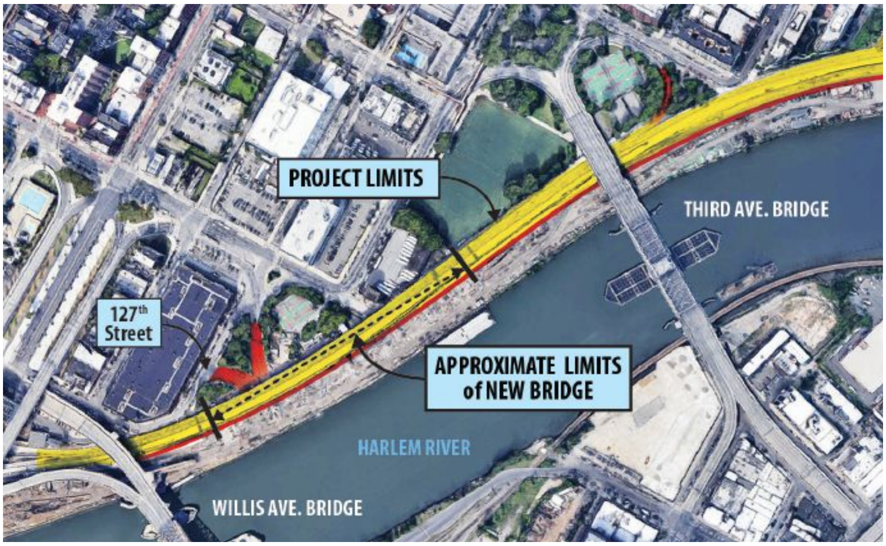
PROJECT

Harlem River Drive Bridge over East 127th Street

by Silvio Garcia, Hardesty & Hanover LLC

Harlem River Drive is a limited-access passenger vehicle highway adjacent to the Harlem River in the New York City borough of Manhattan. The section of Harlem River Drive included in this project extends south to north from the Willis Avenue Bridge to the Park Avenue entrance ramp, a total length of approximately 4500 ft. As part of this project, the 676-ft-long Harlem River Drive Bridge over East 127th Street was reconstructed to improve the operation of this segment of highway and address deficiencies of a structure that carries mainline traffic over the East 127th Street on- and off-ramps.



Aerial view of project limits. The yellow area indicates the project limits, which extended beyond the bridge replacement to accommodate the updated vertical profile and safe traffic patterns during the staged construction. The red areas indicate on- and off-ramps that were impacted by the project and therefore included in the project limits. Photo: Google / Hardesty & Hanover.

A Perilous Stretch of Highway

The existing bridge carried three lanes of southbound traffic and two lanes of northbound traffic plus a wide, striped shoulder on the northbound side. The 11-span structure consisted of seven steel multigirder spans plus two concrete cellular-type spans at each end. The seven main spans were supported by steel columns on concrete footings and founded on concrete-filled steel pipe piles socketed in rock. The cellular spans were composed of a structural reinforced concrete slab supported by reinforced concrete girders and retaining walls in the longitudinal direction founded on steel H-piles driven to bedrock.

This section of Harlem River Drive was categorized as one of the worst segments of highway in New York state, based on the high traffic accident rates and severe congestion, particularly in the southbound direction. The causes of traffic accidents in this area included a weaving condition on southbound Harlem River Drive at the exit to Second Avenue, and substandard stopping sight distance on the bridge. The new bridge addresses these deficiencies with the addition of a left lane exit to Second Avenue, thereby eliminating the weaving condition, and modifications to the vertical profile on the bridge and approaches to increase the stopping sight distance.

