Paper No. 31

Machinery/Mechanics

Swing Bridges over the Lower Harlem River New York City

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TENTH BIENNIAL SYMPOSIUM

OCTOBER 25 - 28, 2004 The Omni Orlando Resort at ChampionsGate The five swing bridges over the Lower Harlem River, owned by New York City Department of Transportation, were all built around the turn of the century, and form a unique and compelling riverscape. Their history is linked to significant developments in economic growth, planning, government and transportation. The bridges were constructed in conjunction with the development of the Harlem River Shipping Canal, which was intended to provide an unobstructed shipping route around the northern tip of Manhattan.

The decisions currently being made regarding preservation, rehabilitation and replacement of the bridges are based on current functional needs, as well as the bridges' historical significance. The following will examine the history and original intention of the bridges, as well as the current demands and implications of the future of the Lower Harlem River bridges. The bridges, from north to south, include:

Macombs Dam (1895) 145th Street (1905) Madison Avenue (1910) Third Avenue (1898) Willis Avenue (1901)



Lower Harlem River – circa 1871

History: Existing Bridges Prior to 1871

No marine link existed between the Harlem River and the Hudson River. The Harlem River was a tidal estuary, separated in its northern reaches from the adjacent Hudson River estuary by a north-south ridge. The estuaries flowed in the opposite directions from each other. Hence, there was a limited exchange of water during high tide at Kingsbridge.

Prior to 1871, crossings over the Hudson River and Harlem River estuaries at the northern tip of Manhattan, included a toll bridge at Kingsbridge Landing (near the current Broadway Bridge), first erected in 1693, and a free crossing at Spuyten Dyvil, also built in 1693. These bridges, each about five feet above high tide obstructed marine traffic.

The first bridge along the Lower Harlem River, called the Coles Bridge, was built over a dam at **Third Avenue** and opened to traffic in 1797. It connected New York to the Bronx, and eventually to Boston via the Boston Post Road. The dam captured tidal power for operation of the gristmills along the banks of the estuaries. The toll bridge had a lock eight feet wide. The lock included a movable draw span and allowed for the passage of vessels with fixed standing masts. This was the Harlem River's first movable bridge. It was replaced in 1868 by an iron swing bridge, the second **Third Avenue Bridge**, and was built under the jurisdiction of the Harlem River Bridge Commission. The replacement bridge was operated by water power from the nearby Croton Aqueduct. It had a 218' swing span with two 80' wide navigation channels.





The first bridge at the **Macombs Dam** was opened in 1814 and was commissioned by Alexander Macombs. It provided a dam and a toll road, connecting Mr. Macombs' land in Bussing's Point in the Bronx to his gristmill at Devoe's Point in Manhattan. The high tide from the East River was admitted through the dam gates and the ebb tide flowing toward the Hudson River provided power to the gristmill. The tolls on the bridge and its obstruction of marine traffic angered many users. It was destroyed in 1839 when Lewis Morris of Westchester County intentionally forced his vessel through the dam. In 1861, it was replaced with a swing bridge and referred to as the **Central Bridge**. This bridge, built by the Harlem River Bridge Commission, was an iron and wood

bridge with a swing span of 210' allowing two 60' navigation channels.

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Lower Harlem River 1871-1895

History

Around 1871, tide mills were in operation on the Harlem River and Hudson River estuaries, with some supporting stonecutting for the quarries in the Marble Hill vicinity. Iron works and other industrial waterway users existed along both banks. There was a trade of foodstuffs and other farm products via the estuaries between the city and Westchester County (which included the Bronx: the western portion was incorporated into the city in 1874; the remainder 1914).

In the early 1870's, the New York, New Haven and Hartford Railroad completed the Hartford Line from New Rochelle to a terminal in the Bronx, setting the stage for further industrial development along the Harlem River.

As a response to the bustling industrial economy, the Army Corp of Engineers began plans for the Harlem River Ship Canal in 1871. This canal, between the Hudson River and the Harlem River, could facilitate marine traffic around the northern tip of Manhattan. The main elements, approved in 1886, provided for a 400' wide channel and a 15' depth at mean low water. The canal opened in 1895; however, unfinished portions inhibited passage of larger vessels north of the **Macombs Dam** (Central Bridge). In fact, the Harlem River Ship Canal was not completed until 1938. In 1891, the United States Department of War, under powers granted to it by Congress three years earlier, dictated that all new and existing crossings over the Harlem River must have a 24' clearance in the closed position to minimize openings.

