between 1794 and 1800 and followed lot lines laid out by the military.[641]

Turnpikes and other roads were built in western New York State in the early 1800s to connect major settlements or military forts, to facilitate communication, and to aid in the supply of materials to build the Erie Canal. As population increased in the region due to the construction of the Erie Canal, demand for roads also increased.

The Great Western Turnpike (now U.S. 20) was constructed around 1800 between Albany and Buffalo.[642] What are now N.Y. 104 and N.Y. 13 were constructed between 1800 and 1810 to connect Fort Stanwix in Rome to Fort Ontario in Oswego.

In Onondaga County, the county assembly granted a charter to the Seneca Turnpike Company in 1800 to construct a turnpike along the line of the old state road between Utica and Canandaigua. Meant to facilitate communication between the east and west, the road was often not passable because it was so muddy. In 1806 an amendment authorized a branch road from Sullivan to intersect the old line at Cayuga Bridge. This branch road became the principal east-west road. Genesee Street in Syracuse follows the line of this turnpike. The Cherry Valley Turnpike opened in 1803-04 and passed through Cazenovia and Manlius and intersected with the Seneca Turnpike. In 1807 roads were authorized from Onondaga Hill to Ox Creek and then to Oswego, and from Ox Creek to Salina. In 1809 a road from Salina to the town of Cicero was authorized. In 1817 the "Cold Springs Road" was authorized from Liverpool to Seneca River at Cold Springs.

In Tompkins County, the Bath and Jericho Turnpike was constructed in 1804 between Caroline, Dryden, Ithaca, and Enfield along what is now N.Y. 79.[643] In 1810 plans began for a turnpike between Geneva and Ithaca, called the Geneva Turnpike. It followed what is now N.Y. 96 from Ithaca to Happy Landing, the old state road (C.R. 139) to Ovid and then Willard, and then followed the old Sullivan Trail (West Lake Road) to Geneva. However, lake steamboats made it unprofitable. A steamer daily schedule began in 1820 between Ithaca and Cayuga and many preferred the steamboat to road travel. As a result, the Geneva Turnpike became a public highway in 1822.[644]

Plank roads were constructed between Oswego and Rome, and Oswego and Mexico (in Oswego County) in the mid-1800s.[645] Part of what is now U.S. 11 in Onondaga County was constructed as a toll plank road beginning in 1846.[646]

(b) State and U.S. Routes

More direct state roads were constructed in western New York State in the early 1900s. For example, in 1922, N.Y. 20 was practically completed and was the most direct route between Syracuse and Rochester.[647] In 1928 a contract was let for the construction of a road between Andover in Allegheny County and Greenwood in Steuben County that would complete the last link in an important route – N.Y. 417 – between the cities of Olean and Elmira.

In the early 1930s the State Emergency Public Works Commission was created, allowing chairman Moses to pursue his park and parkway plans for the “Niagara Frontier” by establishing the Niagara Frontier Bridge Authority. The authority received $2.8 million in federal funds for bridges that linked the north and south ends of Grand Island, near Buffalo, to the mainland in Erie and Niagara Counties.[648] In 1938 the North and South Grand Island Bridges over the Niagara River were completed and now carry Interstate 190.[649]

The New York State Thruway was constructed in the region in the 1950s. Bridges were also built in connection with the construction of the thruway. They include the 1953 West Henrietta Road Bridge carrying N.Y. 15, south of Rochester over the thruway, and the 1953 bridge over the Onondaga Lake Outlet in the towns of Geddes and Salina (northwest of Syracuse) to carry the thruway itself.

In addition to the thruway, arterial routes and state routes were constructed by the Department of Public Works in the 1950s. In 1957 a north-south arterial route, N.Y. 58, was constructed from Amsterdam in Montgomery County to the Schenectady County line; a north-south arterial highway was constructed between Utica and New Hartford in Oneida County; N.Y. 38 was built from Newark Valley to Berkshire, Richford, and

Hartford Mills in Tioga County; and N.Y. 224 was completed from Montour Falls to Alpine in Schuyler County.[650]

E. Transportation Development in Major Urban Areas

(1) New York City

(a) Early Transportation Routes (1600s to 1800s)

In Manhattan, the primary Native American trail ran along the island's spine from the southern tip of the island to Inwood. Another path, located between Houston and 14th Streets in today's Greenwich Village, led west to the Hudson River. Major trails were also located in present-day Staten Island, the Bronx, and Long Island. These included a trail that followed the present course of Jamaica Avenue through Brooklyn and Queens, and then branched out toward what later became Maspeth, Wallabout Bay, and downtown Brooklyn. The trails of Staten Island connected campsites along the present course of Amboy and Richmond Roads, such as Tottenville, Great Kills Park, and Silver Lake Park. Trails in the Bronx ran along the present Harlem, Bronx, and Hutchinson Rivers.[651]

When the Dutch established New Amsterdam, Governor Edmund Andros ordered that all imported and exported goods pass through the city. Thus, all routes (in the surrounding area that was controlled by the Dutch) led to and from New Amsterdam. The street plan of New Amsterdam (today a New York City Landmark) dates to this period.

In 1691 the (English) Colonial Assembly resolved to regulate all streets, lanes, and alleys, and permitted the municipality to build new thoroughfares as needed. In 1695 the assembly passed an act to appoint overseers of public works and buildings in the city. By the early eighteenth century, roads extending north across Manhattan following the older Native American pathways began to be improved.[652]

King's Bridge, the first bridge connecting Manhattan to the mainland (now the Bronx), was built over the Spuyten Duyvil Creek in 1693. In 1713 it was moved westward to the foot of Marble Hill, and later played an important role in the American Revolution as the main passage from New York City to the mainland.[653]

The Common Council (which governed New York City), through its Streets and Roads standing committee, was attentive to street maintenance because of the importance of streets to the local economy. The most important thoroughfare was Broad Street, which was the city's main commercial street well into the 1700s. Outside the urban area, roads, notably Kingsbridge and Bloomingdale Roads, were maintained by a law requiring residents to do road work 2 days per year.[654]

The Montgomerie Charter (1730) confirmed the existence of a corporate political body and gave the city the exclusive right to lay streets.[655] However, it was not until 1764 that the Common Council created the first "highway department," and streets around important public buildings were paved with cobblestones.[656] Other roads were paved over time, often through assessments on the property of nearby residents. Several roads led to farming villages and small market towns. Among these were Heere Straat (Broad Way), Kings Way (also know as Harlem Lane, Great Post Road or Albany Post Road, now St. Nicholas Avenue), Bowery Lane, Kingsbridge Road (both Bowery Lane and Kingsbridge Road were later part of the Boston Post Road), and Bloomingdale Road. As traffic increased, the roads were enlarged. At the time of the Declaration of Independence, the city had been built up to about Roosevelt Street east of Broadway and Chambers Street and west of Broadway. [657]

In the decade after the Revolutionary War, the area below Division Street was laid out in a regular grid, and the city continued to expand northward in a series of overlapping grids.[658] At the end of the eighteenth century, Broadway and Wall Street were the city's primary commercial thoroughfares and streets had extended up to what is now Houston Street. Broadway, 70 feet wide at its maximum, was graded and connected to the Bloomingdale and Kingsbridge Roads with an arched bridge over Collect Pond.[659] With the exception of ferry service to Brooklyn, transportation connections to areas outside Manhattan remained poor.

In the early nineteenth century, Manhattan remained mostly rural in its northern sections. In 1802 the Common Council directed the paving or turnpiking of the main roads leading in and out of town and the construction of two new Harlem River bridges.[660] In 1815 Roger Macomb built a dam across the Harlem River at what is now 155th Street to create a mill pond. The dam also served as a toll bridge, the first of three on the same site.[661] A bridge across the East River was first proposed to the state legislature in 1802, but was not considered feasible.[662] On Staten Island the Richmond Turnpike (now Victory Boulevard) was constructed in 1817.[663]

In 1807 the legislature created a three-man commission to plot Manhattan's undeveloped land to 155th Street. The Commissioner's Plan was released in March 1811. This plan, also called the Randal Plan after chief engineer Jonathan Randal, Jr., laid out a rectilinear gridiron of avenues that traveled north-south and streets that traveled east-west. Concerned with maximizing saleable real estate, the commission avoided the addition of circles and ovals, although several squares and open places were planned. Major modifications of the grid plan after its adoption were the extension of Broadway's angled course and the construction of Central Park.[664] The Commissioner's Plan remains the city's single most influential planning document, and is largely responsible for steering the city's subsequent transportation infrastructure development.

With the opening of the Erie Canal in 1825, New York began to grow more dramatically. While the lack of bridges hampered expansion beyond the island of Manhattan, development to the north was advanced by innovations in transit. Stagecoaches, the first form of public transportation, were supplemented by horse-drawn omnibuses in 1830 and by horse-drawn streetcars in 1832. New Yorkers moved uptown as new areas moved within downtown commuting range. This resulted in extensive residential development and construction of many of the streets previously outlined by the Commissioner's Plan.

After the Civil War, industrial expansion and population growth caused streets and public transportation to become overloaded. The unprecedented levels of congestion increased commuting times and inhibited the commercial growth of the city.

(b) Other Transportation Networks (1600s-1800s)

Transportation to Manhattan had included ferry service since 1642, when Cornelius Dircksen began a service from what is now Fulton Landing under the Brooklyn Bridge to Fly Market Slip (later Peck's Slip) in Manhattan. The ferry service was a vital link between Long Island and Manhattan and encouraged the growth of a small settlement around the Brooklyn terminus. Connections with the Bronx from Manhattan were limited to wading across the water at low tide until 1669, when a ferry service was established and a bridge was constructed over the meadows to the village of Fordham.[665]

Ferry service from Manhattan to Astoria (now part of Queens) at Hell Gate existed intermittently in the 1760s and 1770s and became regular after the military and civilian traffic generated by the Revolutionary War.[666] Irregular ferry service was also available in other locations around the area, including across the Narrows between Brooklyn and Staten Island. Cornelius Vanderbilt established regular ferry service at the Narrows in 1810.[667] The existence of ferry links concomitantly increased usage of feeder roads, which led to calls for improvements.

Regular steam ferry service was established between Brooklyn and New York City in 1814. The increased speed and reliability of the new ferries stimulated the exchange of goods on a regular and dependable basis and created Brooklyn Heights as a commuter suburb to Manhattan.[668] This led to development in Brooklyn and, eventually, to the transportation demand that created the Brooklyn Bridge. The New York and Erie Railroad, along with the Erie Canal, gave New York City a distinct advantage over other eastern cities in trade and commerce with the west.

The New York and Harlem Railroad, the city's first, was chartered in 1831.[669] Northward expansion of the city paralleled transit improvements as commuting times were shortened. In 1840 the New York and Harlem line crossed the Harlem River and expanded northward into Westchester County. [670]

In the second half of the nineteenth century, the Erie and Hudson Railroad lines sustained New York's advantage in the movement of produce to the East Coast. By 1852 the Hudson, Harlem, and New Haven Railroad lines were carrying 2.5 million people a year into the city. The expansion of the Harlem line and its connection with the New Haven line shortened the commute to Manhattan from the Bronx, Connecticut, and Westchester.

In 1861 the Long Island Rail Road moved its operations to Queens, with its western terminus at Hunter's Point and a rail line that ran directly to Jamaica. A ferry across the East River to East 34th Street was established by the railroad. By the early 1870s, rival rail lines connected the Hunter's Point ferry with Rockaway and Whitestone in Queens, and a turnpike (now Jackson Avenue and Northern Boulevard) had been constructed to Flushing.[671]

On Staten Island, ferry service was improved in 1880 with the unification and consolidation of the rail and ferry services. In 1886 a combined rail and ferry terminal was built at St. George, inaugurating regular service on the storied Staten Island Ferry. Dependable links to Manhattan nearly assured, developers flocked to build on the island.[672]

By the 1880s railroad passengers arriving at the Hudson River shore in New Jersey still boarded ferries to reach Manhattan. Gustav Lindenthal, an Austrian-born civil engineer and bridge designer, made continuing efforts to interest investors in a trans-Hudson bridge. On the other side of Manhattan, the Long Island Rail Road was also transporting its Long Island commuters by ferry across the East River. Austin Corbin, the president of the Long Island Rail Road, pursued a joint plan with the Pennsylvania Railroad for the construction of Hudson River and East River crossings before the economic recession of the mid-1890s scuttled their plans. A decade later, the massive development plan for the new Pennsylvania Station in Manhattan called for the river crossings.

The Pennsylvania Railroad and Long Island Rail Road tunnels opened in 1910 under the Hudson and East Rivers, allowing the Pennsylvania Railroad to cross into Manhattan to its new station and the Long Island Rail Road to do the same from Long Island.

Another important railroad link in the city was provided by the New York Connecting Railroad, organized in 1900 to connect the Bronx to Queens, Manhattan (via the East River tunnel), and Brooklyn. The Hell Gate Bridge, opened in 1917 between Ward's Island and Queens, was the central feature of this railroad.

(c) Parkways

Although Olmsted first introduced parkways in New York City, parkway development was also influenced by two other major builders: William Marcy Tweed and Robert Moses.

In the same period when Olmsted was designing Brooklyn's Prospect Park, Eastern Parkway, and Ocean Parkway (1868-1874), Tweed, the city's most notorious politician, was in power. In 1870 he succeeded in having a new charter passed that placed the city's finances in the hands of four officials – the mayor, the controller, the chairman of the Department of Public Works (Tweed himself), and the chairman of the Parks Department.[673] The newly created Parks Department absorbed the Central Park Commission and had jurisdiction over all public parks and public spaces.[674]

Government during the Tweed regime expended money on public improvements with a lavish hand. Many of the improvements were made under the direction of the Central Park Commission within the Parks Department, to whom the legislature had given duties outside the park itself. The commission adopted a plan of improvement for the west side from 55th to 155th Street. The plan included Riverside Park and Morningside Park.[675] Both these parks were designed by Olmsted. The section of the Riverside Drive viaduct south of St. Clair Place and north of Grant's Tomb is included in the New York City Landmark designation for Riverside Park. Roadways and bridges in Central Park and Riverside Park as well as Prospect Park were also designed by Olmsted.

In the twentieth century, parkways in the New York City metropolitan area differed greatly from Olmsted's version. The changes were primarily related to the use of the automobile rather than horse-drawn carriages. According to Moses, their primary builder, parkways were "narrow shoestring parks" and "represent[ed] to the adjacent residents not only traffic arteries of the most modern kind, but also open space, trees and landscaping, walks and benches for pedestrians and occasional playgrounds and play spaces." Parkway construction was funded by the state and, since the Depression, the federal government. Moses stated that "in locating new parkways great care has been taken to pick the least expensive routes where there are fewest buildings and other obstacles, and where construction costs will not be prohibitive."[676]

In 1936 Moses (in his capacity as the chairman of both the New York City Parks Department and the Long Island Parkway Commission) completed the Grand Central, Laurelton, Interborough (now Jackie Robinson), and Henry Hudson parkways. The Grand Central Parkway in western Queens connected the Triborough Bridge with the Northern State Parkway on Long Island. Part of the Grand Central Parkway between the Triborough Bridge and the future Brooklyn-Queens Expressway would become Interstate 278, the oldest pre-existing section of the Eisenhower Interstate System. The Laurelton Parkway had a 1½-mile-long north-south section in eastern Queens along the border with Nassau County. It connected the Belt Parkway with the Cross Island and Southern State Parkways. The Interborough Parkway opened early in the summer of 1936 and traveled west from Forest Hills in Queens through Forest Park to the Brooklyn border at Jamaica Avenue. The Henry Hudson Parkway ran up the west side of Manhattan through Riverside Park to cross the Harlem River on the Henry Hudson Bridge and join the Mosholu (Bronx) and Saw Mill River (Westchester) Parkways in Van Cortlandt Park, Bronx.

The Belt Parkway was completed in 1941 along the shore of Brooklyn and Queens. The Belt Parkway joined the Cross Island Parkway to the Gowanus Parkway. The Whitestone Parkway between the Bronx-Whitestone Bridge to Northern Boulevard and Flushing Meadow Park was completed in 1939 in time for the New York World's Fair.[677]

The Gowanus Parkway, opened in 1941, was built atop the pillars of the old Brooklyn-Manhattan Transit Corporation Elevated Line on Brooklyn's Third Avenue.[678] Residents of the Sunset Park neighborhood had "pleaded" with Moses to build the parkway along more industrial Second Avenue instead of the prosperous commercial and residential mix of Third Avenue. The parkway was 94 feet wide, forced the destruction of 100 stores and more than 1,000 apartments, and isolated the Red Hook neighborhood from rest of Brooklyn. The Gowanus Parkway was eventually incorporated into the Brooklyn-Queens Expressway as the Gowanus Expressway.[679]

(d) Transportation Agencies and the Regional Plan Association

With the reorganization of the city government under the Tweed Charter in 1870, the Department of Public Works was created and Tweed served as the first commissioner of public works.[680] It assumed the work of the former Croton Aqueduct department and the street department. By 1873 the Department of Public Works was constructing miles of macadamized avenues and substantial streets of at least 50 feet in width.[681] The Department of Public Works existed until the Charter of Greater New York in 1897, when the Board of Public Improvements was created to direct infrastructure improvement after the 1898 consolidation of the city. The board had jurisdiction over the plan for the city of New York and over the departments of water supply, highways, street cleaning, sewers, public buildings, lighting and supplies, and bridges. The charter also provided for the Art Commission, which was given jurisdiction over all works of art to become city property or be placed on city property. Its powers were subsequently broadened to include control over the design of all municipal buildings, bridges, piers, and other structures in the public domain.[682]

In 1901 the Greater New York Charter was amended and the Board of Public Improvements was abolished. Its powers were largely transferred to the presidents of the city's boroughs.[683] Then in 1903 the New York City Improvement Commission was created and prepared a comprehensive plan for the development of the city, including the laying out of streets and highways. Parkways were proposed to connect the parks of different boroughs.[684]

A fully comprehensive regional plan was undertaken for New York City in 1922. The goals of this plan, among others, included the stimulation of transportation planning and construction, particularly highway design, population decentralization, and encouragement of the use of public funds for social purposes. The plan was completed in 1931. Its central thrust was the decentralization of New York, in recognition of the impact of the automobile: "for the first time in history, a city plan placed as much emphasis on highway design as on mass transportation."[685] The plan proposed circumferential rail and road belts to bypass the region's center and inner belts to link the outer boroughs and bypass Manhattan. A series of radiating highways from Manhattan to the outer regions was also included. A private organization, the Regional Plan Association of New York, was formed in 1929 to influence implementation of the regional plan. By 1933 many proposals of the plan had been adopted. Most were for park and road developments that were paid for by Depression-era public spending programs. These projects were executed in large part through the efforts of Moses.[686]

(e) Highways and Expressways

Manhattan's elevated highways were built on the west and east sides of the island in the 1920s and 1930s. West Street, edged by busy docks on the Hudson River, was the main highway for the city's incoming and outgoing ocean freight. Also on the lower west side were some of the city's largest produce markets, as well as numerous warehouses interspersed with tenements. Cross streets experienced heavy traffic bound for the ferries to New Jersey still operating at the ends of Chambers, Barclay, Cortlandt, and Liberty Streets. The elevated West Side (or Miller) Highway was constructed in the 1920s and 1930s to help alleviate waterfront congestion. The 1930s extension of the highway went as far south as Duane Street, and by 1947 the elevated structure continued south to Rector Street.