New Southbound and Northbound Bridges

The single existing structure was replaced with two adjacent bridges, one for southbound traffic and one

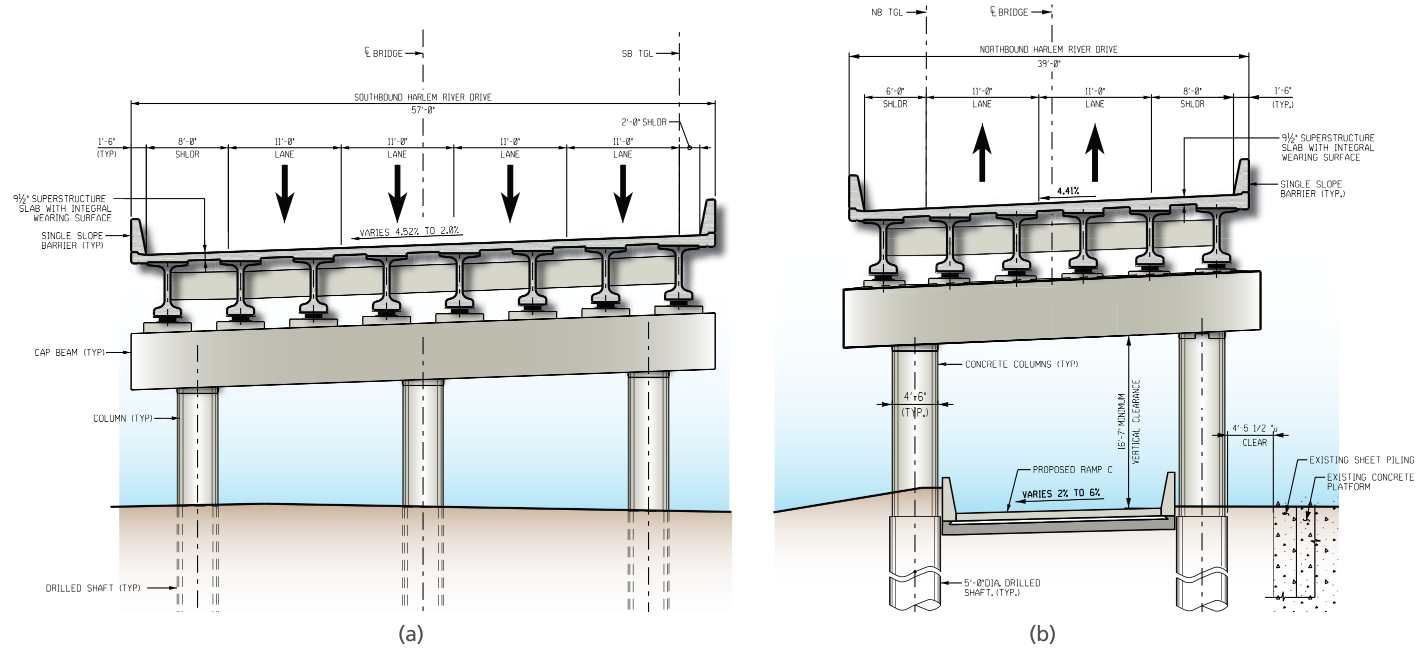
profile

HARLEM RIVER DRIVE OVER EAST 127TH STREET / NEW YORK, NEW YORK

BRIDGE DESIGN ENGINEER: Hardesty & Hanover LLC, New York, N.Y.

PRIME CONTRACTOR: Defoe Corporation, Mount Vernon, N.Y.

PRECASTER: Coastal Precast Systems, Chesapeake, Va.—a PCI-certified producer



Typical cross sections of the new (a) southbound bridge and (b) northbound bridge over an on-ramp. Figure: Hardesty & Hanover.

for northbound traffic. Each bridge is approximately 990 ft long. Two bridges were required to accommodate the new left-hand exit from southbound Harlem River Drive to Second Avenue. The southbound bridge carries four lanes of traffic, and the northbound bridge carries two lanes of traffic. Both bridges include wide shoulders that ease congestion in the case of emergencies.

The new southbound and northbound bridges consist of nine and ten spans, respectively; and the spans range in length from 65 to 132 ft. The bridges are composed of prestressed concrete bulb-tee beams (PCEF-63). The beams are composite with a 9.5-in.-thick reinforced concrete deck and are supported on multicolumn concrete piers founded on 4- and 5-ft-diameter drilled shafts. The prestressed concrete beams have a design concrete compressive strength of 10 ksi with 270-ksi, 0.6-in.-diameter low-relaxation strands. The piers and drilled shafts have a design concrete compressive strength of 4 ksi. All elements, including the beams, use 60-ksi epoxy-coated reinforcing bars.