Rail access increased during this period of the late 19th century. Railroads served the massive industrial development on the Bronx side of the Harlem River and provided links for passengers and freight to upstate New York and New England. The New York, New Haven and Harlem Lines established car floating facilities on the future site of the **Willis Avenue Bridge**. In the mid 1870's, the Port Morris Railroad commenced service between the Hudson River Line and the Mott Haven Terminal in the Bronx. In 1880, New York City and Northern Railroad's Line was completed terminating in the Bronx. In 1881, construction of an elevated railway at 8th Avenue and 155th Street over the Harlem River provided passenger rail service to Harlem, and connecting to the Highbridge Terminal in the Bronx.

Bridges

In 1871, the Harlem River Bridges, including **Third Avenue** and **Macombs Dam (Central)**, were placed under the jurisdiction of the New York City Department of Public Parks, an agency created in 1870. The Department of Public Parks replaced the Board of Commissioners of Central Park, and had broad responsibilities in planning and infrastructure development. The Department of Public Parks completed the construction of Central Park, built Riverside Park, and re-landscaped many other Manhattan Parks. By 1874, the Department of Public Parks established plans for an integrated system of parks, roads, sewers and water mains in upper Manhattan and the Bronx. The DPP also built the Harlem River Speedway, from the **Macombs Dam (Central) Bridge** at 155th Street north to 208th Street. Horse drawn carriages used the speedway, which was flanked by trees and pedestrian walkways, and laid the foundation for future site of Harlem River Dive.

After much discussion regarding size and location, the plans for the first bridge at Madison Avenue were



designed by Alfred P. Boller and General Newton for the New York City Department of Public Parks. The bridge was built to increase traffic capacity. This iron swing bridge opened in 1884. It had a 300' swing span with two 122 _' navigation channels. The vertical clearance met the new 24'standard. The following year, horse drawn trolley service across the bridge began, until it was converted to electric power in 1892. While the bridge was under the jurisdiction of the Department of Public Parks, a number of improvements were undertaken, including new machinery, structural reinforcement and painting of the bridge.

When New York City Department of Public Parks inherited the **Macombs Dam Bridge** (Central Bridge) in 1871, it was severely deteriorated. In the mid 1870's, the Parks Department undertook a major reconstruction: reconstructing the swing span tower, replacing the wooden planks, and repainting the entire structure. Despite these improvements, over the next few years, the bridge continued to decline. Temporary supports with piers were constructed at weak points. Wooden cords of the flanking Howe trusses had rotted and were replaced with iron trusses. The bridge was often closed to traffic to allow for emergency repairs. By 1890, the Department of Public Parks commissioned Alfred P. Boller to design a new bridge. The old bridge was closed to traffic and a temporary bridge was erected one block north.

The new bridge was built in conjunction with the Army Corp of Engineers' Project to construct the Harlem River Ship Canal. In 1895, the bridge opened to traffic and reverted to its original name, **Macombs Dam Bridge**. The bridge was operated by steam and gas lit until it was converted to electric power in 1904. It had a long 415' swing span, providing two 150' channels. The 24' clearance was maintained. It was 60' wide with a 40' wide roadway.





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Under the jurisdiction of the Department of Public Parks, trolley tracks were added to the **Third Avenue Bridge** to provide the first passenger traffic over the Harlem River. The trolley was team powered until an overhead trolley system was added in 1891. By 1886, a replacement bridge at **Third Avenue** was being considered. The existing bridge, which had opened only 18 years before in 1868, was quickly becoming obsolete due to the increased road and river traffic which was causing increased maintenance. The hydraulic turning mechanism was too slow for the frequent openings required for the river traffic and a steam engine was substituted. Increased loads, along with 100 tons of iron ornamentation, exceeded its structural capacity. It did not meet the new requirement of 24' of clearance. The Parks Department determined that the bridge was no longer adequate for the traffic it was carrying and that it was an obstruction to navigation. As a result, a new bridge was commissioned by the Department of Parks and construction was authorized in 1891. It was designed by Thomas C. Clarke and was opened in 1898 under the jurisdiction of the newly established Department of Bridges.

In 1895, the New York State Legislature provided for the construction of a new bridge at **145th Street** to connect growing residential neighborhoods in Harlem with industrial areas in the South Bronx. The location of this bridge filled in the 1 mile gap between the bridges at **Macombs Dam** and **Third Avenue**. Plans were initiated by the Department of Public Parks, which retained architects, Messrs. Clinton and Russel, to design a new bridge. This preliminary design was approved by the Department of War and the New York Board of Estimates. In 1898, responsibility was transferred to the newly created Department of Bridges, which had the bridge redesigned by engineers and built.