On the east side, Manhattan borough president Stanley Isaacs directed the construction of the East River Drive (now Franklin Delano Roosevelt Drive, the FDR) from 1938 to 1941. The only major highway project of the era not built by Moses, it began at Grand Street and continued northward along the waterfront to 92nd Street. (Moses would later extend it to connect with his Triborough Bridge, which was then under construction.) The drive was supplemented with recreational facilities of various types along its length.[687]

At the Bronx connection of the Triborough Bridge, Moses built the Major Deegan Expressway (originally N.Y. 1B, now Interstate 87 and an extension to the New York State Thruway). The original Major Deegan was completed in time for the 1939 World's Fair and terminated at the Grand Concourse. From 1950 to 1956, the Major Deegan was extended to the proposed New York State Thruway terminus at the Bronx-Westchester border.[688]

The Harlem River Drive, north of the Triborough Bridge and along the west bank of the Harlem River, was proposed as early as 1937 but not begun until after World War II. It connected 125th Street and the Triborough Bridge to the Harlem River Speedway at 165th Street. The almost complete lack of parks and other amenities along its length brought criticism on Moses.[689]

In the decades after World War II, expressway construction in New York City was the primary road-building effort, and as such, extensively reshaped the urban landscape of the region. The Van Wyck Expressway (now Interstate 678) in Queens was built in the late 1940s and linked the Idlewild (now John F. Kennedy International) Airport to the Grand Central Parkway. This important route provided a north-south conduit through Queens that was open to commercial vehicles.

In Brooklyn, the Prospect Expressway (now N.Y. 27) was completed in 1955. At the same time, the Sheridan and Bruckner Expressways were being built in the Bronx by Moses and were completed by 1961.[690] The Throgs Neck Expressway (Interstate 695) in the Bronx was first proposed in the 1955 joint report of the Port Authority and Triborough Bridge and Tunnel Authority.[691] The Throgs Neck Expressway joined the north side of the Throgs Neck Bridge in the Bronx with the Bruckner Expressway and was less than 2 miles in length.[692]

Other expressway projects began in the late 1950s. The Clearview Expressway in Queens was also first proposed in the 1955 joint report of the two authorities.[693] It ran from the intersection of the Throgs Neck Bridge and the Cross Island Parkway to the Grand Central Parkway in far east Queens and was completed in 1963. The Brooklyn-Queens Expressway was begun by Moses in 1958.[694] The Brooklyn-Queens Expressway entered the interstate system as a section of Interstate 278. The Cross-Bronx Expressway, a 7-mile highway running east-west through the Bronx, was also built by Moses. The Cross-Bronx Expressway was completed in 1963 and connected with the Trans-Manhattan Expressway in Manhattan over the contemporaneously built Alexander Hamilton Bridge. The Cross-Bronx Expressway became part of Interstate 95.

The Trans-Manhattan Expressway (now part of Interstate 95), which connected the George Washington Bridge with the Cross-Bronx Expressway across Washington Heights, was built from 1958-62. Originally, the 178th Street and 179th Street tunnels (built in 1949) had spanned the distance.[695]

On Staten Island, Moses built the Staten Island Expressway (Interstate 278). Construction began in 1959 and the expressway was completed in 1964 to connect with the Verrazano-Narrows Bridge completed in the same year.

(f) Bridge Agencies and Authorities

Department of Bridges

With the charter of 1897, responsibility for the construction of New York City bridges was established in the Department of Bridges (under the Board of Public Improvement) and continued under the Department of Bridges in the revised charter of 1901. In 1916 the Department of Plant and Structures assumed responsibility, and was in turn replaced by the newly formed Department of Public Works in 1938. The Department of Public Works worked with the Triborough Bridge and Tunnel Authority under Moses throughout much of the twentieth century. The Department of Public Works was consolidated into the New York City Department of Transportation in 1965.

The number of connections between Manhattan and the Bronx and between Manhattan and Brooklyn and Queens increased as projects were undertaken by these city agencies during the first part of the twentieth century. The Willis Avenue Bridge opened in 1901 across the Harlem River at Bronx Kill and connected First Avenue and 125th Street in Manhattan with Willis Avenue and 132nd Street in the Bronx. It was intended to relieve traffic on the earlier Third Avenue Bridge.[696] Two other Harlem River bridges, the 145th Street Bridge (linking 145th Street in Manhattan and 149th Street in the Bronx) and the University Heights Bridge (linking 207th Street in Manhattan and Fordham Road in the Bronx), were built in 1905 and 1908, respectively.[697] The Manhattan Bridge, completed in 1909 between Canal Street in Manhattan and Flatbush Avenue in Brooklyn, was the third East River crossing. The Queensboro Bridge, the fourth East River crossing, opened in 1910 and was the first road link between Queens and Manhattan. It connected 59th Street in Manhattan to Queens Plaza. The bridge initiated a period of great expansion for largely rural Queens County and was built as a symbol of New York City's recent consolidation.[698]

Triborough Bridge Authority

The Triborough Bridge Authority (later the Triborough Bridge and Tunnel Authority) was formed by the state at the request of Mayor John P. O'Brien in 1933, who had been urged to do so by Moses. The legislature authorized the Triborough Bridge Authority to issue its own bonds, which were to be secured by toll revenues, and made the Triborough Bridge Authority eligible for aid from the newly formed Federal Public Works Administration.[699] Originally formed for the sole purpose of building the Triborough Bridge, the Triborough Bridge Authority under Moses's guidance became responsible for financing, constructing, and maintaining new bridges and tunnels in all of New York City.[700]

The Triborough Bridge, which opened in 1936, was actually four bridges combined, with 13,500 feet of viaducts linking three boroughs (Manhattan, Queens, and the Bronx) and two islands (Ward's and Randall's). Until the Bronx-Whitestone Bridge was opened in 1939, the Triborough Bridge was the only vehicular connection between Queens and the Bronx. Moses extended the East River Drive to Harlem in 1953 to serve as the Manhattan approach to the Triborough Bridge.

The Bronx-Whitestone Bridge, connecting Queens and the Bronx over the East River, opened in 1939. (It now carries Interstate 678.) It provided a direct link between the parkway system of Westchester and Connecticut and the Long Island parkways.[701] Its planning began in 1935 to ensure completion for the 1939 World's Fair.[702]

The Henry Hudson Bridge, connecting the northern tip of Manhattan with Spuyten Duyvil in the Bronx, was constructed by the Henry Hudson Parkway Authority in 1936 to carry N.Y. 9A over the Harlem River. The Henry Hudson Parkway Authority was absorbed into the Triborough Bridge Authority in 1940.

The Marine Parkway Bridge was completed by the Marine Parkway Authority (part of the Triborough Bridge Authority by 1940) in 1937. It crosses Rockaway Inlet, connecting Brooklyn with the Rockaway Peninsula in Queens (which could previously be reached only by ferry or by a circuitous route around the eastern end of Jamaica Bay). It made the residential and recreational development of the Rockaway Peninsula possible, including the development of Jacob Riis Park, and tied the Rockaways to the rest of New York City.

Also built by the New York City Tunnel Authority and completed in 1950, the Brooklyn-Battery Tunnel was the longest underwater vehicular tunnel in the Western Hemisphere.[703] It connected West Street (N.Y. 9A) in Manhattan to Hamilton Avenue in Brooklyn. Moses had planned the connection to be a bridge under the control of his Triborough Bridge Authority, but President Roosevelt's directions to the war department in 1939 led to the tunnel. The Tunnel Authority's victory was short-lived, however, as

Moses prevailed upon La Guardia to merge the Tunnel Authority with the Triborough Bridge Authority, forming the powerful Triborough Bridge and Tunnel Authority in 1945.[704]

The Port Authority-Triborough program, announced jointly by the Port Authority and the Triborough Bridge and Tunnel Authority in January 1955, had the basic purpose of serving the rapidly growing trans-metropolitan vehicular traffic. Its new trans-Hudson, upper New York Bay, and East River facilities would facilitate movements of local traffic and permit through traffic to move through and around Manhattan's congested areas. The first joint report of the two authorities in 1955 noted a marked increase in auto ownership and use of trucks and buses and suggested accelerated planning of arterial highways. The program also included the construction of the Narrows Bridge between Fort Hamilton in Brooklyn and Fort Wadsworth in Staten Island, the Throgs Neck Bridge across the East River from Cryders Point in Queens to Fort Schuyler in the Bronx, and the addition of a lower deck to the George Washington Bridge. The extensive connecting highways beyond the immediate approaches to these new bridges were all part of the interstate system and were financed by the state and federal governments.[705]

The Throgs Neck Bridge, first opened to traffic on January 11, 1961, was considered a key link in the interstate system. The bridge connects the Bruckner Expressway in the Bronx to the Clearview Expressway in Queens, carrying Interstate 295 across the East River.[706]

The Verrazano-Narrows Bridge was considered by the Triborough Bridge and Tunnel Authority and Moses to be the most important link in the highway system between Boston and Washington. It carried Interstate 278 over the Narrows between Brooklyn and Staten Island. The Narrows crossing was first attempted in 1921 as a tunnel. After $7 million was spent by the city, work stopped in 1923 and the project was abandoned by 1932, leaving only four excavations in Brooklyn and Staten Island as evidence.[707] The 1955 joint report published by the Triborough Bridge and Tunnel Authority and the Port Authority recommended proceeding with construction of the bridge which was completed in 1964.

(2) Other Major Urban Areas

(a) Albany

Early Roads

Native American trails running north and south along the Hudson River Valley and east and west between Massachusetts and the Niagara Falls area crossed near the confluence of the Hudson and Mohawk Rivers.[708] The Dutch established Fort Nassau in 1614 and then Fort Orange in 1624 at this location. Fort Orange was renamed Beverwyck in 1652 and Beverwyck became Albany in 1664. Subsequent development was largely related to its location at the intersection of the Hudson River, the major north-south transportation corridor in New York, with the Mohawk River part of the corridor that would facilitate trade and settlement in the western part of the state and the country.

Trade with New York City 150 miles to the south brought Albany stable prosperity during its first century.[709] Businesses catering to shipping interests thrived. By 1786, 3 years after the American Revolution, Albany had become the sixth largest city in the United States.[710] In 1797 the state capital was moved from New York City to Albany. Albany became a more important destination for New Yorkers who were part of the state government or who had business with the state government. Not surprisingly, more transportation routes would lead to Albany after 1797. Albany became the destination of most of New York State's major turnpikes and a popular conduit to the west, as New Englanders sought to relocate to the fertile fields of the Midwest. Central Avenue (formerly the Bowery) was the starting point of the "Pioneer Route," where travelers heading west in ox carts and horse-drawn caravans assembled. The Old Loudon Road (U.S. 9 at Boght Corners) was named after Earl Loudon in 1756 and was the route of the British and American armies to Montreal. Traffic into the interior of New York State and the growing settlements at Utica, Syracuse, and Rochester, among others, accounted for a large portion of road use in the Albany area. Passenger-travel south to New York City was a 2-day stagecoach ride along the rutted post road and cost an exorbitant $7.25.[711]

Commercial and residential development in Albany began to move westward along these turnpikes leading west. The turnpikes, which were most prominent in the first half of the nineteenth century, would serve to connect Albany to the west and – as one historian notes – make the city a "significant emporium of westward expansion."[712]

The Western Turnpike (also referred to as the Great Western Turnpike, now Western Avenue) ran westward from Albany, through Guilderland and toward the village of Auburn. It was planked in 1849 and its toll gates were maintained until 1906. Schenectady could be reached on the Albany & Schenectady Turnpike, which entered Albany from the northwest and connected with Bowery Street (now Central Avenue).[713] The Albany and Delaware Turnpike, chartered in March 1804, ran from Albany to Otego. Albany's sister cities, Schenectady and Troy, were connected with the Troy Turnpike. To the south, the old Albany Post Road and the Highland Turnpike, both on the east side of the Hudson River, linked Albany with New York City. The emerging roads allowed Albany to prosper economically by tending to the feeding, lodging, and supply needs of westward travelers. Albany's unique combination of a good river and good roads in the early nineteenth century gave it a distinct advantage over competing cities.[714]

In 1807 Robert Fulton and his steamboat *Clermont* traveled from New York City to Albany for the first time, and by 1825 there were 11 steamboats making regular runs to New York City. The Erie Canal connected Albany with Lake Erie in the same year. Railroad development was not far behind. In 1830 Stephen Van Rensselaer, the largest landholder in New York State, built the nation's first steam-powered railroad, the Mohawk & Hudson Railroad, which connected Albany and Schenectady.[715] The first railroad connection to Boston, only a ferry ride across the Hudson River at Greenbush, was opened in 1840. In the next decade, the Hudson River Railroad, the Albany and Vermont Railroad, and the Albany and Susquehanna Railroad lines also debuted.

A passenger bridge was built across the Hudson River in 1882, as the population of Albany exceeded 90,000. In the last decade of the nineteenth century, Albany's streetcars were electrified, streets were beginning to be paved with asphalt, and two viaducts were built over the Sheridan Avenue ravine. One of these was the Hawk Street Viaduct, which was built by the Hilton Bridge Construction Company and crossed Sheridan Hollow.[716]

Twentieth Century Roads

The automobile arrived in Albany with the beginning of the twentieth century. By 1910 increased use of the automobile prompted demand for better roads. Concrete pavement appeared on Albany's streets in response to greater load demands. The local highway network at the time featured four main "macadam highways improved by the state," according to the 1911 county map.[717]

In 1922 Mayor William S. Hackett appointed a city planning commission to consider extending city streets and purchasing land for new boulevards. Two years later, Albany's first zoning regulations were approved. Traffic lights were installed in 1927. By the late 1920s, the availability of automobile and bus transportation, in combination with improved roads throughout the Albany area, made commuting an attractive option for many residents.[718]

In 1925 Governor Al Smith formed the Albany Port District Commission. The $10 million Albany Port District Project was completed in 1932 and included wharves, sheds and the world's largest single-unit grain elevator at the time. The district was linked to the railroads as well as the New York State Barge Canal System. However, at the same time the increased transfer of commercial use from railroads to trucks continued to drive the improvement and expansion of Albany's roads. By 1933, N.Y. 9W, 9, 9J, and 4 were designated in the Albany area.

Freeways came to Albany almost immediately after World War II. The city began planning studies for the "Albany waterfront arterial highway," a conceptual forerunner of Interstate 787. The consultant's report noted existing state arterial highways as U.S. 20 (Western Avenue) to Syracuse, N.Y. 5 (Central Avenue) to Schenectady, U.S. 9

(Loudonville Road) to Saratoga Springs, N.Y. 85 (Slingerland Road) to N.Y. 43, N.Y. 43 (Delaware Avenue) to Clarkeville, N.Y. 9W (Southern Boulevard) to Catskill and New York City, Dunn Bridge to N.Y. 9 (to New York City) and to U.S. 20 (Pittsfield), N.Y. 2 (a portion of Broadway) to Troy, and N.Y. 32 (another portion of Broadway) to Cohoes.[719]

The New York State Thruway arrived in the Albany area in 1956 and the Adirondack Northway (Interstate 87) from Albany to the Canadian border, including the bridge over the Mohawk River near Dunsbach Ferry, was built in 1960.[720]

(b) Syracuse

Early Roads

The first European settlers and a trading post arrived in the area in 1786 after salt water springs were discovered at the head of Onondaga Lake. The first land chosen for development was hilly and the first roads were hill roads. The first road through what became Onondaga County, called the Wadsworth Road, was constructed in 1790-91 by pioneers traveling west. Low-lying areas near the original settlement were swampy, with some of the early valley roads often becoming impassable in the summer months. The population grew and Onondaga County was created in 1794.[721]

The salt springs near what would become Syracuse attracted settlers to Onondaga County, and all roads in the county eventually led to the salt springs. The county’s first public road was built in 1796 in Salt Point.[722] The salt springs continued to attract settlers in the first part of the nineteenth century. In 1804 the Genesee and Syracuse Turnpike from Manlius around the hills to the west edge of the salt reservation was built by James Geddes, who lived near the salt springs and sold a 250-acre parcel of land with a mill to secure the road-building capital.

The land that Geddes sold became Syracuse. The most important structure in town was a bridge across the Onondaga Creek.[723] In 1819, having reached a population of 250, the village was named Corinth, a name which was promptly changed because another post office in the state had already taken it. In 1820, the year the western section of the Erie Canal to Buffalo was completed, the area was renamed Syracuse.[724]

Genesee Street connected with the Seneca Turnpike by 1825. Lodi Street was constructed in 1826 from the Erie Canal to Salina along sections of an old Native American trail. In 1835 Salina Street became the first paved street in Syracuse. One year later, the first bridge across the Erie Canal in Syracuse was built at Willow Street.[725] In 1839 Lemon Street (later Forman Avenue) and Irving Street were designated as public highways. Water Street was formally opened as a highway in 1841, and Geddes Street was turnpiked in the same year. Two years later the Town of Salina (part of Syracuse since 1847) eliminated the office of overseer of highways and created a street commissioner.[726]

Four plank roads served Syracuse by the mid-nineteenth century. The Brewerton plank road (U.S. 11), first proposed in 1844, ran to the north through Podunk (now North Syracuse), Cicero, Brewerton, Central Square, and Colloss to Union Square. A second northbound plank road (N.Y. 370) ran to Liverpool and then split into two branches – one to Baldwinsville and the other to Euclid (now called Morgan Road). A third plank road (N.Y. 298) ran northwest to Bridgeport. A southbound plank road split into two branches at what is now Nedrow City – one branch (N.Y. 11A) running past the council house of the Indian Reservation and following Onondaga Creek through Cardiff and Tully Valley to Tully, and the other branch (U.S. 11), an unimproved road running through Lafayette (now La Fayette) to Tully. Several other unimproved roads were noted on period maps.[727]

In 1849 Syracuse city aldermen proposed using plank roads in the town in lieu of pavement. An experimental section was completed from the southern end of the Brewerton plank road to the Oswego Canal, but it was discarded when heavy traffic proved the inadequacy of lumber as a paving material.[728]

Genesee Street became the business center of Syracuse by the second half of the nineteenth century.[729] In 1868 Nicholson pavement saw its first use in Syracuse. That same year, the Salina Street Bridge, the first bridge built over the Erie Canal, fell. A new swing bridge replaced it in 1874.[730]

Twentieth Century Roads

The dawn of automobile use in the twentieth century brought highway improvements to Onondaga County. By 1911 the highways through Camillus (N.Y. 5) and to Marcellus and Clintonville (N.Y. 174) were fully improved. Sections of the roads to Collamer (now N.Y. 298), Maycenae (N.Y. 290), and Tully (U.S. 11) were also improved. Many other roads were "under contract" and "designated for future improvement," reflecting the unprecedented road-building efforts of the times.

State highways were numbered for the first time in the mid-1920s. A County Department of Highways map differentiating state highways, county highways, county roads, and town roads appeared in 1927. Major routes were N.Y. 2 to Tully, N.Y. 5 to Elbridge, N.Y. 20 to Oswego (now marked as "Old Route"), N.Y. 2 through North Syracuse to Waterstown, and N.Y. 5 through Fayetteville to Utica. County highways include N.Y. 3 to Baldwinsville and Plainville (now N.Y. 370), a highway through South Onondaga now (N.Y. 80) to Tully, a highway to Fabius (now N.Y. 91), N.Y. 7 to Albany via Cherry Valley, and a highway to Bridgeport (now N.Y. 298). County roads included today's N.Y. 173, and many others.[731] Canal use had declined so substantially that 100 years after its creation, the bed of the Erie Canal in Syracuse began to be filled. Trains on the Syracuse streets were elevated in 1936.[732]

The thruway was built just north of Syracuse in the 1950s.