The alignment for the southbound bridge is on a compound horizontal curve with radii of 1885 and 2828 ft followed by a tangent. The northbound alignment is on a compound horizontal curve with radii of 2920 and 1937 ft followed by a tangent. The bridge profiles have a 5% maximum grade and the decks are superelevated, with the cross slopes varying from 2.00% to 4.52%.

Why Precast Concrete Bulb Tees?

A structure justification study was performed during the preliminary design to determine the best superstructure/substructure combination for the replacement bridges. The study considered both steel and concrete alternatives, including several prestressed concrete girder shapes, and evaluated them for future maintenance requirements, construction duration, construction cost, life-cycle cost, geometry needs, staging needs, and other parameters.

The life-cycle cost analysis assumed a 4% discount rate and a 75-year service life. For the estimated future costs, a 3% inflation rate was used. Periodic steel painting, joint replacement, and bearing replacement were considered. A full bridge rehabilitation including deck replacement was assumed after 45 years of service.

The proposed bridges would be located adjacent to an existing park that includes a large mural, "Crack Is Wack," painted by the artist Keith Haring, as well as the planned Harlem River Waterfront Park; therefore, it was important to provide a structure that blended into its surroundings. Accessibility for future painting of the bridges would have been problematic given their location. Because the prestressed concrete superstructures would not require painting, both maintenance costs and potential for future park disruptions were minimized.

Prestressed concrete bulb tees, specifically the PCEF-63, were found to be the best alternative for the superstructure because they provided the lowest life-cycle cost of all the superstructure types analyzed, eliminated the need for painting, and offered a neutral, nonintrusive appearance. Also,

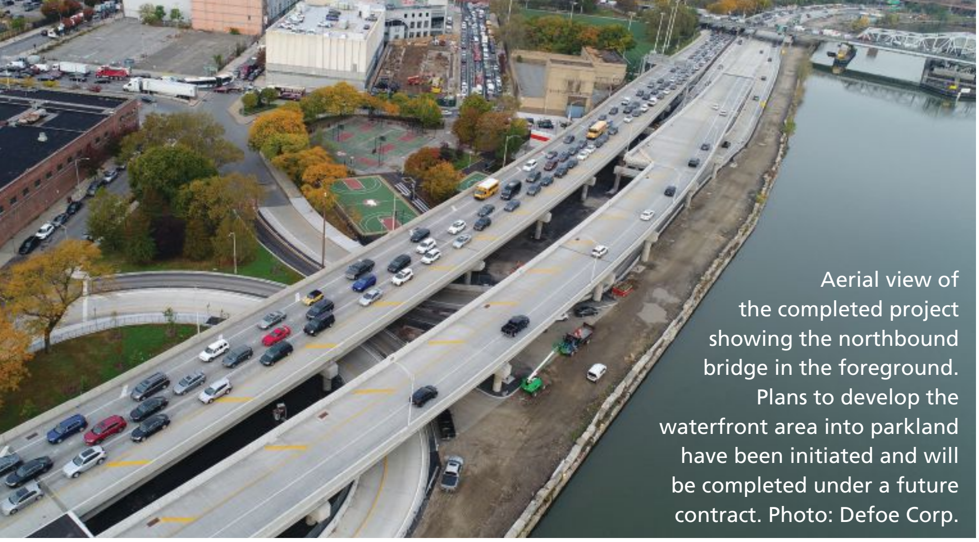
NEW YORK CITY DEPARTMENT OF TRANSPORTATION, OWNER

BRIDGE DESCRIPTION: Twin 990-ft-long bridges on a horizontally curved alignment with precast, prestressed concrete bulb-tee beams placed on chords, a cast-in-place 9.5-in.-thick concrete deck, and multicolumn concrete piers supported on 4- and 5-ft-diameter drilled shafts

STRUCTURAL COMPONENTS: 139 PCEF-63 bulb-tee beams, 9.5-in.-thick cast-in-place concrete deck, cast-in-place concrete pier caps, columns, and drilled shafts

BRIDGE CONSTRUCTION COST: $126.9 million

AWARD: 2020 Diamond ACEC New York Engineering Excellence Award



Aerial view of the completed project showing the northbound bridge in the foreground. Plans to develop the waterfront area into parkland have been initiated and will be completed under a future contract. Photo: Defoe Corp.