Lower Harlem River 1895-1910

History

In 1895, New York City established the Department of Bridges, which assumed responsibility for the Harlem River Bridges from the Department of Public Parks. Simultaneous with ambitious projects on the Lower Harlem Bridges, the new department also built four suspension bridges over the East River during this period, demonstrating its commitment to bridge design.

In 1898, with the consolidation of New York City, the New York City Art Commission was established. This new commission, which approved all plans for major river crossings, became very influential in approving bridge design.

Bridges

In 1898, the Department of Bridges opened the **Third Avenue Bridge**, which had been designed by Thomas Clarke and commissioned by the Department of Public Parks. It had a 300' swing span with two 102' wide channels and a 25' clearance in the closed position. Rail service operated on the bridge until 1953.



In 1898, the architects who had prepared the preliminary plans for **145th Street** were replaced by engineers, Professor William H. Burr and Alfred P. Boller. Mr. Boller also designed the bridges at **Madison Avenue**, **Macombs Dam** and **University Heights**. Based on lessons learned from the **Macombs Dam Bridge**, changes were made to improve the economy of the bridge, including reducing the swing span from 400' to 300', increasing the width of the bridge from 70' to 90', using steel and reinforced concrete approaches in lieu of earthen-filled masonry, and eliminating almost all ornamentation. The machinery utilized electric power rather than steam. **145th Street Bridge** opened to traffic in 1905. Under the Department of Bridges, there was a new focus on engineering economy and less of a focus on aesthetics and ornamentation, which had been cultivated by the Department of Public Parks.

When the Department of Bridges received jurisdiction, a new bridge at **Willis Avenue** had already been approved by the New York City Board of Estimates. The site chosen was at the location of the car transfer for the New York, New Haven and Hartford Line. Negotiations with the railroad were unsuccessful, delaying construction until legislation could be passed permitting the city to acquire the right-of-way. Thomas C. Clarke, who also designed **Third Avenue Bridge**, was commissioned to design the new bridge. **Willis Avenue Bridge** opened in 1901. The bridge had a 304' swing span with two 108' wide channels and the required 24' clearance, conforming to the new requirements of the Department of War. In 1910, electric lighting, electric motors and gate houses on the rest piers were added.



During this period, the Interborough Rapid Transit (IRT) began running trolley service across the **Macombs Dam Bridge.** With the consolidation of New York City, there was a greater demand for easier access into Manhattan. The trolley services continued until 1918 when the IRT built a new parallel span, the Sedwick Avenue Bridge.

When the Department of Bridges assumed jurisdiction over **Madison Avenue Bridge**, it was determined that although the bridge was structurally sound, it did not meet the capacity for the growing bridge traffic. The department commissioned Alfred P. Boller, who had designed the original bridge, as well as **145th Street Bridge**, to design the replacement bridge. The Army Corp approved the new bridge in 1905, and two years later, the New York City Art Commission approved the bridge. The new swing bridge maintained the previous bridge's 122 _' channels, as well as the 24' vertical clearance. The new bridge, with two 27' wide roadways and two 9' wide sidewalks, doubled the capacity of the original bridge. This bridge still had considerable ornamental ironwork, including four spires at the center of the swing span. New building methods, including reinforced concrete approaches, were used in lieu of the earthen fill granite masonry of the previous bridge for economy of engineering and to minimize maintenance. During the two and one-half years of construction, traffic was carried on a temporary timber and iron bridge located adjacent to the new bridge. The bridge opened in 1910 and continues to occupy the site. Although it was designed to accommodate trolley traffic, it never carried out its original function.

1910-1990

In 1938, the Harlem River Ship Canal was ultimately completed after title to a parcel of underwater land was obtained from Johnson Iron Works. An unobstructed marine waterway around the tip of northern Manhattan was finally established. However, industrial activity had peaked and started its long decline. The need for the canal was no longer crucial to economic development. By World War II, waterfront operators were in decline. By 1978, only five commercial waterfront sites were active.