(c) Rochester

Early Roads

As was the case for Syracuse, the growth of Rochester was largely a result of its location on the path of the Erie Canal and later the New York Central Railroad. The mountainous regions in the Finger Lakes area to the south meant that the earliest and most important lines of communication across the state were in the vicinity of the south shore of Lake Ontario.[733]

The earliest development in Rochester was in 1789 when Ebenezer Allen built a mill on a 100-acre tract of land on the west bank of the Genesee River, just south of the current Main Street Bridge.[734] In 1802 Colonel Nathaniel Rochester and his partners purchased Allen's land. By 1812 it was surveyed and divided into village lots. The first bridge, at the site of the present Main Street Bridge, was built across the river that year. This bridge connected a road from Niagara and Lewiston along what is now Ridge Road with a new road to Canandaigua, where it joined the Genesee Turnpike. After the completion of this first bridge, Rochester began a steady growth cycle which continued for the next century and a half.[735] The village was incorporated as Rochesterville in 1817 and the name was shortened to Rochester in 1822. The Erie Canal was built through Rochester in 1824. Along its route through Rochester there were two bridges and one aqueduct.

An 1826 map showed a road northward to Charlotte (on Lake Ontario), roughly following the west bank of the Genesee River. On the east bank there was a road to Carthage, which then ran eastward, later becoming East Ridge Road. It also showed a bridge across the Genesee River at Carthage, just south of the falls. South of Rochester, there were also roads along both sides of the Genesee River. The road on the west was labeled Ridge Road (now West Ridge Road). It began at Charlotte Road in the area of Hanford's Landing and ran west, north of the Erie Canal, through Parma and Clarkson and to points west.[736]

By the mid-nineteenth century, an early road network had been developed in Rochester. The Buffalo Road (now N.Y. 33) ran west through North Chili and Churchville to Buffalo. South of Rochester, two important plank roads were developed. The Rochester and West Henrietta Plank Road (now N.Y. 15) ran south to West Henrietta (just south of the current New York State Thruway). Roughly parallel and about 2 to 3 miles east, the Rochester and Hemlock Lake Plank Road ran south through Henrietta to Hemlock Lake, one of the Finger Lakes. The State Road (now N.Y. 31) came into Rochester from the east through Fairport. Another road called "The State Road" (now N.Y. 404) ran west from West Webster, south of the Ridge Road, and east of Irondequoit Bay.[737]

The immediate future of Rochester's transportation infrastructure development, like so many other towns statewide, was in railroads. By 1852, five railroad lines served the growing town, providing long-range transportation needs. In 1853 some of lines became part of the New York Central Railroad system.[738] The canal network had also been modestly expanded with the Genesee Valley Canal running southward on the west side of the Genesee River, but the railroad was to eclipse the canal as the prime economic force in the city. Street construction in Rochester was spurred by the existence of both.

Twentieth Century Roads

Some of the early roads had changed names by the early twentieth century. The Rochester and West Henrietta Plank Road had become Mt. Hope Avenue. The road from Rochester to Pittsford had become Monroe Street. The State Road to Fairport (through Brighton) had become East Avenue.[739] The rise of automobile use, as in other areas of the state, led to the expansion and improvement of county and state highways. In Monroe County, most of the older roads, including Ridge Road, were improved highways by 1911. The remainder of the road network was a patchwork of sections that were already improved, were under contract for future improvement, or were designated for future improvement.[740]

The New York Barge Canal System, a series of improvements to the Erie Canal completed around 1910-13, made the section of the Erie Canal through downtown Rochester obsolete. This section was eliminated in the 1920s.[741]

By the 1920s Rochester was the third most populous city in the state.[742] East Avenue was a main route through the city.[743] Rochester benefitted by its proximity to major east-west routes. While the main highway across western New York (U.S. 20, also N.Y. 5) ran south of the city, another road, N.Y. 31, ran close to the shore of Lake Ontario, east from Buffalo over the historic Ridge Road (known as the Million Dollar Highway in the 1920s) through Rochester and Oswego and then north through Watertown to the Thousand Islands, the Adirondacks, Lake Champlain, and Canada. About this time, the Erie Canal aqueduct was converted to use as a highway bridge.[744]

The first section of the New York State Thruway was completed from Rochester to Lowell (in Onondaga County) in June 1954. The Rochester to Buffalo section was completed in August 1954. The Ontario Parkway from Hamlin State Park to Charlotte Road was built by 1960.

(d) Buffalo

Early Roads

Located south of Niagara Falls at the northeast corner of Lake Erie, the area that would become Buffalo was as far from the Dutch settlement at New Amsterdam as possible. However, it was on the route of the French explorers who came down the St. Lawrence River to Lake Ontario and Lake Erie. When the Seven Years War broke out, Fort Niagara belonged to the French. Four years later, in 1759, the British took Fort Niagara.

The Holland Land Company purchased much of New York west of the Genesee River to the east, Lake Ontario to the north, the Niagara River and Lake Erie to the west, and Pennsylvania to the south. From 1797 to 1804, the company had the village of Buffalo surveyed by Joseph Ellicott, whose brother Andrew had assisted in the planning of Washington, D.C. Buffalo's street plan shared Washington's dominant feature: wide avenues emanating from a center point marked with public circles and squares.[745]

Buffalo became a town in February 1810, but grew slowly because of its remote location. The War of 1812 brought some military occupation, but the village suffered from vast destruction at the hands of the British and Native Americans. Erie County was formed out of Niagara County in 1821 and Buffalo was established as the county seat. Buffalo's slow development pattern changed with the opening of the Erie Canal, which initiated explosive growth. Buffalo was transformed from a frontier village to a vital city contributing to the state's economy. As Albany became a conduit for westward bound immigrants and travelers, Buffalo also prospered from its role in providing food and other goods to those passing by.[746]

As early as 1834, horse-drawn rail vehicles appeared in Buffalo. The first chartered steam railroad in the area was the Buffalo and Niagara Falls, which began operation in 1836. Seven years later, a railroad to Attica connected Buffalo with Albany through a series of small lines.[747] By the mid-nineteenth century, the Erie Canal would be supplemented by what would become the New York Central Railroad, linking Buffalo to New York City. Several other railroad lines served Buffalo from various directions.

Road development was well advanced by 1850. The Hamburgh Turnpike Road (now N.Y. 5) ran south along Lake Erie towards Erie, Pennsylvania. Also known as the Buffalo-Erie Road, this was the only route from the west into New York State as late as the 1930s and was as busy as the Boston Post Road in New York City.[748] Another route, the Military Road, ran north to Tonawanda and the vicinity of Niagara Falls. A plank road (now N.Y. 354) began southeast of Buffalo in the town of Lower Ebenezer and then ran east through Marilla. Buffalo's Main Street extended northeast to the towns of Williamsville, Harris Hill, and Clarence. Many other unnamed local roads served Buffalo from all directions, most of which would eventually be improved as state and county highways in the early twentieth century.[749] Walden Street, now Fillmore Avenue, was already a major north-south artery in Buffalo by mid-century. Ellicott Turnpike (now Kensington Avenue) branched to the northeast from Main Street at Forest Avenue. White's Corners Plank Road (now U.S. 62) ran due south from Abbott Street (now Southside Park Avenue South and South Abbott Road). Abbott Street itself continued in a southeasterly direction as Potter's Corner's Plank Road (now simply Potter's Road or N.Y. 16 in Buffalo, then N.Y. 240 to Orchard Park) to Webster's Corners and Orchard Park. A second Main Street and Aurora Plank Road (now N.Y. 16 and 78) ran southeast through Spring Brook to east Aurora. Two toll bridges were built over the Buffalo River on what is now Ohio Street near Lake Erie and on South Abbott Road, approximately 1 mile to the east.[750] Regular ferry service to Canada across the Niagara River in the vicinity of the later Peace Bridge was established around the time of the Civil War.[751]

Despite a large and dense rail network with at least 15 distinct lines, the increasing demands on the transportation system required continued improvements to the streets in the built-up sections of Buffalo, many of which already had asphalt pavement by the early 1890s.[752] Ellicott Turnpike had become Kensington Avenue within the Buffalo city limits. Hamburg Turnpike to West Hamburg and Erie, Pennsylvania, had similarly been renamed as Lake Shore Road (now Fuhrmann Boulevard and N.Y. 5).

In the 1890s Walden Avenue (now N.Y. 130) ran through Forks to Lancaster. The present N.Y. 354 roughly followed what was Mineral Spring Road to Elma, and the International Bridge at Buffalo over the Niagara River had been built.[753]

Parkways

The post-Civil War era in Buffalo featured a significant development in the parks and parkways system. Designed by Olmsted, work on the parks and parkways began in 1868 and lasted into the 1890s. Olmsted's design for Buffalo consisted of three parks – the Park, the Front (now Front Park), and the Parade (a military drill ground redesigned by Olmsted as Humboldt Park in 1896, now Martin Luther King, Jr. Park.) – connected by broad parkways. The original parkways designed by Olmsted were the Humboldt Parkway, the Lincoln Parkway, the Bidwell Parkway, the Chapin Parkway, the Avenue (now Richmond Avenue), Porter Avenue, and Fillmore Avenue.[754] The Humboldt Parkway section (now the Kensington Expressway north of Best Street) ran from what is now Delaware Park to the parade grounds on Best Street.[755]

Twentieth Century Roads

During the first half of the twentieth century, more than 30 different automobile companies manufactured cars in Buffalo, including the noted Pierce-Arrow by George N. Pierce, a prominent local bicycle manufacturer at the end of the nineteenth century.[756] The response to increased automobile usage, as in other areas, began to direct attention away from rail-based transport and toward road construction and improvement. The

Main Road (now N.Y. 5) north and east of Buffalo ran through Clarence as an improved highway by 1910. Other improved highways by this time were White's Road straight south to Hamburg (now U.S. 62), Hamburg and North Collins Road southwest from Hamburg (also now U.S. 62), a road from Hamburg to Springerville following Eighteen Mile Creek, Aurora State Road (now N.Y. 16) to Aurora, Clinton Street (now N.Y. 354) through New Ebenezer, New Home Road from Main Street to the north through Getzville, Transit Road, and Niagara River Road to Tonawanda. Many other unnamed roadways serving Buffalo were "under contract for improvement" and "approved and designated for future improvement" in the manner of counties across New York State.[757]

In 1952 the Erie County Planning Board published a map showing proposed parkways and expressways for the Buffalo metropolitan area. Roads included: Boston Hills Expressway (now U.S. 219 from Interstate 90 to Springville), the Erie Thruway/Expressway (New York State Thruway from Exit 50 on Interstate 90 to the Pennsylvania state line), the Ontario Thruway (New York State Thruway from Exit 50 to the east, called Interstate 90), Aurora Expressway (now N.Y. 400), an unnamed expressway along the shore (perhaps part of the unbuilt Outer Belt Parkway, which exists in part as N.Y. 5), the Niagara Thruway (New York State Thruway Interstate 190 over the Peace Bridge and Queen Elizabeth Way into Canada), and the Powerline Expressway (now Interstate 290, Youngman Memorial Expressway).

5. Conclusion

A. Project Scope

The Historic Bridge Inventory and Management Plan is intended to simplify NYSDOT's treatment of its population of nearly 11,000 pre-1961 bridges. The completion of this effort will eliminate the need for case-by-case review of individual bridge rehabilitation and replacement projects. Currently, NYSDOT reviews bridge projects individually for compliance with Section 106 of the National Historic Preservation Act and Section 14.09 of Chapter 36B, New York State Consolidated Laws. Consultation with preservation agencies and interested members of the public and development of management strategies, as required to comply with these regulations, can take NYSDOT a year or more.

NYSDOT initiated the Historic Bridge Inventory and Management Plan project to streamline its efforts in rehabilitating and replacing pre-1961 bridges. The project involves four principle steps:

1. Develop a contextual study for historic bridges in New York State.

2. Prepare a methodology for inventorying New York's pre-1961 bridges and criteria for determining which bridges are eligible for listing in the National Register of Historic Places.

3. Conduct an inventory, including field survey, to identify historic bridges and make recommendations for inclusion in the National Register of Historic Places.

4. Prepare a management plan for state and locally owned historic bridges.

The Historic Bridge Inventory and Management Plan's overall objective is to identify, categorize, and prioritize historic bridges; it does not involve any engineering analysis of the structural condition of studied bridges. With the conclusion of this effort, NYSDOT will be better able to meet its obligation to take into account the effects of agency-sponsored rehabilitation and replacement projects on eligible and listed bridges statewide.

B. Contextual Study Objectives

The contextual study concludes step one of the project. This study lays the foundation for the development of criteria that will be used to select bridges for field inventory and provides the background for subsequent evaluation of the eligibility of bridges for the National Register of Historic Places. Chapter 2 – *History of Bridge Engineering in the United States* – will facilitate the application of Criterion C for significance in the area of engineering. The historic context established in Chapter 3 – *History of Bridge Design and Construction in New York State* – contributes to the assessment of bridges' eligibility under three criteria: Criterion A for significance in transportation, Criterion B for an association with significant persons, and Criterion C for representing the work of a master or a period of construction. Chapter 4 – *Development of New York's Transportation Networks* – will contribute to the determination of bridges' eligibility under Criterion A for significance in the areas of settlement or transportation.

C. Subsequent Steps

In step two, a methodology for stratifying and subsequently inventorying bridges will be developed. This methodology will include a list of bridge categories and an explanation of the level and kind of data that will need to be collected to evaluate the eligibility of bridges in each category. The entire bridge population will be stratified into appropriate categories. Categories are expected to be informed by historic events, trends and innovations in bridge design and materials, developments in transportation, and activities of prominent individuals and companies disclosed in the contextual study.

Mead & Hunt will also prepare recommendations for evaluation criteria, based on the State and National Register Criteria, to be applied to surveyed bridges. The bridge evaluation criteria will be developed using the contextual study's framework for understanding the historic and engineering significance of New York's bridges. The methodology for inventorying bridges and bridge evaluation criteria will be the products of this second step.

The third step of the project involves inventorying New York's historic bridges. Up to 2,100 bridges will be selected for field survey. Bridges will be selected for field survey based on the potential significance of the category to which they belong. One category for consideration will be bridges that are recognized components of potential historic districts. Surveyors will document selected bridges with photographs and a survey form. After collected data has been analyzed, bridges will be evaluated for National Register-eligibility. A Historic Bridge Inventory Database will be developed to record survey results.

In step four, a management plan will be prepared to establish practices, which are consistent with the needs of transportation and preservation, that the NYSDOT can apply to its eligible and listed bridges. Management practices will be based on engineering feasibility, cost, and preservation value. The management plan will build upon lessons learned from other state transportation agencies and will draw upon input provided by NYSDOT, Federal Highway Administration, and State Historic Preservation Office staff.

D. Expected Results

The Historic Bridge Inventory and Management Plan project is expected to streamline NYSDOT's efforts in rehabilitating and replacing pre-1961 bridges. Its products will allow NYSDOT to be pro-active and will greatly reduce the need for case-by-case review of individual bridge rehabilitation and replacement projects for compliance with Section 106 and Section 14.09. At the earliest stage of planning for its projects, NYSDOT will know which bridges are eligible for the National Register of Historic Places and which are not. When an eligible bridge will be affected, NYSDOT will be able to seek input from preservation agencies and interested members of the public at an early stage in project development. The management plan will recommend management practices for state and locally owned eligible and listed bridges, simplifying NYSDOT's consideration of alternatives for an individual project.

6. Bibliography

A. Bridges – General

Ashton, Ned L. “First Welded Aluminum Girder Bridge Spans Interstate Highway in Iowa.” Civil Engineering, 28 (October 1958), 79-80.

Berlow, Lawrence H. The Reference Guide to Famous Engineering Landmarks of the World. Phoenix, Ariz.: Oryx, 1998.

Billings, Henry. Bridges. New York: Viking Press, 1956.

Billington, David P. “Building Bridges: Perspectives on Recent Engineering” in Margaret Latimer, Brooke Hindle, and Melvin Kranzberg, eds. Bridge to the Future: A Centennial Celebration of the Brooklyn Bridge. New York: New York Academy of Sciences, 1984.

Burroughs, Edward A. “Fifty-Year Development Construction of Steel Girder Bridges,” Journal of the Construction Division, American Society of Civil Engineers. 101:C03 (September 1975): 463-475.

California State Highway Transportation Agency. Manual of Bridge Design Practice. State of California, 1965.

Chettoe, C.S. and Haddon C. Adams. Reinforced Concrete Bridge Design. 2nd. ed. London: Chapman & Hall, Ltd., 1946.

Condit, Carl W. American Building: Materials and Techniques From the First Colonial Settlements to the Present. Chicago: The University of Chicago Press, 1968.

Darnell, Victor C. A Directory of American Bridge-Building Companies 1840-1900. Washington, D.C.: Society for Industrial Archaeology, 1984.

Darnell, Victor. “Lenticular Bridges from East Berlin, Connecticut.” IA: The Journal of the Society for Industrial Archeology, 5:1 (1979),19-32.

DeLony, Eric. “The Golden Age of the Iron Bridge.” Invention and Technology (Fall 1994).

Dwyer, James D. “Fifty-Year Development: Construction of Steel Suspension Bridges.” Journal of the Construction Division, American Society of Civil Engineers, 101:C01 (March 1975), 105-125.

Evans, L.T. "Vierendeel Girder Bridge Introduced in America." Engineering News-Record, 117 (October 1, 1936), 471-72.

Finch, J.K. "A Hundred Years of American Civil Engineering." Transactions of the American Society of Civil Engineers, Volume CT (1953), 28-96.

Fish, Gilbert Dudley. Arc-welded Steel Frame Structures. New York: McGraw-Hill Book Company, Inc., 1933.

Gies, Joseph. Bridges and Men. London: Cassell & Company, 1963.

Gimsing, Niels J. Cable Supported Brides: Concept and Design. 3rd. ed. New York: John Wiley & Sons, 1998.

Hardesty, Egbert R., Henry W. Fischer, and Richard W. Christie. "Fifty-Year History of Movable Bridge Construction - Part I." Journal of the Construction Division, American Society for Civil Engineers, 101:C03 (September 1975), 511-527.

Hardesty, Egbert R., Henry W. Fischer, and Richard W. Christie. "Fifty-Year History of Movable Bridge Construction - Part II." Journal of the Construction Division, American Society for Civil Engineers, 101:C03 (September 1975), 529-543.

"The Hell Gate Steel Arch Bridge." Engineering News, 71:2 (January 8, 1914), 59-64.

Historic American Engineering Record, National Park Service. Trusses. Poster, HAER T1-1. Delineated by Arnold David Jones, 1976.

Hollingsworth, William F. "Fifty-Year Development: Construction of Steel Arch Bridges." Journal of the Construction Division, American Society of Civil Engineers, 101:C01 (March 1975), 85-103.

Jackson, Donald L. Great American Bridges and Dams. Great American Places Series, Preservation Press, 1988.

Jacobs, David and Anthony E. Neville. Bridges, Canals & Tunnels. New York: American Heritage Publishing Co., Inc., 1968.

Kemp, Emory L. "The Fabric of Historic Bridges." IA: The Journal of the Society for Industrial Archeology, 15:2 (1989), 5, 14.

Kemp, Emory L. "The Introduction of Cast and Wrought Iron in Bridge Building." IA: The Journal of the Society for Industrial Archeology, 19:2 (1993), 5-16.

Kemp, Emory L. "National Styles in Engineering: The Case of the 19th-Century Suspension Bridge." IA: The Journal of the Society for Industrial Archeology, 19:1 (1993), 21-36.

Ketchum, Milo Smith. The Design of Highway Bridges and the Calculation of Stresses in Bridge Trusses. New York: McGraw-Hill Book Company, 1912.