In stage 2 of the project, a portion of the southbound bridge was constructed. The close proximity of the new construction (left) to the existing structure (right) required extensive coordination and surveying throughout the project. Photo: Hardesty & Hanover.

the bulb-tee shape best accommodated construction staging and vertical clearance requirements.

Substructure Selection

For any project in an urban environment, utilities play a large role in the selection of the substructure and foundation. For the Harlem River Drive project, multicolumn concrete piers supported on drilled shafts were the preferred substructure/foundation option due to the numerous underground utilities that needed to be maintained and protected during construction. Underground utilities within the project limits included electrical lines, intelligent traffic system lines, communications lines, water mains, and stormwater systems.

Among the underground utilities within the project limits are approximately fifteen 270-kV electrical submarine cables, owned by Con Edison, which supply electricity to Manhattan's East Side. To minimize the risk of damaging the lines, the following requirements were placed on the contractor for all shaft and substructure excavation work adjacent to these high-voltage facilities:

- Con Edison needed to locate the facilities prior to any substructure work. This entailed hand digging or test pitting to verify the location of shallow buried facilities and a gyroscope survey for the submarine cable river crossing. The survey established the limits of the zones in which no drilled shafts or driven piles could be installed.
- Vibration velocity was limited to less than 0.5 ft/s and was to be monitored via vibration monitoring.
- Outage time was restricted, with no summer outages permitted.
- Minimum clearance of 11 ft was required between drilled shafts and submarine cables.

Construction in a High-Traffic Urban Environment

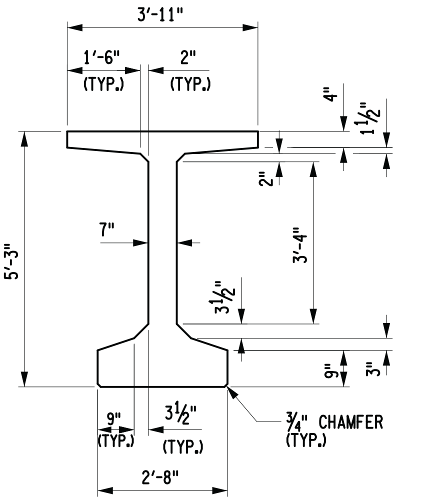
Northbound and southbound lanes of Harlem River Drive have annual average daily traffic in excess of 28,000 and 68,000 vehicles, respectively. Because of the high traffic volumes and the highway's importance as a main route into and through Manhattan, all traffic lanes and the major on- and off-ramps needed to be maintained throughout construction.

The space limitations imposed by a dense urban environment and the need to maintain all lanes required that the project be built in five stages, from west to east.

In stage 3 of the project, construction of the southbound bridge continued, while northbound traffic was maintained on the at-grade temporary roadway. Note that the prestressed concrete bulb tees are set on chords of the horizontal curves. Photo: Defoe Corp.

The new southbound bridge was initially opened for traffic in both directions, with its shoulders used as temporary lanes. The temporary roadway along the river was removed and the northbound bridge was constructed. Photo: Defoe Corp.

The prestressed concrete bulb tees were transported by barge from the producer to the site and lifted directly from the barge onto the new piers. Photo: Defoe Corp.