Throughout this period from 1910-1990, various upgrades and repairs took place to accommodate the increase in traffic. Bridges which had not yet switched to electric power from steam were converted. Decks and approaches were replaced. The four swing span trusses of the **Third Avenue Bridge** were replaced with three to allow more efficient use of the roadway for automobile traffic. Traffic gates were added. Bridges had open metal grating installed on the swing spans. In the 1950's, the bridge approaches were modified to allow the construction of the extension of the Harlem River Drive. During the 1960's and 1970's, New York City bridges, as well as bridges nationwide, fell into disrepair as the Department of Transportation focused on building the interstate highway system. In an effort to curb this deterioration, in 1971 the National Bridge Inspection Standards (NBIS) were established, which led to annual inspections and laid the groundwork for the current capital program.

Current Capital Program

New York City is now in the midst of a major capital program to rehabilitate the Harlem River Bridges.



Madison Avenue Bridge has been undergoing major structural rehabilitation since 1994. Work includes major superstructure rehabilitation and painting. Additional work includes a seismic retrofit and mechanical and electrical upgrades.



Macombs Dam Bridge has undergone a rehabilitation to preserve and refurbish the historic bridge. Work includes major reconstruction of the superstructure, rehabilitation of the substructure, repainting, rehabilitation of the mechanical and electrical systems and new bridge and ramp decking. Historic rails were replicated and the bridge house restored. The bridge will undergo a seismic retrofit under this capital program.

Third Avenue Bridge is being replaced on the existing alignment with a new swing span, which was floated to the site in July of this year.





Construction is starting on the rehabilitation of **145th Street Bridge**. The project includes replacement of the superstructure, including the swing span, reconstruction of the substructure, and a seismic retrofit.



Willis Avenue Bridge will be replaced with a new off-line bridge just south of the existing bridge.

Current

The historical significance of each bridge, along with its structural condition and capacity and safety for vehicular traffic, is considered in the decision to rehabilitate or replace each bridge. There has been an effort to balance the economics of engineering with the preservation of the past in an effort to build what is efficient and appropriate for each site.

The federal Department of Transportation (DOT) Act of 1966 was significant in that it required preservation of all structures eligible for inclusion on the National Register unless there is no prudent and feasible alternative and the project includes all possible planning to minimize harm resulting from such use. All of the swing spans of these bridges, except the **Third Avenue Bridge**, were deemed eligible for listing on the National Register. **Third Avenue Bridge** was determined to have been historically compromised by the replacement of the swing span trusses in 1956.

Macombs Dam Bridge, the oldest existing swing bridge in New York City, and the 3rd oldest bridge in the New York City, was designated an official New York City Landmark in 1992.

In addition, these bridges are considered critical to transportation infrastructure in the event of a seismic occurrence.

Under the current program this set of bridges will retain its overall integrity. The bridges at **Macombs Dam** and **Madison Avenue** are being rehabilitated. **Third Avenue Bridge** and **145th Street Bridge** are essentially being replaced on the existing alignment. As one looks back historically, this is a continuation of the process that has been going on for over 100 years. An interesting fact remains: by the time the Harlem River Ship Canal was finished in the 1938 and the Harlem River Bridges built so as not to obstruct marine traffic, the need for a navigation channel had largely disappeared. Industry in the area was declining and vessels found it more convenient to travel around lower Manhattan, where frequent bridge openings were not required. Perhaps one day the energy of the tides in this estuary will be rediscovered as our nation looks for new sources of renewable energy.

"Trying to plan for the future without a sense of the past is like trying to plant cut flowers." --Daniel Boorstin

Works Consulted

- New York City Department of Transportation, "New York City's Harlem River Bridges: The Reauthorization of the Transportation Equity Act for the 21st Century." (1/23/2004). (http://www.nyc.gov/html/dot/pdf/harlemrvbdrpt.pdf).
- New York City Department of Transportation, Bridge Reconstruction Project Reports (BRPR): Macombs Dam Bridge, 145th Street Bridge, Third Avenue Bridge, Madison Avenue Bridge and Willis Avenue Bridge.
- NYC Department of Transportation's New York City Waterways Study and Analysis by Parsons Brinkerhoff.

Raber, Michael. "2.2.1 Historic Land Use and Associated Shipping." Raber, Micahel. "2.3.2 Historical Maritime Activity."

New York City Department of Parks and Recreation. (http://www.nycgovparks.org/)

New York City Roads. (http://www.nycroads.com/crossings/harlem-river/).

Reier, Sharon. The Bridges of New York City. 1977.

"A Guide to Civil Engineering Projects in and Around New York City," American Society of Civil Engineers (1997).

Harlem Bridge Committee. 1864.