Lin, Tung Y. and Felix Kulka. "Fifty-Year Advancement in Concrete Bridge Construction." Journal of the Construction Division, American Society of Civil Engineers, 101:C03 (September 1975), 491-510.

Marsh, Cedric. "Fifty Years of Aluminum in Construction." Journal of the Construction Division, Proceedings of the American Society of Civil Engineers, 101:CO2 (June 1975), 583-592.

McKee, Brian J. Historic American Covered Bridges. New York: Oxford University Press, 1997.

Miller, Carol Poh. "The Rocky River Bridge: Triumph in Concrete." IA: The Journal of the Society for Industrial Archeology, 2:1 (1976), 47-58.

Moisseiff, Leon S. "Growth in Suspension Bridge Knowledge." Engineering News-Record, 123:6 (10 August 1939), 206-09.

Peirson, J. Gordon. The Work of the Bridge Builders. [London]: Pen-in-Hand, 1948.

Plowden, David. Bridges: The Spans of North America. New York: Viking Press, 1974.

Podolny, Walter and John B. Scalzi. Construction and Design of Cable-Stayed Bridges. New York: J. Wiley & Sons, 1986.

Praeger, E.H. and T.C. Kavanagh. "Longest Plate-Girder Span in U.S. Completed." Civil Engineering, 42 (December 1959), 856-57.

Reppert, Charles M. "Aluminum Enters Bridge Construction." Engineering News-Record, 111 (23 November 1933), 611-615.

"The Saguenay is Bridged with Aluminum." Engineering News-Record, 144 (12 January1950), 32-35.

Stamp, Robert M. Bridging the Border: The Structures of Canadian-American Relations. Toronto: Dundurn Press, 1992.

Steinman, David. Suspension Bridges & Cantilevers. New York: D. Van Nostrand Company, 1913.

Steinman, D.B. The Wichert Truss. New York: D. Van Nostrand Company, Inc., 1932.

"Transportation." Engineering News-Record, 144 (23 March 1950), 108-15.

Tyrrell, Henry Grattan. Bridge Engineering. Evanston, Ill.: N.p., 1911.

United States Department of Interior, National Park Service. National Register Bulletin 15: How to Apply the National Register Criteria for Evaluation. Washington, D.C.: Government Printing Office, revised 1991.

United States Department of Transportation, Federal Highway Administration. Safety Inspection of In-Service Bridges. Participant Notebook, Volume II. Publication No. FHWA-HI-91-021. Washington, D.C.: Federal Highway Administration, 1992.

Watson, Wilbur J. A Decade of Bridges: 1926-36. Cleveland , Ohio: J.H. Jansen, 1937.

Weitzman, David L. Traces of the Past: A Field Guide to Industrial Archaeology. New York: Scribner, 1980.

Wengenroth, Reece H. and Howard A. Mix. "Fifty-Year History of Movable Bridge Construction – Part III." Journal of the Construction Division, American Society of Civil Engineers, 101:C03 (September 1975), 545-557.

"World's Longest Girder Lift Span." Engineering News-Record, 144 (February 16, 1950), 42-43.

B. Bridges – New York

Allen, Richard Sanders. Covered Bridges of the Northeast. Brattleboro, N.Y.: The Stephen Greene Press, 1957.

Allen, Richard Sanders. Old North Country Bridges: Upstate New York. Utica, N.Y.: North Country Books, 1983.

"The Arch and Colonnade of the Manhattan Bridge." Landmarks Preservation Commission Designation, November 1975.

Bartlett, Ted. "Stone Arch Bridge Thematic Resources." National Register of Historic Places Nomination. Listed: 11 October 1984.

Betts, Charles H. Highway Manual of the State of New York. Albany, N.Y.: New York State Statutory Revision Commission, 1904.

Bishop, William S. Highways, Ways and Plank Roads: The Statutes of New York in Relation to Highways, Bridges, Ferries, and Plank Roads. Rochester, N.Y.: Steele, Avery & Co., 1859.

Bonanos, Christopher. "The Father of Modern Bridges." American Heritage of Invention and Technology, (Summer 1992), 9-20.

Bonifide, John A. "Elm Street Stone Arch Bridge." National Register of Historic Places Nomination.

Bonifide, John A. "Mill Street Stone Arch Bridge." National Register of Historic Places Nomination.

"Brooklyn Bridge." Landmarks Preservation Commission Designation, August 1967.

Bureau of Municipal Investigation and Statistics. Report on the Maintenance of the Department of Bridges of the City of New York. For the years 1913 and 1914, and 1914 and 1915. [New York]: N.p., 1915, 1916.

Caro, Robert A. The Power Broker. New York: Alfred A. Knopf, 1974.

Chamberlin, William P. "The Cleft-ridge Span: America's First Concrete Arch." IA: The Journal of the Society for Industrial Archaeology, 9:1 (1983), 29-44.

Cohn, Arthur. The Great Bridge: "From Ticonderoga to Independant Point." New York: Lake Champlain Management Conference, May 1995.

Cole, Andrew and Charles Scott. "HAER Inventory," forms for bridges in New York. Historic American Engineering Record, National Park Service.

Correspondence File. Mead & Hunt, Inc., 1999. Responses to the bridge survey form and press releases.

The Department of Bridges of the City of New York. New York: The City Club of New York, 1903.

Dillon, James. "Old Blenheim Bridge." National Register of Historic Places Nomination.

Ellis, David M., et al. A History of New York State. Ithaca, New York: Cornell University Press, 1967.

Engelhart, Steven. AuSable Valley Historic Bridge Survey. Friends of Keeseville, Inc., April 1991.

Fagan, Thomas James. Metal Truss Bridges in Chenango County. Chenango County Planning Board, 1979.

Gilbert, Frank B. The Highway Code of the State of New York. Albany, N.Y.: J.B. Lyon Company, Publishers, 1908.

"Gilbertsville Historic District." National Register of Historic Places Nomination.

Gobrecht, Larry E. "Washington Bridge." National Register of Historic Places Nomination.

Graubard, Janice. "Stone Arch Bridge." National Register of Historic Places Nomination.

HNTB/Steinman. "Bridge Reconstruction Project Report, Shore Road Bridge over the Hutchinson River," July 1998.

The Heritage Foundation of Oswego, Inc. "Historic Bridges of Oswego County, New York." Pamphlet, n.d. Correspondence file, Mead & Hunt, Inc., n.p.

Hungerford, Edward. The Williamsburg Bridge. Brooklyn, N.Y.: The Eagle Press, 1903.

Jackson, Kenneth T. "Robert Moses and the Planned Environment: A Re-evaluation," in Robert Moses: Single-minded Genius, ed. Joann P. Krieg, 21-30. Papers presented at Long Island Studies Conference. Interlaken, N.Y.: Heart of Lakes Publishing, 1989.

Kaufman, Peter S. "The Public Works of Aymar Embury II in New York City and Long Island," in Robert Moses: Single-minded Genius, ed. Joann P. Krieg, 213-218. Papers presented at Long Island Studies Conference. Interlaken, N.Y.: Heart of Lakes Publishing, 1989.

Krekeler, Brenda. Covered Bridges Today. Canton, Ohio: Daring Publishing Group, Inc., 1989.

Krieg, Joann P., ed. Robert Moses: Single-minded Genius. Papers presented at Long Island Studies Conference. Interlaken, N.Y.: Heart of Lakes Publishing, 1989.

Liebs, Chester H. "Whipple Cast and Wrought-Iron Bowstring Truss Bridge." National Register of Historic Places Nomination.

McDougall, Ellen T. "Three Lenticular Truss Bridges." National Register of Historic Places Nomination.

Miller, Robert. "The Long Island Motor Parkway: Prelude to Robert Moses." In Robert Moses: Single-minded Genius, ed. Joann P. Krieg, 151-58. Papers presented at Long Island Studies Conference. Interlaken, N.Y.: Heart of Lakes Publishing, 1989.

Millett, John D. The Works Progress Administration in New York City. Chicago: Public Administration Service, 1938.

Moses, Robert. Public Works: A Dangerous Trade. New York: McGraw-Hill, Inc., 1970.

MTA Bridges and Tunnels. From the Archive. Newsletter from Spring 1994, Winter 1996, and Winter 1997-98.

New York City Department of Transportation. Annual Condition Report: Bridges & Tunnels. New York City Department of Transportation, 1987.

New York City Department of Transportation. Spanning the 21st Century: Reconstructing A World Class Bridge Program, A Report to Mayor Edward I. Koch. New York: New York City Department of Transportation, 1988.

New York City Landmarks Preservation Commission files.

New York State. Report of the State Commission of Highways. For the years 1909-13. Albany, N.Y.: J.B. Lyon Co., 1910-14.

New York State. Report of the State Commissioner of Highways. For the years 1914-23. Albany, N.Y.: J.B. Lyon Co., 1915-24.

New York State Archives and Records Administration. Guide to Records in the New York State Archives. New York: published by the state, 1993.

New York State Bridge Authority. Proposed Kingston-Rhinecliff Bridge over the Hudson River, 1948.

New York State Bridge Authority. Report on Twenty-five Years of Operation. N.p., 1958.

New York State Bridge and Tunnel Commission. Report of the New York State Bridge and Tunnel Commission. Albany, N.Y.: J.B. Lyon Co., printers, 1913-30.

New York State Department of Commerce. "Covered Bridges in New York State." Albany, N.Y.: published by New York State, (c. 1956).

New York State Department of Highways. Directions Prescribed by the Commission for the Guidance of County and Town Superintendents Regarding the Erection and Repair of Bridges. Albany, N.Y.: J.B. Lyon Co., 1910.

New York State Department of Public Works. A Short History of the New York State Department of Public Works. New York: published by the state, c. 1961.

New York State Department of Public Works. Annual Report of the Superintendent. For the years 1924-28, 1932, 1936-40, 1942-44, 1946-48, 1950-60. Albany, N.Y.: J.B. Lyon Co., 1925-29, 1933, 1937-41, 1943-45, 1947-49, 1951-61.

New York State Department of Public Works, Division of Engineering. "Standard 25-foot to 45-foot I-beam Bridge." Plan sheet dated August 28, 1928.

New York State Department of Transportation. Bridge Inventory Manual. New York State Department of Transportation, December 1990, Amended November 1991.

New York State Department of Transportation. Users' Manual for Structural Rating Program for Bridges. New York State Department of Transportation, Structures Design and Construction Division, August 1995.

"New York State Highway Bridge Statistics," Engineering News-Record, 90:6 (February 8, 1923), 257.

New York State Historic Preservation Office files. Copies of survey forms and National Register nominations.

"Olmsted Parks and Parkways Thematic Resources." National Register of Historic Places Nomination.

Peckham, Mark. "Newport Stone Arch Bridge." National Register of Historic Places Nomination.

Petrick, Michelle. "Caneadea Bridge." National Register of Historic Places Nomination.

"Queensboro Bridge." Landmarks Preservation Commission Designation, April 1974.

Rastorfer, Darl. Six Bridges: The Making of the New York Megalopolis. Exhibit pamphlet from the PaineWebber Art Gallery, 1996.

Reier, Sharon. The Bridges of New York. New York: Quadrant Press, c. 1977.

Rennenkampf, Lenore M. "Perrine's Bridge." National Register of Historic Places Nomination.

Rethi, Lili, and Edward M. Young. The Great Bridge: The Verrazano-Narrows Bridge. New York: Farrar, Straus & Giroux, 1965.

Rosenberg-Naparsteck, Ruth. Runnin' Crazy: A Portrait of the Genesee River. Virginia Beach, VA.: Donning Co., c. 1996.

Sanchis, Frank E. American Architecture: Westchester County, New York: Colonial to Contemporary. Croton-on-Hudson, N.Y.: North River Press, Inc., 1977.

Shockley, Jay. "Carroll Street Bridge." Landmarks Preservation Commission Designation, September 1987.

Shockley, Jay. "Macomb's Dam Bridge." Landmarks Preservation Commission Designation, January 1992.

Shockley, Jay. "University Heights Bridge." Landmarks Preservation Commission Designation, September 1984.

Shockley, Jay. "Washington Bridge." Landmarks Preservation Commission Designation, September 1982.

Siebel, George A. Bridges over the Niagara Gorge: Rainbow Bridge – 50 years, 1941-1991. Niagara Falls, Ontario: Niagara Falls Bridge Commission, 1991.

Smith, Raymond W. "Covered Bridges of Washington County." National Register of Historic Places Nomination.

Smith, Raymond W. "Hadley 'Parabolic' Bridge." National Register of Historic Places Nomination.

Smith, Raymond W. "Keeseville Village Multiple Resource Area." National Register of Historic Places Nomination. Listed: 15 March 1983.

Smith, Raymond W. "Kingston-Port Ewen Suspension Bridge." National Register of Historic Places Nomination.

Smith, Raymond W. "Manhattan Bridge." National Register of Historic Places of Nomination.

Smith, Raymond W. "Tioronda Bridge." National Register of Historic Places Nomination.

Sweeny, Harry, Jr. Bronx-Whitestone Bridge. New York: Triborough Bridge Authority, 1939.

Thurber, Pamela Jo. "A Study of the Groton Iron Bridge Company and the Preservation of America's Historic Metal Truss Bridges." Master's thesis, Cornell University, 1985.

Triborough Bridge and Tunnel Authority. Annual Report, 1946-1958. N.p.,1947-1959.

United States Department of Transportation. Federal Highway Administration. Office of Program Administration. Listing of PR-511 File [Interstate System data] supplied on July 22, 1999.

"Warrensburg Mills Historic District." National Register of Historic Places Nomination.

Weaver, Lynn B., Doris Manley, and Paul Huey. "Spangler Bridge." National Register of Historic Places Nomination.

Wells, John W. Cayuga Bridge. Ithaca, N.Y.: DeWitt Historical Society of Tompkins County, Inc., 1961.

Willensky, Elliot and Norval White. AIA Guide to New York City. New York: Harcourt Brace Jovanovich, Publishers, 1988.

Zaykowski, Dorothy Ingersoll. Sag Harbor: The Story of an American Beauty. Sag Harbor, N.Y.: Sag Harbor Historical Society, n.d.

C. Bridges – Designers and Engineers

American Society of Civil Engineers. A Biographical Dictionary of American Civil Engineers. New York: ASCE Historical Publication, 1972.

Billington, David P. Robert Maillart and the Art of Reinforced Concrete. New York; Cambridge, Mass.: Architectural History Foundation, MIT Press, 1990.

Harrison, Mitchell C. New York State's Prominent and Progressive Men: An Encyclopedia of Contemporaneous Biography. New York: New York Tribune, 1900.

"Henry Hornbostel (1867-1961) Collection." Carnegie Mellon Libraries. http://www.library.cmu.edu/Libraries/ArchArch/hornbost.html; Internet.

Melan Arch Construction Company. New York: n.p., [1900?].

Pelkey, Rosemary Miner. Adirondack Bridgebuilder from Charleston: The Life and Times of Robert Codgell Gilchrist. Utica, N.Y.: North Country Books, 1993.

Petroski, Henry. Engineers of Dreams: Great Bridge Builders and the Spanning of America. New York: Alfred A. Knopf, 1995.

Shockley, Jay. "Empire Building." Landmarks Preservation Commission Designation, June 1996.

Sloan, Allan King. "Discovering Zenas King." Paper presented at the Annual Meeting of the Society for Industrial Archeology, Savannah, Georgia, 5 June 1999. Collection of Mead & Hunt, Inc.

D. Statewide Bridge Inventories

Cooper, James L. Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942. Greencastle, Ind.: De Paul University, 1997.

Hess, Jeffrey A. and Robert M. Frame, III. Historic Highway Bridges in Wisconsin: Volume 3, Historical Survey of Wisconsin Movable Bridges, Part 1. Wisconsin Department of Transportation, 1996.

Hess, Jeffrey A. and Robert M. Frame, III. Historic Highway Bridges in Wisconsin: Volume 1, Stone and Concrete Arch Bridges. Wisconsin Department of Transportation, 1986.

Miller, Ann B. and Kenneth M. Clark. A Survey of Movable Span Bridges in Virginia. Charlottesville, VA.: Virginia Transportation Research Council, May 1998.

Miller, Ann B., et al. A Survey of Non-arched Historic Concrete Bridges in Virginia Constructed Prior to 1950. Charlottesville, VA.: Virginia Transportation Research Council, July 1996.

Shank, William H. Historic Bridges of Pennsylvania. 2nd. edition. York, Penn.: American Canal Association, Transportation Center, 1974.

E. Transportation Networks

"1911 Series of Maps: Albany County, Erie County, Monroe County, Onondaga County." N.p., 1911. Collection of New York Public Library Map Division.

"Adirondack History," on Adirondack.Net [on-line] (accessed July 1999); available from http://www.adirondack.net/history/history.html; Internet.

A.G. Lichtenstein & Associates, Inc., "New Jersey Historic Bridge Survey," 1994.

Albany County Highway Department. Highway Map of Albany County, New York. Voorheesville, N.Y.: County Highway Department, 1968.

American Public Works Association. History of Public Works in the United States 1776-1976. Chicago: American Public Works Association, 1976.

Anderson, Steve. "The Roads of Metro New York," on The Complete Guide to New York Area Roads, Crossings and Exits Web Site [on-line] (accessed August 1999); available from http://www.nycroads.com/roads; Internet.

Beers, F.W. & Co. Illustrated Historical Atlas of Erie Co., New-York from actual surveys and records. New York: F.W. Beers & Co., 1880.

Beers, S.N. & D.G. New Topographical Atlas of the counties of Albany and Schenectady, New York. Philadelphia: Stone & Stewart Publishers, 1866.

Billington, David P. The Tower and the Bridge. Princeton, N.J.: Princeton University Press, 1983.

Billington, David P. The Innovators. New York: John Wiley & Sons, Inc., 1996.

Broderick, Stanton M. “Olmsted Parks in Buffalo, New York,” Web Site [on-line] (accessed July 1999); available from http://www.geocities.com/Heartland/7172/index.htm; Internet.

Brown, Richard C. and Bob Watson. Buffalo, Lake City in Niagara Land: An Illustrated History. Woodland Hills, Calif.: Windsor Publications, 1981.

Browne, P.J. P.J. Browne’s Map of Monroe County, New York. N.p., 1852.

Buell & Wilgus. Complete Road Map of Erie County and Part of Niagara County, N.Y., Buffalo, 1891.

Buffalo and Fort Erie Public Bridge Authority. “Financial Statements and Supplementary Information,” n.p., 1959.

Bugbeel, C.L. County of Monroe, from Actual Survey. N.p., 1826.

Burrows, Edwin G. and Mike Wallace. Gotham, A History of New York City to 1898. New York: Oxford University Press, 1999.

Candeub, Fleissig & Associates. The City of Albany, New York: Comprehensive plan for downtown. Albany, N.Y., 1965.

Chase, Franklin H. Syracuse and Its Environs: A History. Vol. I. New York: Lewis Historical Publishing Company, Inc., 1924.

“Connecticut Department of Transportation 100 Year History,” on the State of Connecticut Web Site [on-line] (accessed July 1999); available from http://www.state.ct.us/dot/about; Internet.

Cortright, Robert S. Bridging. Tigard, Oreg.: Bridge Ink, 1998.

Darrow, Erastus. Map of Monroe County. N.p., 1903.

“Development and Administration of New York’s Canal System,” on the New York State Archives and Records Administration Web Site [on-line] (accessed July 1999); available from http://www.sara.nysed.gov/holding/aids/canal/dev.htm; Internet.

Dolkart, Andrew S. “Bronx River Parkway Reservation.” National Register of Historic Places Nomination, 1990.

Dolph & Stewart. Map of Albany County and part of Rensselaer County. New York: Dolph & Stewart, 1933.