PCEF-63

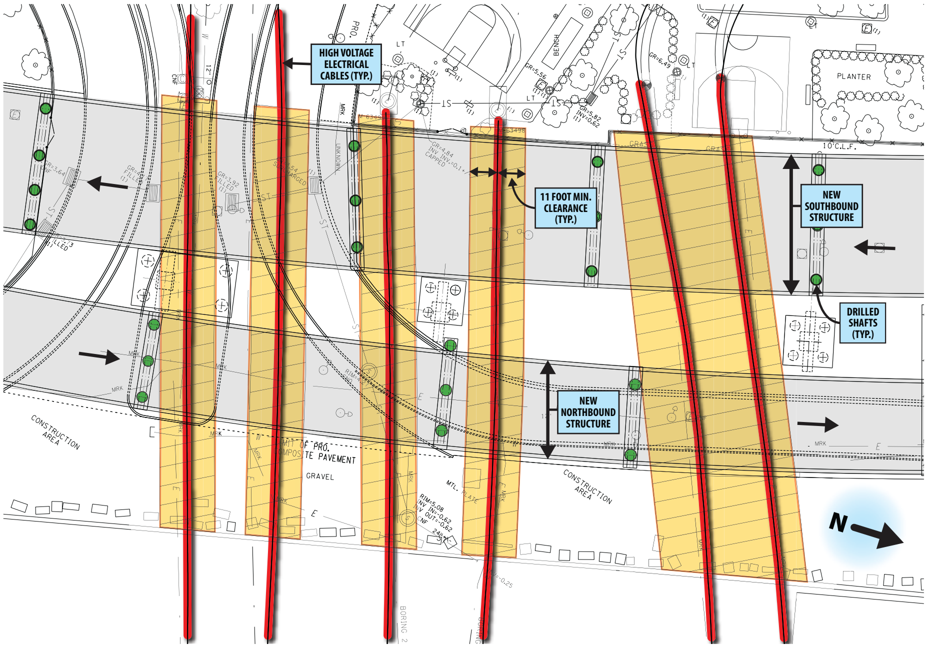
The cross section of the 63-in.-deep prestressed concrete bulb tee (PCEF-63) from New York State Department of Transportation (NYSDOT) standards.[1] Based on a justification study, the PCEF-63 was the best alternative and was used for all spans. Span lengths ranged from 65 to 132 ft. Figure: NYSDOT.

During stage 1, a temporary at-grade roadway was constructed adjacent to the river. Northbound traffic was moved to the temporary roadway and the southbound traffic shifted to the east side of the existing structure. This accommodated the demolition of the first half of the existing bridge and construction of approximately two-thirds of the new southbound bridge (stage 2).

In stage 3, southbound traffic was moved onto the new structure. The remainder of the southbound bridge was built during this stage, which required additional coordination and safety precautions as construction occurred between active traffic on the new southbound bridge and the temporary roadway carrying northbound traffic along the river. The prestressed concrete bulb tees were transported by barge from the producer to the site and erected directly from the barge onto the new piers. Intermittent night closures of northbound traffic lanes were approved by local authorities to allow the bulb tees to be lifted from the barge, over the temporary roadway, and into place.

Once stage 3 was completed, all traffic was shifted to the new southbound bridge, with the wide shoulders used to accommodate temporary lanes during construction. In stage 4, the temporary roadway was removed, and the northbound bridge was constructed. During the fifth and final stage, tie-ins and approaches at each end were completed.

Drilled shafts were strategically placed outside the required minimum 11 ft clearance limit from each of the Con Edison submarine high-voltage cables. Figure: Hardesty & Hanover.



Conclusion

The project was substantially complete and open to traffic in May 2019. Continuous communication and coordination among all parties ensured the success of this project, which provides a safer facility with minimal required maintenance of the new bridges. The new structures will provide at-grade access to the new waterfront park and a direct connection between the Robert F. Kennedy Bridge and northbound Harlem River Drive via a ramp currently being constructed by the Triborough Bridge and Tunnel Authority.

Reference

1. New York State Department of Transportation. 2017. "Prestressed Concrete PCEF and AASHTO I-Beam Typical Sections." https://www.dot.ny.gov/main/business-center/engineering/cadd-info/bridge-details-sheets-repostitory-usc/BD-PC14E.pdf. Accessed January 11, 2020.

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