Ellis, Edward Robb. The Epic of New York City. New York: Old Town Books, 1966.

Erie County Planning Board. Preliminary General Plan. Erie County, N.Y., December 1952.

Federal Writers' Project of the Works Progress Administration. Albany Guide. Albany, N.Y., 1937.

Fein, Albert, ed. Landscape Into Cityscape: Frederick Law Olmsted's Plans for a Greater New York City. New York: Van Nostrand, Reinhold Company, 1967.

"FHWA By Day - August 30" on the Federal Highway Administration Web Site [on-line] (accessed July 1999); available from http://www.fhinter.fhwa.dot.gov/fhwabyday/fhbd0830.htm; Internet.

"Footpaths to Freeways: The Story of Ontario's Roads," on the Ontario Ministry of Transportation Web Site [on-line] (accessed July 1999); available from http://www.mto.gov.on.ca/english/about/footpaths/queen.htm; Internet.

Geil, Samuel. Map of Erie County, New York From Actual Surveys. Philadelphia: Gillette Matthews & Co., 1855.

G.M. Hopkins Co. City Atlas of Albany, New York. Philadelphia: G.M. Hopkins, 1876.

Greene, Nelson, ed. History of the Valley of the Hudson, River of Destiny, 1609-1930. Chicago: The S.J. Clarke Publishing Company, 1931.

Hagstrom. Map of Sullivan County, New York, Hagstrom, 1958.

Hammond, C.S. & Co. Auto Route Atlas of New Jersey and New York, C.S. Hammond & Co., 1920.

Harland Bartholomew & Associates. A Major Street Plan for Rochester New York. Rochester, N.Y.: Leo Hart Company, 1929.

Historical Perspectives, Inc. "Phase IA Archaeological Impact Report for the Atlantic Terminal and Brooklyn Center Projects, Brooklyn, New York," November 1985.

Historical Perspectives, Inc. "Phase IA Archaeological Assessment Report for the Tibbet Gardens Project, Bronx, New York," January 1987.

Historical Perspectives, Inc. "Analysis of Eligibility of Belt Parkway (Brooklyn) for NR Listing," December 1996.

Homberger, Eric. The Historical Atlas of New York City. New York: Henry Holt and Company, 1994.

Homberger, Eric. The Penguin Historical Atlas of North America. New York: Penguin Books USA, Inc., 1995.

Hudson Gazette. Columbia County at the End of the Century. Hudson, N.Y.: The Record Printing and Publishing Co., 1900.

Hugill, Peter J. "The Elite, the Automobile, and the Good Roads Movement in New York: The Development and Transformation of a Technological Complex, 1904-1913." Discussion Paper: Department of Geography, 70 (March 1981), 2-28.

Hungerford, Edward. Rochester: A Good Town to Live In. Rochester, N.Y.: University of Rochester, 1923.

Jackson, Kenneth T., ed. The Encyclopedia of New York City. New Haven, Conn.: Yale University Press, 1995.

Kay, Jane Holtz. Asphalt Nation. Los Angeles, Calif.: University of California Press, 1977.

Kowsky, Francis R., ed. The Best Planned City: The Olmsted Legacy in Buffalo. Buffalo, N.Y.:Burchfield Art Center, 1992.

LaFrank, Kathleen. "Bronx River Parkway Reservation." National Register of Historic Places Nomination, 1990.

LaFrank, Kathleen. "Taconic State Parkway." National Register of Historic Places Nomination, 1997.

LaFrank, Kathleen and Susan E. Smith. "Palisades Interstate Parkway." National Register of Historic Places Registration Form, 1998.

"Lake Champlain Facts and History," on the Lake Champlain Ferries Web Site [on-line] (accessed July 1999); available from http://ferries.com/history.html; Internet.

Lake Champlain Transportation Company. "Lake Champlain Ferries," pamphlet. N.p., 1999.

Larson, Neil. "Metal Truss Bridges of Tompkins County, New York." National Register of Historic Places Nomination.

Lay, M.G. Ways of the World: A History of the World's Roads and of the Vehicles That Used Them. New Brunswick, N.J.: Rutgers University Press, c. 1992.

Levy, Steven S. "Susquehannah Turnpike." National Register of Historic Places Nomination.

Mallamo, J. Lance. "Building the Roads to Greatness: Robert Moses and Long Island's State Parkways." In Robert Moses: Single-minded Genius, ed. Joann P. Krieg, 151-58. Papers presented at Long Island Studies Conference. Interlaken, N.Y.: Heart of Lakes Publishing, 1989.

McEneny, John J. Albany: Capital City on the Hudson. Woodland Hills, Calif.: Windsor Publications, 1981.

Munson, Lilian Steele. Syracuse, the City that Salt Built. New York: Pageant Press International Corp., 1969.

National Park Service. New York State Canals Special Resource Study: Preliminary Findings – Significance Statements. Washington, D.C.: U.S. Department of the Interior, n.d.

National Trust for Historic Preservation. "Preserving Historic Bridges," Preservation Information, 1995.

New York City Department of Parks. New Parkways in New York City. New York: Department of Parks, 1937.

New York State Bridge Authority Web Site [on-line] (accessed July 1999); available from http://www.nysba.state.ny.us; Internet.

New York State Canal Corporation. "Unlock the Legend of The New York State Canal System." Pamphlet. New York State Canal Corporation, 1999.

New York State Office of Parks, Recreation and Historic Preservation. "New York State's Hudson Valley Parkways." The New York State Preservationist, 2:1, Spring/Summer 1998.

New York State State Engineer and Surveyor. "State Engineer and Surveyor Sub-Agency History Record."

New York State Thruway Web Site [on-line] (accessed July 1999); available from http://www.thruway.state.ny.us; Internet.

Newsday. Long Island: Our Story. Canada: Newsday, Inc., 1998.

Ogdensburg Bridge and Port Authority Web Site [on-line] (accessed July 1999); available from http://www.ogdensport.com; Internet.

Oglesby, Clarkson H. and Laurence I. Hewes. Highway Engineering. New York: John Wiley & Sons, Inc., 1963.

Parsons, Brinckerhoff, Hall & Macdonald. Albany Waterfront Arterial Highway. New York: Parsons, Brinckerhoff, Hogan & Macdonald, 1946.

"The Peace Bridge Overview," on The Peace Bridge Web Site [on-line] (accessed July 1999); available from http://www.peacebridge.com/overview.html; Internet.

Philip Habib & Associates. "Rehabilitation of the Marine Parkway Bridge, Draft Environmental Assessment Form," August 1997.

Quinlan, James Eldridge. History of Sullivan County. South Fallsburg, N.Y.: Marielle Press, 1993.

Raber, Michael S. "Colgate & Company: Office Building." Draft Historic American Engineering Record, 1988. Collection of Allee King Rosen & Fleming, Inc. archives.

Rand McNally. Main Highway Map of New York. Rand McNally, 1923.

Rand McNally. Official 1925 Auto Trails Map of New York. Rand McNally, 1925.

"Revolutionary Trail: Scenic Byways of the Adirondack North County," on The Adirondack North Country Association's (ANCA) Web Site [on-line] (accessed July 1999); available from http://www.adirondack.org/nomaps/revolutionary_revolutionary.html; Internet.

Ritter, Joyce N. The History of Highway Statistics. Washington, D.C.: Federal Highway Administration, 1994.

Rose, Mark H. Interstate: Express Highway Politics 1939-1989. Knoxville, Tenn.: The University of Tennessee Press, 1979.

Ruttenber, E.M. and L.H. Clark. History of Orange County New York. Philadelphia: Everts & Peck, 1881.

St. Lawrence Seaway Development Corporation. "A History of the Great Lakes Seaway System," on the United States Department of Transportation Web Site [on-line] (accessed August 1999); available from http://www.dot.gov/slsdc/about/exthist.html; Internet.

Schul, Dave. "North American Auto Trails: Introduction" [on-line] (accessed August 1999); available from http://www.falcon.cc.ukans.edu/~dschul/trails/intro.html; Internet.

Seely, Bruce E. Building the American Highway System. Philadelphia: Temple University Press, 1987.

Seyfried, Vincent F. 300 Years of Long Island City 1630-1930. Garden City, N.Y.: Edgian Press, Inc., 1984.

Shaver, Peter D., compiler. The National Register of Historic Places in New York State. New York: Rizzoli International Publications, Inc., 1993.

Stanne, Stephen P., Roger G. Panetta, and Brian E. Forist. The Hudson: An Illustrated Guide to the Living River. New Brunswick, N.J.: Rutgers University Press, 1996.

Stern, Robert A.M., Gregory Gilmartin and Thomas Mellins. New York 1930. New York: Rizzoli International Publications, Inc., 1987.

Stoddard & Babcock. Onondaga County & Adjacent Territory. Syracuse, N.Y.: Stoddard & Babcock, 1848.

Stokes, I.N. Phelps. The Iconography of Manhattan Island, 1498-1909. New York: R.H. Dodd, 1916.

Tanner, C.B. Onondaga County Road Map. Kirkville, N.Y.: n.p., 1948.

Traver, R.B. Map of Onondaga County, New York. Onondaga County Department of Highways, 1927.

United States Coast Guard. "Staten Island Bridges Program: Modernization and Capacity Enhancement Project Final Environmental Impact Statement/Section 4(f) Statement," Volume 1, October 1997.

United States Department of Transportation, Federal Highway Administration. America's Highways 1776-1976: A History of the Federal-Aid Program. Washington, D.C.: United States Department of Transportation, Federal Highway Administration, 1977.

United States Department of Transportation, Federal Highway Administration. Public Roads: Special Edition 1996; 40th Anniversary of the Interstate System. Washington, D.C.: Federal Highway Administration, 1996.

United States Department of Transportation, Federal Highway Administration. "Public Roads," 6:1, Summer 1996 [on-line] (accessed July 1999); available from http://www.tfhrc.gov/pubrds/summer96; Internet.

"Unlock the Legend: New York State Canal System," on the New York State Canal Corporation's Web Site [on-line] (accessed July 1999); available from http://www.canals.state.ny.us; Internet.

Zimm, Louise Hasbrouck, Rev. A. Elwood Corning, Joseph W. Emsley, and Willitt C. Jewell, eds. Southeastern New York: A History of the Counties of Ulster, Dutchess, Orange, Rockland, and Putnam, Volume II. New York: Lewis Historical Publishing Company, Inc., 1946.

Endnotes

1. Joseph Gies, Bridges and Men (London: Cassell & Company, 1963), 215-16; Carl W. Condit, American Building: Materials and Techniques From the First Colonial Settlements to the Present (Chicago: The University of Chicago Press, 1968), 144-46.

2. M.G. Lay, Ways of the World: A History of the World's Roads and of the Vehicles That Used Them, (New Brunswick, N.J.: Rutgers University Press, c. 1992), 273.

3. Condit, 151.

4. Jeffrey A. Hess and Robert M. Frame, III, Historic Highway Bridges in Wisconsin: Volume 1, Stone and Concrete Arch Bridges (Wisconsin Department of Transportation, 1986), 207-09.

5. Condit, 54.

6. Allen, Covered Bridges of the Northeast (Brattleboro, N.Y.: The Stephen Greene Press, 1957), 80-81. Most of the state's surviving examples were bypassed by the main highway decades ago and/or have been restored; Brenda Krekeler, Covered Bridges Today (Canton, Ohio: Daring Publishing Group, Inc., 1989), 147-55.

7. Allen, Covered Bridges of the Northeast , 6-19.

8. Allen, Covered Bridges of the Northeast, 9.

9. New York State Department of Commerce, "Covered Bridges in New York State," (Albany, N.Y.: published by New York State, [c. 1956]), n.p.

10. Lay, 280.

11. David L. Weitzman, Traces of the Past: A Field Guide to Industrial Archaeology (New York: Scribner, 1980), 51-53.

12. Weitzman, 51.

13. Lay, 280.

14. David Plowden, Bridges: The Spans of North America (New York: Viking Press, 1974), 65.

15. Lay, 280.

16. Lay, 281.

17. D.B. Steinman, The Wichert Truss (New York: D. Van Nostrand Company, Inc., 1932), 1.

18. Walter Podolny and John B. Scalzi, Construction and Design of Cable-Stayed Bridges (New York: J. Wiley & Sons, 1986), 1.

19. Jay Shockley, "Carroll Street Bridge," Landmarks Preservation Commission Designation (September 1987).

20. Milo Smith Ketchum, The Design of Highway Bridges and the Calculation of Stresses in Bridge Trusses, (New York: McGraw-Hill Book Company, 1912), 12.

21. Ann B. Miller and Kenneth M. Clark, A Survey of Movable Span Bridges in Virginia (Charlottesville, Va.: Virginia Transportation Research Council, May 1998), 5-6; and Jeffrey A. Hess and Robert M. Frame, III, Historic Highway Bridges in Wisconsin: Volume 3, Historical Survey of Wisconsin Movable Bridges, Part 1 (Wisconsin Department of Transportation, 1996), 43-45, 51-52, 65.

22. California State Highway Transportation Agency, Manual of Bridge Design Practice (State of California, 1965), 78.

23. David Jacobs and Anthony E. Neville, Bridges, Canals & Tunnels (New York: American Heritage Publishing Co., Inc., 1968), 139; and Lawrence H. Berlow, The Reference Guide to Famous Engineering Landmarks of the World (Phoenix: Oryx, 1998), 215.

24. Plowden, 320.

25. Ann Miller, et al., A Survey of Non-arched Historic Concrete Bridges in Virginia Constructed Prior to 1950 (Charlottesville, VA.: Virginia Transportation Research Council, July 1996), 20-21; and Wilbur J. Watson, A Decade of Bridges: 1926-1936 (Cleveland , Ohio: J.H. Jansen, 1937), 282.

26. New York State Department of Public Works, Division of Engineering, "Standard 25-foot to 45-foot I-beam Bridge," plan sheet dated August 28, 1928.

27. Plowden, 290.

28. Edward A. Burroughs, "Fifty-Year Development Construction of Steel Girder Bridges," Journal of the Construction Division, American Society of Civil Engineers. 101:C03 (September 1975), 464.

29. James Dillon, "Old Blenheim Bridge," National Register of Historic Places Nomination; and Krekeler, 147.

30. Shockley, "Macomb's Dam Bridge," Landmarks Preservation Commission Designation (January 1992); and Shockley, "Carroll Street Bridge."

31. Plowden, 33-39; and Lay, 275-78.

32. Plowden, 9, 32.

33. Janice Graubard, "Stone Arch Bridge," National Register of Historic Places Nomination.

34. Ted Bartlett, "Stone Arch Bridge Thematic Resources," National Register of Historic Places Nomination. Listed: 11 October 1984.

35. The location of Howe's bridge is not provided; Lay, 280.

36. Lay, 280.

37. Donald L. Jackson, Great American Bridges and Dams (Great American Places Series, Preservation Press. 1988), 126; "Building-Structure Inventory Form for the Van Wyck Lane Bridge," collection of the New York State Historic Preservation Office.

38. Plowden, 57; and Emory L. Kemp, "The Introduction of Cast and Wrought Iron in Bridge Building," IA: The Journal of the Society for Industrial Archeology 19:2 (1993), 5-10.

39. Kemp, "The Introduction of Cast and Wrought Iron," 10; Plowden, 57-58.

40. Lay, 280-84.

41. Plowden, 297-98.

42. Ned L. Ashton, "First Welded Aluminum Girder Bridge Spans Interstate Highway in Iowa," Civil Engineering 28 (October 1958): 79-80; Cedric Marsh, "Fifty Years of Aluminum in Construction," Journal of the Construction Division, Proceedings of the American Society of Civil Engineers 101:CO2 (June 1975), 589.

43. Victor Darnell, "Lenticular Bridges from East Berlin, Connecticut," IA: The Journal of the Society for Industrial Archeology 5:1 (1979), 21.

44. Plowden, 62.

45. Lay, 284.

46. Plowden, 175.

47. William F. Hollingsworth, "Fifty-Year Development: Construction of Steel Arch Bridges," Journal of the Construction Division, American Society of Civil Engineers 101:C01 (March 1975), 88-89.

48. Gies, 177.

49. Plowden, 130.

50. Gies, 219.

51. Jay Shockley, "Washington Bridge," Landmarks Preservation Commission Designation (September 1982).

52. Hollingsworth, 90.

53. "The Hell Gate Steel Arch Bridge," Engineering News 71:2 (January 8, 1914), 59.

54. The Bayonne Bridge held this title until the completion of the New River Gorge Bridge in West Virginia in 1978, Condit, 231-32.

55. Plowden, 257.

56. Hollingsworth, 91-92.

57. Plowden, 59.

58. Plowden, 73.

59. Emory L. Kemp, "National Styles in Engineering: The Case of the 19th -Century Suspension Bridge," IA: The Journal of the Society for Industrial Archeology, 19:1(1993), 22.

60. Niels J. Gimsing, Cable Supported Brides: Concept and Design (3d ed.; New York: John Wiley & Sons, 1998), 6; and James D. Dwyer, "Fifty-Year Development: Construction of Steel Suspension Bridges," Journal of the Construction Division, American Society of Civil Engineers 101:C01 (March 1975), 105.

61. Plowden, 80.

62. Steinman, Suspension Bridges & Cantilevers, 25.

63. Steinman, Suspension Bridges & Cantilevers, 25.

64. Berlow, 98.

65. Berlow, 98.

66. Condit, 233-34.

67. Condit, 234.

68. Gies, 239-40; and Condit 235.

69. Darl Rastorfer, Six Bridges: The Making of the New York Megalopolis (Exhibit pamphlet from the PaineWebber Art Gallery, 1996), n.p.

70. Plowden, 248-249.

71. Condit, 236-37.

72. Harry Sweeny Jr., Bronx-Whitestone Bridge (New York: Triborough Bridge Authority, 1939), n.p.; and Leon S. Moisseiff, "Growth in Suspension Bridge Knowledge." Engineering News-Record, 123:6 (10 August 1939), 206.

73. Plowden, 290.

74. Plowden, 290.

75. Plowden, 290-291.

76. Statistics from New York City Department of Transportation, Spanning the 21st Century: Reconstructing A World Class Bridge Program, A Report to Mayor Edward I. Koch (New York: New York City Department of Transportation, 1988), 25.

77. Plowden, 123-24 and Gies, 215.

78. There appears to be some discrepancy on the construction date of this bridge. Plowden states both 1882 and 1886. Plowden 138-39; and Gies, 215.

79. J.K. Finch, "A Hundred Years of American Civil Engineering," Transactions of the American Society of Civil Engineers Volume CT (1953), 42.

80. Plowden, 180.

81. Egbert R. Hardesty, Henry W. Fischer, and Richard W. Christie, "Fifty-Year History of Movable Bridge Construction - Part I," Journal of the Construction Division, American Society for Civil Engineers 101:C03 (September 1975), 513.

82. Hess and Frame, Historic Highway Bridges in Wisconsin: Volume 3, Movable Bridges, 13-14.

83. Egbert R. Hardesty, Henry W. Fischer, and Richard W. Christie, "Fifty-Year History of Movable Bridge Construction - Part II," Journal of the Construction Division, American Society for Civil Engineers 101:C03 (September 1975), 535; and Reece H. Wengenroth and Howard A. Mix, "Fifty-Year History of Movable Bridge Construction - Part III," Journal of the Construction Division, American Society of Civil Engineers 101:C03 (September 1975), 547.

84. Hess and Frame, Historic Highway Bridges in Wisconsin: Volume 3, Movable Bridges, 28.

85. Hess and Frame, Historic Highway Bridges in Wisconsin: Volume 3, Movable Bridges, 52.

86. Hardesty et al., "Fifty-Year History of Movable Bridge Construction - Part 1, 522.

87. William P. Chamberlin, "The Cleft-ridge Span: America's First Concrete Arch," IA: The Journal of the Society for Industrial Archaeology 9:1 (1983), 29.

88. Henry Grattan Tyrrell, Bridge Engineering, (Evanston, Ill., 1911), 408.

89. Tyrrell, 408; and Plowden, 298.

90. Plowden, 298; and Tyrrell, 409-10.

91. Condit, 175.

92. James Cooper, Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942 (Greencastle, Ind.: DePauw University, 1997), 39-41.

93. Condit, 257.

94. Tyrrell, 436.

95. Condit, 243.

96. Plowden, 318.

97. Condit, 243; and Plowden, 320.

98. Plowden, 299.

99. Condit, 253.

100. Condit, 253.

101. Plowden, 320-21; and Condit, 259.

102. "Transportation," Engineering News-Record, 144 (23 March 1950), 111.

103. Plowden, 318-320.

104. Tung Y. Lin and Felix Kulka, "Fifty-Year Advancement in Concrete Bridge Construction," Journal of the Construction Division, American Society of Civil Engineers 101:C03 (September 1975), 492-96.

105. Lin and Kulka,509.

106. Charles M. Reppert, "Aluminum Enters Bridge Construction," Engineering News-Record, 111 (November 23, 1933): 611-612.

107. "The Saguenay is Bridged with Aluminum," Engineering News-Record, 144 (January 12, 1950): 32-33.

108. Ashton, 79-80.

109. New York State Department of Public Works, Annual Report of the Superintendent for 1959 (Albany, N.Y.: J.B. Lyon Co., 1960), 55; and New York State Department of Public Works, Annual Report of the Superintendent for 1960, 53.

110. Plowden, 58.

111. Plowden, 62.

112. Plowden, 119-20.

113. Condit, 291; and Tyrrell, 432.

114. Plowden, 175.

115. The Bear Mountain Bridge record was surpassed in 1926 by the 1,750-foot Philadelphia-Camden Bridge. Plowden, 241.

116. Gilbert Dudley Fish, Arc-welded Steel Frame Structures (New York: McGraw-Hill Book Company, Inc., 1933), 13.

117. Condit, 226-27.

118. Plowden, 319

119. Frank E. Sanchis, American Architecture: Westchester County, New York: Colonial to Contemporary (Croton-on-Hudson, N.Y.: North River Press, Inc., 1977), 885.

120. New York State Department of Public Works, Annual Report of the Superintendent for 1932, 8, 103; Watson, 1.

121. Plowden, 258.

122. Evans, L.T. "Vierendeel Girder Bridge Introduced in America," 471-72.

123. Hardesty, et al., "Fifty-Year History of Movable Bridge Construction - Part II, 533-34.

124. Condit, 258.

125. "World's Longest Girder Lift Span," Engineering News-Record, (16 February 1950), 42-43.

126. E.H. Praeger and T.C. Kavanagh, "Longest Plate-Girder Span in U.S. Completed," Civil Engineering 42 (December 1959), 42-43.

127. New York State Department of Public Works, Annual Report of the Superintendent for 1959, 55.

128. Arthur Cohn, The Great Bridge: "From Ticonderoga to Independant Point" (New York: Lake Champlain Management Conference, May 1995), 13, 26.

129. Steven Engelhart, AuSable Valley Historic Bridge Survey (Friends of Keeseville, Inc., April 1991), 5.

130. Ruth Rosenberg-Naparsteck, Runnin' Crazy: A Portrait of the Genesee River (Virginia Beach, Va.: Donning Co., c. 1996), 77-78.

131. Ellen T. McDougall, "Three Lenticular Truss Bridges," National Register of Historic Places Nomination.

132. Charles H. Betts, Highway Manual of the State of New York (Albany, N.Y.: New York State Statutory Revision Commission, 1904), 260.

133. Betts, 213-14.

134. Edward D. Lewis, "Historical Data on Roads and Bridges," 1947 manuscript provided with the "Historic Bridge and Road Survey for St. Lawrence County," correspondence file, Mead & Hunt, Inc., 1999.

135. Staten Island Historian (Summer-Fall 1997) newsletter provided with the "Historic Bridge and Road Survey for Richmond County," correspondence file, Mead & Hunt, Inc., 1999.

136. Dorothy Ingersoll Zaykowski, Sag Harbor: The Story of an American Beauty (Sag Harbor, N.Y.: Sag Harbor Historical Society, n.d.), 24.

137. John W. Wells, Cayuga Bridge (Ithaca: DeWitt Historical Society of Tompkins County, Inc., 1961), 1-18.

138. Rosenberg-Naparsteck, 79-81.

139. Frank B. Gilbert, The Highway Code of the State of New York (Albany, N.Y.: J.B. Lyon Company, Publishers, 1908), 316.

140. William S. Bishop, Highways, Ways and Plank Roads: The Statutes of New York in Relation to Highways, Bridges, Ferries, and Plank Roads (Rochester, N.Y.: Steele, Avery & Co. 1859), 76-80.

141. Bishop, 9-11, 75-76; and New York State Archives and Records Administration, Guide to Records in the New York State Archives (New York: published by the State, 1993), 308.

142. Bishop, 82-87.

143. Pamela Jo Thurber, "A Study of the Groton Iron Bridge Company and the Preservation of America's Historic Metal Truss Bridges" (M.A. thesis, Cornell University, 1985), 37, 62.

144. Darnell, "Lenticular Bridges from East Berlin, Connecticut," 19, 27, 31-32.

145. McDougall.

146. Smith, "Keeseville Multiple Resource Area."

147. Thomas James Fagan, Metal Truss Bridges in Chenango County (Chenango County Planning Board, 1979), 11; and Rosenberg-Naparsteck, 89.

148. Thurber, 34-35.

149. George A. Siebel, Bridges over the Niagara Gorge: Rainbow Bridge–50 years, 1941-1991 (Niagara Falls, Ontario: Niagara Falls Bridge Commission, 1991), 8-12, 15-22, 41-48.

150. Siebel, 87-90. The 1899 suspension bridge closed in 1962.

151. Siebel, 127-33.

152. Siebel, 50-56, 144-55.

153. Betts, 215-16, 248.

154. Betts, 212-13, 267; and Fagan, 6.

155. Betts, 225.

156. Betts, 247-49.

157. Thurber, 35-36, 93.

158. Michelle Petrick, "Caneadea Bridge," National Register of Historic Places Nomination;" and "Building-Structure Inventory Form for the Mill Road Bridge;" and "Building-Structure Inventory Form for the Rapids Road Bridge," collection of the New York State Historic Preservation Office.

159. Engelhart, 74.

160. New York City Department of Transportation, Spanning the 21st Century, 12; and Berlow, 134.

161. "Brooklyn Bridge," Landmarks Preservation Commission Designation; and The Department of Bridges of the City of New York (New York: The City Club of New York, 1903), 127.

162. Montgomery Schuyler, American Architecture and Other Writings, Volume II (Cambridge, Mass.: Belknap Press, 1961), 357, quoted in Larry E. Gobrecht, "Washington Bridge, " National Register Nomination.

163. Shockley, "Macomb's Dam Bridge;" and Shockley, "Carroll Street Bridge."

164. Shockley, "Macomb's Dam Bridge;" and "Harlem River Bridges," New York City Landmarks Preservation Commission files.

165. Bureau of Municipal Investigation and Statistics, Report on the Maintenance of the Department of Bridges of the City of New York in 1913 and 1914, ([New York]: N.p., 1915), 3-4.

166. New York City Department of Transportation, Spanning the 21st Century, 26; and The Department of Bridges of the City of New York, 125-26.

167. The Department of Bridges of the City of New York, 127; and Report on the Maintenance of the Department of Bridges of the City of New York in 1914 and 1915 (New York: Department of Bridges, 1916), 7-8.

168. The Department of Bridges of the City of New York, 177-79.

169. Shockley, "University Heights Bridge," Landmarks Preservation Commission Designation (September 1984).

170. "Harlem River Bridges," New York City Landmarks Preservation Commission files.

171. HNTB/Steinman, "Bridge Reconstruction Project Report, Shore Road Bridge over the Hutchinson River," July 1998.

172. Bureau of Municipal Investigation and Statistics, Report on the Maintenance of the Department of Bridges of the City of New York in 1913 and 1914, 3-4.

173. The Department of Bridges of the City of New York, 143.

174. The Department of Bridges of the City of New York, 148-53; and New York City Department of Transportation, Spanning the 21st Century, 11, 13.

175. New York City Department of Transportation, Spanning the 21st Century, 30; and The Department of Bridges of the City of New York, 137-38, 143, 162.

176. "The Arch and Colonnade of the Manhattan Bridge," Landmarks Preservation Commission Designation (November 1975); Donald L. Jackson, 135; and Henry Petroski, Engineers of Dreams: Great Bridge Builders and the Spanning of America (New York: Alfred A. Knopf, 1995), 165-69.

177. "Queensboro Bridge," Landmarks Preservation Commission Designation (April 1974); and Petroski, 178, 185-88.

178. New York State Archives and Records Administration, 308.

179. Betts, 225, 247-49; and Gilbert, 318.

180. New York State, Report of the State Commissioner of Highways for 1919 (Albany, N.Y.: J.B. Lyon Co., 1920), 58-60; and Gilbert, 314-18.

181. New York State, Report of the State Commission of Highways for 1910 (Albany, N.Y.: J.B. Lyon Co., 1911), 471; and New York State, Report of the State Commission of Highways for 1912, 418.

182. New York State Department of Highways, Directions Prescribed by the Commission for the Guidance of County and Town Superintendents Regarding the Erection and Repair of Bridges (Albany, N.Y.: J.B. Lyon Co., 1910), 22-26.

183. The state reviewed 14 bridge and culvert plans in 1909; eight in 1910; 20 in 1911; 28 in 1912; 20 in 1913; and 15 in 1914. Compiled from New York State, Report of the State Commission of Highways, for the years 1909-13 and New York State, Report of the State Commissioner of Highways, for the year 1914.

184. New York State Department of Highways, Directions Prescribed, 22.

185. New York State Department of Highways, Directions Prescribed, 22, 27.

186. New York State, Report of the State Commission of Highways for 1909, 6; New York State, Report of the State Commission of Highways for 1913, 69.

187. New York State Department of Highways, Directions Prescribed, 23-24.

188. Thurber, 96.

189. New York State, Report of the State Commission of Highways for 1912, 419.

190. Clipping provided with the "Historic Bridge and Road Survey for St. Lawrence County," correspondence file, Mead & Hunt, Inc., 1999. A new bridge was built in 1965.

191. New York State Department of Highways, Directions Prescribed, 22-24, 27.

192. New York State Department of Highways, Directions Prescribed, 23-24.

193. New York State, Report of the State Commission of Highways for 1909, 5-6.

194. "Historic Bridge and Road Survey for Cattaraugus County," correspondence file, Mead & Hunt, Inc., 1999; "Building-Structure Inventory Form for the Lyndon Road Bridge," collection of the New York State Historic Preservation Office.

195. New York State Department of Highways, Directions Prescribed, 24-26, Plates 8-11.

196. Robert Miller, "The Long Island Motor Parkway: Prelude to Robert Moses," in Robert Moses: Single-minded Genius, ed. Joann P. Krieg, (Papers presented at Long Island Studies Conference, Interlaken, N.Y.: Heart of Lakes Publishing, 1989), 154-55.

197. New York State, Report of the State Commission of Highways for 1913, 26, 69-70.

198. New York State, Report of the State Commissioner of Highways for 1914, 33.

199. New York State, Report of the State Commissioner of Highways for 1914, 32-33.

200. New York State, Report of the State Commissioner of Highways for 1915, 71-73.

201. "Building-Structure Inventory Form for the Hinckley Dam Bridge," collection of the New York State Historic Preservation Office.

202. "Building-Structure Inventory Form for the New Street Bridge," collection of the New York State Historic Preservation Office.

203. New York State, Report of the State Commissioner of Highways for 1921, 23.

204. New York State, Report of the State Commissioner of Highways for 1918, 95.

205. New York State, Report of the State Commissioner of Highways for 1919, 60.

206. Edward D. Lewis, "Historical Data on Roads and Bridges," 1947 manuscript provided with the "Historic Bridge and Road Survey for St. Lawrence County," correspondence file, Mead & Hunt, Inc., 1999.

207. "New York State Highway Bridge Statistics," Engineering News-Record , 90:6 (February 8, 1923), 257.

208. New York State, Report of the State Commission of Highways for 1913, 31.

209. New York State, Report of the State Commissioner of Highways for 1922, 56-57.

210. Watson, 109-10; Plowden, 320-21; and Condit, 259.

211. Andrew S. Dolkart, "Bronx River Parkway Reservation," National Register of Historic Places Nomination (1990).

212. Dolkart.

213. Kathleen LaFrank, "Taconic State Parkway," National Register of Historic Places Nomination (1997).

214. Lay, 314.

215. Robert A. Caro, The Power Broker (New York: Alfred A. Knopf, 1974), 230.

216. Berlow, 16; and Watson, 4.

217. New York State Department of Public Works, Annual Report of the Superintendent for 1936, 97-103.

218. New York State Archives and Records Administration, 309.

219. New York State Department of Public Works, Annual Report of the Superintendent for 1926, 8.

220. New York State Department of Public Works, Annual Report of the Superintendent for 1924, 43.

221. New York State Department of Public Works, Annual Report of the Superintendent for 1925, 15; and New York State Department of Public Works, Annual Report of the Superintendent for 1926, 8.

222. New York State Department of Public Works, Annual Report of the Superintendent for 1925, 15-16; and New York State Department of Public Works, Annual Report of the Superintendent for 1926, 8.

223. New York State Department of Public Works, Annual Report of the Superintendent for 1927, 23; and New York State Department of Public Works, Annual Report of the Superintendent for 1928, 10.

224. Robert M. Stamp, Bridging the Border: The Structures of Canadian-American Relations (Toronto: Dundurn Press, 1992), 81-92; and Watson, 4.

225. New York State Department of Public Works, Annual Report of the Superintendent for 1928, 61, 64-65, 67-68.

226. New York State Department of Public Works, Annual Report of the Superintendent for 1928, 64-65.

227. Edward D. Lewis, “Historical Data on Roads and Bridges,” 1947 manuscript provided with the “Historic Bridge and Road Survey for St. Lawrence County,” correspondence file, Mead & Hunt, Inc., 1999.

228. “Historic Bridge and Road Survey for Tompkins County,” and clippings from the Lansing Historical Association, correspondence file, Mead & Hunt, Inc., 1999.

229. Watson, 19-20.

230. “Bridges Under the Jurisdiction of the Department of Highways,” December 31, 1960, chart in the collection of the New York City Landmarks Preservation Commission files.

231. Henry Billings, Bridges (New York: Viking Press, 1956), 86-87.

232. Watson, 45, 96-97.

233. Watson, 45.

234. New York State Department of Public Works, Annual Report of the Superintendent for 1932, 4, 101.

235. Noting that 1,181 load-restricted bridges remained on the state’s highway system, the department pledged to replace or strengthen the 14 bridges that stood on Class A highways in 1933. If funds allowed, the department sought to rebuild 185 restricted bridges on Class B highways. New York State Department of Public Works, Annual Report of the Superintendent for 1932, 106.

236. New York State Department of Public Works, Annual Report of the Superintendent for 1932, 105.

237. "Historic Bridge and Road Survey for Tioga County," correspondence file, Mead & Hunt, Inc., 1999.

238. "Historic Bridge and Road Survey for Madison County," correspondence file, Mead & Hunt, Inc., 1999.

239. New York State Department of Public Works, Annual Report of the Superintendent for 1932, 106.

240. New York State Department of Public Works, Annual Report of the Superintendent for 1936, 96.

241. Watson, 78-80.

242. New York State Department of Public Works, Annual Report of the Superintendent for 1932, 8, 103; and Watson, 1.

243. New York State Department of Public Works, Annual Report of the Superintendent for 1937, 100.

244. New York State Department of Public Works, Annual Report of the Superintendent for 1940, 97-98.

245. New York State Department of Public Works, Annual Report of the Superintendent for 1936, 97-103.

246. New York State Department of Public Works, Annual Report of the Superintendent for 1927, 5-6; and Watson, 75-76.

247. New York State Department of Public Works, Annual Report of the Superintendent for 1932, 8-9.

248. Billings, 85; New York State Bridge Authority, Report on Twenty-five Years of Operation (N.p., 1958), 9, 11. The New York State Bridge Authority purchased the Bear Mountain Bridge in 1940.

249. Stamp, 78, 108-13.

250. Watson, 28.

251. The north and south bridges were replaced in the 1960s; "Historic Bridge and Road Survey for Erie County," correspondence file, Mead & Hunt, Inc., 1999.

252. Structure was defined as "over five feet in span;" New York State Department of Public Works, Annual Report of the Superintendent for 1936, 92.

253. New York State Department of Public Works, Annual Report of the Superintendent for 1937, 100.

254. Sanchis, 505.

255. New York State Department of Public Works, Annual Report of the Superintendent for 1938, 87, 103-04.

256. Robert Moses, Public Works: A Dangerous Trade (New York: McGraw-Hill, Inc., 1970), 162.

257. John D. Millett, The Works Progress Administration in New York City (Chicago: Public Administration Service, 1938), 206.

258. Kenneth T. Jackson, "Robert Moses and the Planned Environment: A Re-evaluation" in Robert Moses: Single-minded Genius, ed. Joann P. Krieg, (Papers presented at Long Island Studies Conference, Interlaken, N.Y.: Heart of Lakes Publishing, 1989), 21.

259. New York City Department of Transportation, Spanning the 21st Century, 14.

260. Triborough Bridge and Tunnel Authority, Annual Report, 1954 (N.p., 1955).

261. Triborough Bridge and Tunnel Authority, Annual Report, 1954; and Rastorfer, n.p.

262. Triborough Bridge and Tunnel Authority, Annual Report, 1954.

263. Triborough Bridge and Tunnel Authority, Annual Report, 1954.

264. Triborough Bridge and Tunnel Authority, Annual Report, 1954; and Sweeny, n.p.

265. Triborough Bridge and Tunnel Authority, Annual Report, 1954; the low-level bascule bridge was replaced by a high-level fixed bridge in 1970.

266. Watson, 44-51.

267. Rastorfer, n.p.; and Donald L. Jackson, 134.

268. Watson, 1-3.

269. New York City Department of Transportation, Spanning the 21st Century, 26; and MTA Bridges and Tunnels, From the Archive (Winter 1997-98).

270. Shockley, "Carroll Street Bridge."

271. "Bridges Under the Jurisdiction of the Department of Highways," New York City Landmarks Preservation Commission files.

272. New York State Department of Public Works, Annual Report of the Superintendent for 1936, 91, 93; and New York State Department of Public Works, Annual Report of the Superintendent for 1937, 101.

273. New York State Department of Public Works, Annual Report of the Superintendent for 1937, 112.

274. Stamp, 123-28.

275. Billings, 93.

276. New York State Department of Public Works, Annual Report of the Superintendent for 1942, 4.

277. New York State Department of Public Works, Annual Report of the Superintendent for 1943, 110-11.

278. The department did not issue an annual report for 1941. New York State Department of Public Works, Annual Report of the Superintendent for 1942, 4, 102-03.

279. New York State Department of Public Works, Annual Report of the Superintendent for 1944, 57; and New York State Department of Public Works, Annual Report of the Superintendent for 1943, 108-09.

280. New York State Department of Public Works, Annual Report of the Superintendent for 1942, 102-03.

281. New York State Department of Public Works, Annual Report of the Superintendent for 1944, 57.

282. New York State Department of Public Works, Annual Report of the Superintendent for 1943, 110.

283. New York State Department of Public Works, Annual Report of the Superintendent for 1947, 123.

284. New York State Department of Public Works, Annual Report of the Superintendent for 1946, 164.

285. New York State Department of Public Works, Annual Report of the Superintendent for 1946, 93, 97.

286. New York State Department of Public Works, Annual Report of the Superintendent for 1942, 102.

287. New York State Department of Public Works, Annual Report of the Superintendent for 1944, 57.

288. New York State Department of Public Works, Annual Report of the Superintendent for 1946, 95-96.

289. Compiled from New York State Department of Public Works, Annual Report of the Superintendent, for the years 1946-47.

290. New York State Department of Public Works, Annual Report of the Superintendent for 1946, 94.

291. New York State Department of Public Works, Annual Report of the Superintendent for 1946, 95.

292. New York State Department of Public Works, Annual Report of the Superintendent for 1947, 40.

293. New York State Department of Public Works, Annual Report of the Superintendent for 1947, 41.

294. New York State Department of Public Works, Annual Report of the Superintendent for 1947, 42-59, 124.

295. New York State Department of Public Works, Annual Report of the Superintendent for 1947, 121.

296. New York State Department of Public Works, Annual Report of the Superintendent for 1947, 124-25.

297. New York State Bridge Authority. Proposed Kingston-Rhinecliff Bridge, (N.p., 1948), n.p.

298. New York State Bridge Authority, Report on Twenty-five Years of Operation, 5.

299. New York State Bridge Authority. Proposed Kingston-Rhinecliff Bridge, n.p.

300. Billings, 94.

301. New York State Department of Public Works, Annual Report of the Superintendent for 1948, 98, 100.

302. New York State Department of Public Works, Annual Report of the Superintendent for 1950, 66.

303. New York State Department of Public Works, Annual Report of the Superintendent for 1950, 67.

304. New York State Department of Public Works, Annual Report of the Superintendent for 1950, 67-71.

305. New York State Department of Public Works, Annual Report of the Superintendent for 1953, 36.

306. New York State Department of Public Works, Annual Report of the Superintendent for 1951, 35-37.

307. New York State Department of Public Works, Annual Report of the Superintendent for 1953, 36.

308. New York State Department of Public Works, Annual Report of the Superintendent for 1954, 33 and 38.

309. New York State Department of Public Works, Annual Report of the Superintendent for 1955, 40.

310. Billings, 93.

311. New York State Department of Public Works, Annual Report of the Superintendent for 1956, n.p.

312. New York State Department of Public Works, Annual Report of the Superintendent for 1957, 44-45.

313. New York State Department of Public Works, Annual Report of the Superintendent for 1958, 49; and New York State Department of Public Works, Annual Report of the Superintendent for 1959, 55.

314. Stamp, 133-35.

315. New York State Department of Public Works, Annual Report of the Superintendent for 1959, 55.

316. New York State Department of Public Works, Annual Report of the Superintendent for 1960, 53.

317. Stamp, 138-40.

318. New York State Department of Public Works, Annual Report of the Superintendent for 1954, 38.

319. New York State Department of Public Works, Annual Report of the Superintendent for 1960, 53.

320. New York State Bridge Authority, Report on Twenty-five Years of Operation, 6.

321. This bridge is described as “discontinued” in Shockley, “Carroll Street Bridge.”

322. “Bridges Under the Jurisdiction of the Department of Highways,” New York City Landmarks Preservation Commission files.

323. Christopher Bonanos, “The Father of Modern Bridges,” American Heritage of Invention and Technology (Summer 1992), 10-11; and Sharon Reier, The Bridges of New York (New York: Quadrant Press, c. 1977), 96-98.

324. Bonanos, 13; Petroski, 286; and MTA Bridges and Tunnels, From the Archive (Spring 1994).

325. Berlow, 16; Watson, 109-10; and Sanchis, 505.

326. American Society of Civil Engineers, A Biographical Dictionary of American Civil Engineers (New York: ASCE Historical Publication, 1972) , 10-11.

327. Mitchell C. Harrison, New York State’s Prominent and Progressive Men: An Encyclopedia of Contemporaneous Biography (New York: New York Tribune, 1900), 19-20; Shockley, “University Heights Bridge;” and Berlow, 166.

328. Reier, 31.

329. The Department of Bridges of the City of New York, 137-38; American Society of Civil Engineers, 17-18.

330. Emory L. Kemp, “The Fabric of Historic Bridges,” IA: The Journal of the Society for Industrial Archeology 15:2 (1989), 5.

331. Allen, Covered Bridges of the Northeast, 83.

332. Berlow, 164; and Allen, Covered Bridges of the Northeast, 13-14.

333. Plowden, 180, 248; and Shockley, “University Heights Bridge.”

334. American Society of Civil Engineers, 26-27; and Gies, 225-26.

335. Plowden, 72-73, 75-78.

336. Siebel, 8-12; and Berlow, 198.

337. Peter S. Kaufman, "The Public Works of Aymar Embury II in New York City and Long Island," in Robert Moses: Single-minded Genius, ed. Joann P. Krieg, (Papers presented at Long Island Studies Conference, Interlaken, N.Y.: Heart of Lakes Publishing, 1989), 213-15; and MTA Bridges and Tunnels, From the Archive (Winter 1996).

338. Elliot Willensky and Norval White, AIA Guide to New York City (New York: Harcourt Brace Jovanovich, Publishers, 1988), 899; and Peter S. Kaufman, "The Public Works of Aymar Embury II in New York City and Long Island," in Robert Moses: Single-minded Genius, ed. Joann P. Krieg (Papers presented at Long Island Studies Conference, Interlaken, N.Y.: Heart of Lakes Publishing, 1989), 215-16.

339. MTA Bridges and Tunnels, From the Archive (Winter 1997-98).

340. Allan King Sloan, "Discovering Zenas King," Paper presented at the Annual Meeting of the Society for Industrial Archeology, Savannah, Georgia, 5 June 1999.

341. The Department of Bridges of the City of New York, 143; and Shank, 30-31.

342. Plowden, 184, 248.

343. Stamp, 84.

344. American Society of Civil Engineers, 151; and Rosemary Miner Pelkey, Adirondack Bridgebuilder from Charleston: The Life and Times of Robert Codgell Gilchrist (Utica, N.Y.: North Country Books, 1993), 79-87. MacDonald was listed in the New York City directory in 1870 under the heading "Burton and MacDonald, Engineers and Contractors for the construction of iron and wooden bridges."

345. Condit, 253; and Plowden, 318.

346. David P. Billington, Robert Maillart and the Art of Reinforced Concrete (New York; Cambridge, Mass.: Architectural History Foundation, MIT Press, 1990), xii, 116; and David P. Billington, "Building Bridges: Perspectives on Recent Engineering," in Bridges to the Future: A Centennial Celebration of the Brooklyn Bridge, eds. Margaret Latimer, Brooke Hindle, and Melvin Kranzberg, (New York: New York Academy of Sciences, 1984), 316.

347. Gobrecht.

348. Plowden, 298.

349. Melan Arch Construction Company (New York: N.p., [1900?], n.p.

350. Melan Arch Construction Company, n.p.; and HNTB/Steinman, 7-5, 7-6.

351. Stamp, 136.

352. Watson, 76; and New York State Bridge Authority, Report on Twenty-five Years of Operation, n.p.; and Shank, 31-32.

353. Berlow, 202.

354. Plowden, 289-91.

355. The Department of Bridges of the City of New York City, 170; and American Society of Civil Engineers, 92.

356. Caro, 48, 55, 70.

357. Joann P. Krieg, ed., Robert Moses: Single-minded Genius, (Papers presented at Long Island Studies Conference, Interlaken, N.Y.: Heart of Lakes Publishing, 1989), 9-11.

358. Andrew Cole and Charles Scott, “HAER Inventory,” forms for bridges in New York. Historic American Engineering Record, National Park Service, “Court Street Bridge,” HAER No. NY-173.

359. American Society of Civil Engineers, 153.

360. Petroski, 331; and Shockley, “University Heights Bridge.”

361. Petroski, 330-31.

362. American Society of Civil Engineers, 103-04; and Lili Rethi and Edward M. Young, The Great Bridge: The Verrazano-Narrows Bridge (New York: Farrar, Straus & Giroux, 1965), 3.

363. American Society of Civil Engineers, 104-06.

364. Petroski, 80-81.

365. Gies, 215; and Gobrecht.

366. Bonanos, 10-11; The Department of Bridges of the City of New York, 170.

367. Petroski, 322-23.

368. Berlow, 77, 99; and Reier, 11.

369. New York State Bridge Authority, Report on Twenty-five Years of Operation, 15.

370. Stamp, 111, 135.

371. American Society of Civil Engineers, 116; and Kemp, “The Fabric of Historic Bridges,” 14.

372. American Society of Civil Engineers, 116; Cooper, 39-40; and Kemp, “The Fabric of Historic Bridges,” 14.

373. Plowden, 299; and Cole and Scott, “Court Street Bridge,” HAER No. NY-173.

374. Petroski, 198.

375. Petroski, 193-94.

376. Waddell died in 1938, however Hardesty did not change the firm’s name until 1945 after he gained a new partner.

377. Watson, 1, 28, 96-97; MTA Bridges and Tunnels, From the Archive (Winter 1996).

378. New York State Department of Public Works, Annual Report of the Superintendent for 1932, 104; and Stamp, 126.

379. Plowden, 61; Eric DeLony, “The Golden Age of the Iron Bridge,” Invention and Technology (Fall 1994), 20.

380. Allen, Covered Bridges of the Northeast, 84; and American Society of Civil Engineers, 125.

381. Fagan, 11.

382. Engelhart, 61-62; and New York State Department of Public Works, Annual Report of the Superintendent for 1927, 5.

383. Raymond W. Smith, “Hadley ‘Parabolic’ Bridge,” National Register of Historic Places Nomination.

384. Engelhart, 63; and Fagan, 5.

385. Cole and Scott, “Court Street Bridge,” HAER No. NY-173.

386. The final year of operation is unclear, noted as both 1901 and 1914 in Victor C. Darnell, A Directory of American Bridge-Building Companies 1840-1900 (Washington, D.C.: Society for Industrial Archaeology, 1984), 40, 85.

387. Thurber, 24-26.

388. Petrick.

389. Thurber, 34-5, 37.

390. Lynn B. Weaver, Doris Manley, and Paul Huey, “Spangler Bridge,” National Register of Historic Places Nomination.

391. Raymond W. Smith, “Tioronda Bridge,” National Register of Historic Places Nomination.

392. Shockley, “Macomb’s Dam Bridge.”

393. The location of company noted in Darnell as Phoenixville, PA, and in New York State Preservation Office Building-Structure Inventory Form for the “Wood Road Bridge (BIN 2216570)” as Chester, PA.

394. Gobrecht.

395. Fagan, 9, 11.

396. Cole and Scott, “Locust Street Bridge,” HAER No. NY-181.

397. Engelhart, 63-4; Fagan, 5-6; and “Building-Structure Inventory Form for the Hinkley Dam Bridge,” collection of the New York State Historic Preservation Office.

398. “Gilbertsville Historic District,” National Register of Historic Places Nomination.

399. “Warrensburg Mills Historic District,” National Register of Historic Places Nomination.

400. Cole and Scott, “Quantuck Canal Bridge,” HAER No. NY-182.

401. Letter from George H. Vollmuth, received July 9, 1999. In response to NYSDOT Historic Bridge and Road Survey Questionnaire, Correspondence file, Mead & Hunt, Inc., 1999.

402. "Olmsted Parks & Parkways Thematic Resources," National Register of Historic Places Nomination.

403. Engelhart, 74.

404. Engelhart, 67.

405. The Heritage Foundation of Oswego, Inc., "Historic Bridges of Oswego County, New York," pamphlet, n.d., correspondence file, Mead & Hunt, Inc.

406. Raymond W. Smith, "Keeseville Village Multiple Resource Area," National Register of Historic Places Nomination, Listed: 15 March 1983; and Engelhart, 65-6.

407. DeLony, "The Golden Age of the Iron Bridge," 20.

408. The Heritage Foundation of Oswego, Inc.

409. Shockley, "Carroll Street Bridge."

410. Cole and Scott, "Hegeman-Hill Street Bridge," HAER No. NY-153.

411. The Heritage Foundation of Oswego, Inc.

412. J. Gordon Peirson, *The Work of the Bridge Builders* ([London]: Pen-in-Hand, 1948), 100; "Building-Structure Inventory Form for the River Street Warren Truss Bridge," "Building-Structure Inventory Form for the Mill Street Bridge," and "Building-Structure Inventory Form for the Double Intersecting Warren Bridge," collection of the New York State Historic Preservation Office.

413. Peirson, 109-10; and Hungerford, *The Williamsburg Bridge* (Brooklyn, N.Y.: The Eagle Press, 1903), 107.

414. Cole and Scott, "Blood Road Bridge and Woodworth Road Bridge," HAER No. NY-180.

415. Cole and Scott, "Blood Road Bridge and Woodworth Road Bridge," HAER No. NY-180.

416. "Building-Structure Inventory Form for the River Street Pratt Bridge No. 1," "Building-Structure Inventory Form for the River Road Pratt Bridge No. 2," and "Building-Structure Inventory Form for the Valley Road Bridge," collection of the New York State Historic Preservation Office.

417. Jay Shockley, "Empire Building," Landmarks Preservation Commission Designation (June 1996).

418. Gies, 125.

419. Raymond W. Smith, "Kingston-Port Ewan Suspension Bridge," National Register of Historic Places Nomination.

420. Heritage Foundation of Oswego, Inc., n.p.

421. Historical Perspectives, Inc., "Phase IA Archaeological Assessment Report for the Tibbet Gardens Project, Bronx, New York," (January 1987), 18.

422. I.N.P. Stokes, The Iconography of Manhattan Island, 1498-1909 Volume 4, (New York: R.H. Dodd, 1916), 373, 381.

423. Lay, 91.

424. Lay, 64.

425. United States Department of Transportation, Federal Highway Administration, America's Highways 1776-1976: A History of the Federal-Aid Program (Washington, D.C.: United States Department of Transportation, Federal Highway Administration, 1976), 3.

426. Steven S. Levy, "Susquehannah Turnpike," National Register of Historic Places Nomination.

427. Edwin G. Burrows & Mike Wallace, Gotham: A History of New York City to 1898 (New York: Oxford University Press, 1999), 335.

428. Lay, 343-344; A.G. Lichtenstein & Associates, "New Jersey Historic Bridge Survey" (1994), BER-3.

429. United States Department of Transportation, Federal Highway Administration, America's Highways, 11.

430. Lay, 206-7.

431. Lay, 73-7.

432. Lay, 207, 223-27.

433. New York State Office of Parks, Recreation and Historic Preservation, "New York State's Hudson Valley Parkways," The New York State Preservationist, 2:1, (Spring/Summer 1998), 10-11.

434. United States Department of Transportation, Federal Highway Administration, America's Highways, 133.

435. Lay, 164.

436. Lay, 181.

437. United States Department of Transportation, Federal Highway Administration, America's Highways, 44.

438. Lay, 168.

439. Clarkson H. Oglesby and Laurence I. Hewes, Highway Engineering (New York: John Wiley & Sons, Inc., 1963), 3.

440. Lay, 118.

441. United States Department of Transportation, Federal Highway Administration, "Public Roads," 6:1 (Summer 1996); available from http://www.tfhrc.gov/pubrds/summer96, Internet.

442. National Trust for Historic Preservation, "Preserving Historic Bridges," Preservation Information (1995), 3.

443. A.G. Lichtenstein & Associates, 33.

444. Lay, 172.

445. United States Department of Transportation, Federal Highway Administration, America's Highways, 105.

446. Oglesby and Hewes, 6.

447. United States Department of Transportation, Federal Highway Administration, "Public Roads," Internet.

448. A.G. Lichtenstein & Associates, 35.

449. United States Department of Transportation, Federal Highway Administration, "Public Roads," Internet.

450. United States Department of Transportation, Federal Highway Administration, America's Highways, 135.

451. Dave Schul, "North American Auto Trails: Introduction," available from http://www.falcon.cc.ukans.edu/~dschul/trails/intro.html, Internet.

452. United States Department of Transportation, Federal Highway Administration, America's Highways, 123; and Bruce E. Seely, Building the American Highway System (Philadelphia: Temple University Press, 1987), 88.

453. A.G. Lichtenstein & Associates, 36; and Seely, 89-96.

454. Oglesby and Hewes, 8; and Seely, 97.

455. United States Department of Transportation, Federal Highway Administration, "Public Roads," Internet.

456. Lay, 98-99.

457. Lay, 317.

458. Lay, 98-99.

459. United States Department of Transportation, Federal Highway Administration, "Public Roads," Internet.

460. Lay, 317.

461. "Connecticut Department of Transportation 100 Year History," available from http://www.state.ct.us/dot/about, Internet.

462. Caro, 921.

463. Lay 317-318; Caro, 921.

464. New York State Office of Parks, Recreation and Historic Preservation, 11.

465. Lay, 315-316, 321-322.

466. New York State Archives and Records Administration, 307.

467. Oglesby and Hewes, 5.

468. New York State Archives and Records Administration, 307.

469. Lilian Steele Munson, Syracuse, the City that Salt Built (New York: Pageant Press International Corp., 1969), 91.

470. Edward Robb Ellis, The Epic of New York City (New York: Old Town Books, 1966), 223.

471. United States Department of Transportation, Federal Highway Administration, America's Highways, 10; Burrows and Wallace, 335.

472. New York State Archives and Records Administration, 30

473. New York State State Engineer and Surveyor, "State Engineer and Surveyor Sub-Agency History Record," 1, 3.

474. New York State, Report of the State Commission of Highways for 1909, vii-ix.

475. Ellis, David M., and others, A History of New York State (Ithaca, N.Y.: Cornell University Press, 1967), 562.

476. Ellis and others, 382.

477. New York State, Report of the State Commission of Highways for 1909, vii-ix, 8.

478. New York State, Report of the State Commissioner of Highways for 1914, 92.

479. New York State Archives and Records Administration, 308.

480. Neil Larson, "Metal Truss Bridges of Tompkins County, New York," National Register of Historic Places Nomination.

481. New York State, Report of the State Commission of Highways for 1917, 46-47.

482. New York State, Report of the State Commissioner of Highways for 1918, 41.

483. New York State, Report of the State Commissioner of Highways for 1920, 20-21.

484. New York State, Report of the State Commissioner of Highways for 1920, 20-21; and New York State, Report of the State Commissioner of Highways for 1921, 29.

485. New York State, Report of the State Commissioner of Highways for 1920, 11.

486. New York State, Report of the State Commissioner of Highways for 1920, 21-22.

487. New York State, Report of the State Commissioner of Highways for 1919, 13, 22; and New York State, Report of the State Commissioner of Highways for 1920, 22.

488. New York State, Report of the State Commissioner of Highways for 1921, 13.

489. New York State, Report of the State Commission of Highways for 1920, 15.

490. New York State, Report of the State Commissioner of Highways for 1921, 14-15; and New York State, Report of the State Commissioner of Highways for 1922, 12.

491. New York State, Report of the State Commission of Highways for 1920,15, 16; and Ellis, et al., 406.

492. Ellis, et al., 393.

493. New York State Archives and Records Administration, 309.

494. New York State Department of Public Works, Annual Report of the Superintendent for 1924, 43.

495. New York State Archives and Records Administration, 309.

496. New York State Department of Public Works, Annual Report of the Superintendent for 1923, 23.

497. New York State Department of Public Works, Annual Report of the Superintendent for 1924, 42.

498. New York State Department of Public Works, Annual Report of the Superintendent for 1924, 42.

499. New York State Department of Public Works, Annual Report of the Superintendent for 1924, 9, 42.

500. Rand McNally, Main Highway Map of New York, (Rand McNally, 1923); Rand McNally, Official 1925 Auto Trails Map of New York, (Rand McNally, 1925).

501. New York State Department of Public Works, Annual Report of the Superintendent for 1928, 59.

502. "Historic Bridge and Road Survey for St. Lawrence County," correspondence file, Mead & Hunt, Inc., 1999.

503. New York State Department of Public Works, Annual Report of the Superintendent for 1943, 4.

504. United States Department of Transportation, Federal Highway Administration, America's Highways, 150.

505. New York State Department of Public Works, Annual Report of the Superintendent for 1947, 40.

506. New York State Department of Public Works, Annual Report of the Superintendent for 1958, 43.

507. New York State Department of Public Works, Annual Report of the Superintendent for 1960, 48.

508. New York State Archives and Records Administration, 309.

509. New York State Office of Parks, Recreation and Historic Preservation, 10.

510. Ellis, et al., 563.

511. New York State Department of Public Works, Annual Report of the Superintendent for 1946, 92.

512. Caro, 11; and United States Department of Transportation, Federal Highway Administration, Public Roads: Special Edition 1996; 40th Anniversary of the Interstate System, (Washington, D.C.: Federal Highway Administration, 1996), 39.

513. In 1964 the legislature approved naming the thruway system "The Governor Thomas E. Dewey Thruway." The thruway is also part of the 43,000-mile network designated by Congress in 1990 as the "Dwight D. Eisenhower System of Interstate and Defense Highways;" New York State Thruway Web Site, available from http://www.thruway.state.ny.us, Internet.

514. New York State Thruway, Internet.

515. United States Department of Transportation, Federal Highway Administration, America's Highways, 7.

516. Michael S. Raber, "Colgate & Company: Office Building," (Draft Historic American Engineering Record, 1988), 3.

517. A.G. Lichtenstein & Associates, 19.

518. Vincent F. Seyfried, 300 Years of Long Island City 1630-1930 (Garden City, N.Y.: Edgian Press, Inc., 1984), 12.

519. Seyfried, 15.

520. Louise Hasbrouck Zimm, Rev. A. Elwood Corning, Joseph W. Emsley, and Willitt C. Jewell, eds., Southeastern New York: A History of the Counties of Ulster, Dutchess, Orange, Rockland, and Putnam, Volume II (New York: Lewis Historical Publishing Company, Inc., 1946), 865.

521. Franklin H. Chase, Syracuse and Its Environs: A History, Volume I (New York: Lewis Historical Publishing Company, Inc., 1924), 91.

522. National Park Service, New York State Canals Special Resource Study: Preliminary Findings – Significance Statements (Washington, D.C.: U.S. Department of the Interior, n.d.), 1-2.

523. New York State Canal Corporation, "Unlock the Legend of The New York State Canal System." Pamphlet, 1999.

524. New York State Canal Corporation.

525. National Park Service, 11.

526. "Unlock the Legend: New York State's Canal System," on the New York State Canal Corporation's Web Site, available from http://www.canals.state.ny.us, Internet.

527. James Eldridge Quinlan, History of Sullivan County (South Fallsburg, N.Y.: Marielle Press, 1993), 118.

528. "Development and Administration of New York's Canal System" on the New York State Archives and Records Administration Web Site, available from http://www/sara/nysed.gov/holding/aids/canal/dev.htm, Internet.

529. New York State Archives and Records Administration, 308.

530. "Unlock the Legend: New York State's Canal System," Internet.

531. "Development and Administration of New York's Canal System," Internet.

532. New York State Department of Public Works, Annual Report of the Superintendent for 1927, 23; New York State Department of Public Works, Annual Report of the Superintendent for 1928, 10.

533. National Park Service, 5.

534. Munson, 260.

535. Ellis, 259.

536. Burrows & Wallace, 564.

537. Ellis, 259.

538. Burrows & Wallace, 567.

539. Burrows & Wallace, 873.

540. National Park Service, 3.

541. A.G. Lichtenstein & Associates, 26.

542. New York State Archives and Records Administration, 309.

543. Richard C. Brown and Bob Watson, Buffalo, Lake City in Niagara Land: An Illustrated History (Woodland Hills, Calif.: Windsor Publications, 1981), 152.

544. "The Peace Bridge Overview," on the Peace Bridge Web Site, available from http://www.peacebridge.com/overview.html, Internet.

545. Stamp, 78, 108-113.

546. Caro, 345.

547. Stamp, 123-28.

548. "Footpaths to Freeways: The Story of Ontario's Roads," on the Ontario Ministry of Transportation Web Site, available from http://www.mto.gov.on.ca/english/about/footpaths/queen.htm, Internet.

549. "FHWA By Day—August 30," on the Federal Highway Administration Web Site, available from http://www.fhinter.fhwa.dot.gov/fhwabyday, Internet.

550. United States Department of Transportation, Federal Highway Administration, Office of Program Administration. Listing of PR-511 File supplied on July 22, 1999.

551. Stamp, 138-40.

552. St. Lawrence Seaway Development Corporation, "A History of the Great Lakes Seaway System," on the United States Department of Transportation Web Site, available on http://www.dot.gov/slsdc/about/exthist.html, Internet.

553. United States Department of Transportation, Federal Highway Administration, America's Highways, 6; and Lay, 91.

554. "Connecticut Department of Transportation 100 Year History," Internet.

555. "Connecticut Department of Transportation 100 Year History," Internet.

556. Parsons, Brinckerhoff, Hall & Macdonald. Albany Waterfront Arterial Highways (New York: Parsons, Brinckerhoff, Hogan & Macdonald, 1946), n.p.

557. Lay, 91; and A.G. Lichtenstein & Associates, Inc., SUS-1.

558. E.M. Ruttenber and L.H. Clark, History of Orange County New York (Philadelphia: Everts & Peck, 1881), 110.

559. A.G. Lichtenstein & Associates, BER-2.

560. New York State Bridge and Tunnel Commission, Report of the New York State Bridge and Tunnel Commission for 1920, 3, 4.

561. Eric Homberger, The Historical Atlas of New York City (New York: Henry Holt and Company, 1994), 144.

562. Petroski, 254.

563. A.G. Lichtenstein & Associates, BER-9.

564. United States Coast Guard, "Staten Island Bridges Program: Modernization and Capacity Enhancement Project Final Environmental Impact Statement/Section 4(f) Statement," Volume 1, (October 1997), 4-36.

565. United States Coast Guard, 2-1.

566. Caro, 345.

567. Kenneth T. Jackson, ed., The Encyclopedia of New York City (New Haven, Conn.: Yale University Press, 1995), 678.

568. Kathleen LaFrank and Susan E. Smith, "Palisades Interstate Parkway," National Register of Historic Places Nomination (1998).

569. LaFrank and Smith.

570. Ruttenber and Clark, 113; and Quinlan, 129.

571. Quinlan, 129.

572. New York State Department of Public Works, Annual Report of the Superintendent for 1924, 45.

573. "Historic Bridges and Roads," Vermont Agency of Transportation, correspondence file, Mead & Hunt, Inc., 1999.

574. Lake Champlain Transportation Company, "Lake Champlain Ferries," pamphlet (N.p., 1999).

575. Ruttenber and Clark, 110-11; and "Historic Bridge and Road Survey for Orange County," correspondence file, Mead & Hunt, Inc., 1999.

576. Zimm, et al., 859.

577. Ruttenber and Clark, 111.

578. Levy.

579. Quinlan, 96-97.

580. Ruttenber and Clark, 111-16.

581. Quinlan, 110.

582. Zimm, et al., 860-62.

583. "Historic Bridge and Road Survey for Columbia County," correspondence file, Mead & Hunt, Inc., 1999.

584. Nelson Greene, ed., History of the Valley of the Hudson, River of Destiny, 1609-1930 (Chicago: The S.J. Clarke Publishing Co., 1931), 49.

585. Ruttenber and Clark, 124.

586. New York State Office of Parks, Recreation and Historic Preservation, 10.

587. New York State Office of Parks, Recreation and Historic Preservation, 10.

588. Dolkart.

589. LaFrank, “Bronx River Parkway Reservation,” National Register of Historic Places Nomination (1990).

590. Dolkart.

591. New York State Office of Parks, Recreation and Historic Preservation, 10.

592. Steve Anderson, “The Roads of Metro New York,” on The Complete Guide to New York Area Roads, Crossings and Exits Web Site, available from http://www.nycroads.com/roads; Internet.

593. LaFrank, “Taconic State Parkway.”

594. LaFrank, “Taconic State Parkway.”

595. LaFrank, “Taconic State Parkway.”

596. C.S. Hammond & Co., Auto Route Atlas of New Jersey and New York, (C.S. Hammond & Co., 1920); Rand McNally, Main Highway Map of New York; and Rand McNally, Official 1925 Auto Trails Map of New York.

597. New York State, Report of the State Commissioner of Highways for 1920, 18.

598. New York State Bridge Authority Web Site, Internet.

599. Sanchis, 503; New York State Thruway Web Site, Internet.

600. Hagstrom, Map of Sullivan County, New York, 1958.

601. New York State Bridge Authority, Report on Twenty-five Years of Operation, 1958, 4.

602. New York State Bridge Authority Web Site, Internet.

603. New York State Bridge Authority, Report on Twenty-five Years of Operation, 1958, 4.

604. New York State Bridge Authority, Report on Twenty-five Years of Operation, 1958, 5.

605. Historical Perspectives, “Phase IA Archaeological Impact Report for the Atlantic Terminal and Brooklyn Center Projects, Brooklyn, New York,” November 1985, 11.

606. Seyfried, 63.

607. Newsday, Long Island: Our Story (Canada: Newsday, Inc., 1998), 389.

608. Newsday, 84.

609. “Historic Bridge and Road Survey for Suffolk County,” correspondence file, Mead & Hunt, Inc., 1999.

610. Newsday, 389.

611. Newsday, 256-260.

612. J. Lance Mallamo, "Building the Roads to Greatness: Robert Moses and Long Island's State Parkways," in *Robert Moses: Single-minded Genius*, ed. Joann P. Krieg (Papers presented at Long Island Studies Conference, Interlaken, N.Y.: Heart of Lakes Publishing, 1989), 159.

613. Mallamo, 161.

614. Mallamo, 165.

615. Newsday, 361.

616. Caro, 485, 362, 616.

617. Mallamo, 161.

618. Newsday, 389.

619. New York State Department of Public Works, *Annual Report of the Superintendent for 1928*, 61.

620. New York State Department of Public Works, *Annual Report of the Superintendent for 1960*, 53.

621. "Revolutionary Trail: Scenic Byways of the Adirondack North Country," on the Adirondack North Country Association's (ANCA) Web Site, available from http://www.adirondack.net/history/history.html, Internet.

622. Engelhart, 2.

623. Engelhart, 5.

624. "Historic Bridge and Road Survey for Clinton County," correspondence file, Mead & Hunt, Inc., 1999.

625. "Historic Bridge and Road Survey for St. Lawrence County," correspondence file, Mead & Hunt, Inc., 1999.

626. "Historic Bridge and Road Survey for Oswego County," correspondence file, Mead & Hunt, Inc., 1999.

627. Engelhart, 3.

628. Engelhart, 1, 3.

629. "Historic Bridge and Road Survey for St. Lawrence County," correspondence file, Mead & Hunt, Inc., 1999.

630. "Historic Bridge and Road Survey for St. Lawrence County," correspondence file, Mead & Hunt, Inc., 1999.

631. New York State Department of Public Works, *Annual Report of the Superintendent for 1928*, 60.

632. New York State, *Report of the State Commissioner of Highways for 1917*, 46.

633. New York State Department of Public Works, *Annual Report of the Superintendent for 1928*, 60.

634. New York State Department of Public Works, Annual Report of the Superintendent for 1928, 60.

635. New York State, Report of the State Commissioner of Highways for 1922, 13.

636. New York State Department of Public Works, Annual Report of the Superintendent for 1928, 60.

637. Lay, 7.

638. Larson.

639. Larson.

640. Munson, 92.

641. "Historic Bridge and Road Survey for Clinton County," correspondence file, Mead & Hunt, Inc., 1999.

642. "Historic Bridge and Road Survey for Onondaga County," correspondence file, Mead & Hunt, Inc., 1999.

643. Larson.

644. "Historic Bridge and Road Survey for Tompkins County," correspondence file, Mead & Hunt, Inc., 1999.

645. "Historic Bridge and Road Survey for Oswego County," correspondence file, Mead & Hunt, Inc., 1999.

646. "Historic Bridge and Road Survey for Onondaga County," correspondence file, Mead & Hunt, Inc., 1999.

647. New York State, Report of the State Commissioner of Highways for 1922, 13.

648. Caro, 345.

649. New York State Department of Public Works, Annual Report of the Superintendent for 1938, 88.

650. New York State Department of Public Works, Annual Report of the Superintendent for 1957, 4.

651. Burrows & Wallace, 6-8.

652. Burrows & Wallace, 110.

653. Historical Perspectives, Inc., "Phase IA Archaeological Assessment Report for the Tibbet Gardens Project," 18.

654. Burrows & Wallace, 184.

655. Burrows & Wallace, 138-39.

656. Burrows & Wallace, 184.

657. Homberger, 57.

658. Homberger, 68.

659. Homberger, 57-58; and Ellis, 1; Kenneth T. Jackson, ed., The Encyclopedia of New York City, 1131.

660. Burrows & Wallace, 364.

661. Shockley, "Macomb's Dam."

662. Ellis, 197.

663. "Historic Bridge and Road Survey for Richmond County," correspondence file, Mead & Hunt, Inc., 1999.

664. Ellis, 202; Stokes, Vol. 3, 477-78; and Kenneth T. Jackson, ed., The Encyclopedia of New York City, 510.

665. Historical Perspectives, Inc., "Phase IA Archaeological Assessment Report for the Tibbet Gardens Project," 17-18.

666. Seyfried, 12, 15.

667. Petroski, 315.

668. Historical Perspectives, Inc., "Phase IA Archaeological Assessment Report for the Atlantic Terminal and Brooklyn Center Projects," 12.

669. Ellis, 258-59.

670. Burrows & Wallace, 656.

671. Burrows & Wallace, 937, 1132.

672. Kenneth T. Jackson, ed., The Encyclopedia of New York City, 1114.

673. Stokes, Vol. 3, 751-752.

674. Stokes, Vol. 5, 1938.

675. Stokes, Vol. 3, 763.

676. New York City Department of Parks, New Parkways in New York City (New York: Department of Parks, 1937), 4-5.

677. New York City Department of Parks, 19.

678. Caro, 520.

679. Caro, 522, 925.

680. Stokes, Vol. 5, 1938.

681. Kenneth T. Jackson, ed., The Encyclopedia of New York City, 137.

682. Stokes, Vol. 3, 800-801, 827.

683. Stokes, Vol. 5, 1901.

684. Stokes, Vol. 3, 1903.

685. Robert A. M. Stern, Gregory Gilmartin, and Thomas Mellins, New York 1930 (New York: Rizzoli International Publications, Inc., 1987), 44.

686. Stern, Gilmartin, and Mellins, 41-45.

687. Stern, Gilmartin, and Mellins, 700.

688. Anderson, Internet.

689. Stern, Gilmartin, and Mellins, 716.

690. Caro, 885.

691. Caro, 925.

692. Caro, 885.

693. Caro, 925.

694. Caro, 709.

695. Anderson, Internet.

696. Kenneth T. Jackson, ed., The Encyclopedia of New York City, 1265.

697. Homberger, 109.

698. Kenneth T. Jackson, ed., The Encyclopedia of New York City, 970.

699. Caro, 345.

700. Kenneth T. Jackson, ed., The Encyclopedia of New York City, 1200.

701. Triborough Bridge and Tunnel Authority, Annual Report, 1954.

702. Petroski, 288.

703. Caro, 844.

704. Caro, 693.

705. Triborough Bridge and Tunnel Authority, Annual Report, 1958; Petroski, 309.

706. Caro, 925, 844.

707. Caro, 331.

708. Federal Writers' Project of the Works Progress Administration, Albany Guide (Albany, N.Y., 1937), 1.

709. John J. McEneny, Albany: Capital City on the Hudson (Woodland Hills, Calif.: Windsor Publications, 1981), 14.

710. McEneny, 14.

711. McEneny, 14.

712. McEneny, 14.

713. F.W. Beers & Co., Illustrated Historical Atlas of Erie Co, New-York from actual surveys and records (New York: F.W. Beers & Co., 1866; G.M. Hopkins Co., 1876).

714. McEneny, 14.

715. McEneny, 16; and Burrows & Wallace, 873.

716. McEneny, 21.

717. "1911 Series of maps: Albany County," N.p., 1911.

718. McEneny, 27.

719. Parsons, Brinckerhoff, Hall & Macdonald, n.p.

720. New York State Department of Public Works, Annual Report of the Superintendent for 1960, 53; and "FHWA By Day – August 30," on the Federal Highway Administration Web Site, available from http://www.fhinter.fhwa.dot.gov/fhwabyday, Internet.

721. Chase, 2, 23, 25, 37.

722. Munson, 92, 121.

723. Chase, 38.

724. Chase, 42-43.

725. Chase, 170-71.

726. Chase, 173.

727. Stoddard & Babcock, Onondaga County & Adjacent Territory (Syracuse, N.Y.: Stoddard & Babcock, 1848).

728. Chase, 170.

729. Chase, 175.

730. Chase, 15-18.

731. R.B. Traver, Map of Onondaga County, New York (Onondaga County Department of Highways, 1927).

732. Munson, 321.

733. Harland Bartholomew & Associates, A Major Street Plan for Rochester New York (Rochester, N.Y.: Leo Hart Company, 1929), 11.

734. Harland Bartholomew & Associates, 9.

735. Harland Bartholomew & Associates, 9.

736. Edward Hungerford, Rochester: A Good Town to Live In (Rochester, N.Y.: University of Rochester, 1923), 9; C.L. Bugbeel, County of Monroe, from Actual Survey, (N.p., 1826).

737. P.J. Browne, P.J. Browne's Map of Monroe County, New York, (N.p., 1852).

738. Hungerford, 17-18.

739. Erastus Darrow, Map of Monroe County, (N.p., 1903).

740. "1911 Series of Maps: Monroe County," N.p., 1911.

741. Harland Bartholomew & Associates, 9.

742. Hungerford, 5.

743. Hungerford, 36.

744. Hungerford, 7-8.

745. Brown and Watson, 15.

746. Brown and Watson, 10, 44.

747. Brown and Watson, n.p.

748. New York State Department of Public Works, Annual Report of the Superintendent for 1928, 64.

749. Samuel Geil, Map of Erie County, New York From Actual Surveys (Philadelphia: Gillette Matthews & Co., 1855).

750. S.N. & D.G. Beers, New Topographical Atlas of the Counties of Albany and Schenectady, New York (Philadelphia: Stone & Stewart Publishers, 1866).

751. F.W. Beers & Co.

752. Brown and Watson, 110.

753. Buell & Wilgus, Complete Road Map of Erie County and Part of Niagara County, N.Y. (Buffalo, 1891).

754. Broderick, Stanton M., "Olmsted Parks in Buffalo, New York," available from http://www.geocities.com/Heartland/7172/index.html, Internet.

755. F.W. Beers & Co.

756. Brown and Watson, 168.

757. "1911 Series of Maps: Erie County," N.p., 1911.