Managing risks in the reconstruction/rehabilitation of 9 bridges over the Van Wyck Expressway

S. Butler
Dewberry Engineers Inc., New York, NY, USA

ABSTRACT: Dewberry was the lead designer on this complex Design-Build project with contractor Posillico/El Sol Joint Venture for the New York State Department of Transportation. This contract was the first phase of a three-phase project which will increase capacity on the Van Wyck Expressway between Kew Gardens Interchange and JFK Airport in order to improve access to and from the airport. The scope of work included the reconstruction and lengthening of nine overpass bridges to accommodate a widened Van Wyck Expressway which will be constructed in the third phase. The project location was a dense urban neighborhood in Queens requiring extensive coordination and innovative design solutions in order to minimize impacts to traffic on the expressway, overpass bridges, service roads, numerous vital utilities, and the PANYNJ Air Train which runs above seven of the nine bridges. One key strategy was utilizing a top-down construction method for the new abutments where the existing abutments were left in place, new abutment pile caps were constructed behind them, and finally a new concrete abutment wall facing was constructed from the new pile cap down to the roadway level after removing the existing abutments. Despite a multitude of challenges, this project was constructed with minimal delays or impacts to the community and traveling public.

1 INTRODUCTION

In 2019 the New York State Department of Transportation (NYSDOT) began advertising the first of three Design-Build contracts included in the Van Wyck Expressway Capacity and Access Improvements to JFK Airport. The overall goal of this three-phase project is to add a lane in each direction on the Van Wyck Expressway (I-678) between the Kew Gardens Interchange and JFK Airport to reduce travel time to and from the airport. Furthermore, the project will reconstruct a number of structures spanning over the Van Wyck Expressway to accommodate the additional lanes and address geometrical and structural deficiencies identified along the project corridor. Figures 1-2 show a before and after view of the project corridor, respectively.

The first contract of the project involved the reconstruction and lengthening of nine overpass bridges and geometric modifications to two existing ramps. Contract 2 comprises the retrofit/replacement of 1 overpass bridge and 4 bridges carrying LIRR tracks over the Van Wyck Expressway. To conclude the project, Contract 3 calls for the widening of several mainline bridges, the retrofitting/lengthening of an overpass bridge and a pedestrian bridge, and the reconstruction of the retaining walls on either side of the Van Wyck Expressway to allow for the widened roadway also constructed in this contract. All three contracts are currently under construction.

Figure 1. Existing view of the Van Wyck Expressway looking south from Hillside Avenue. Photo courtesy of NYSDOT (NYSDOT 2019).

Figure 2. Proposed view of the Van Wyck Expressway looking south from Hillside Avenue. Additional lane is shown in green. Rendering courtesy of NYSDOT (NYSDOT 2019).

2 CONTRACT 1

2.1 *Schedule and Risks*

The Design-Build Team of Posillico/El Sol JV (PESJV) with Dewberry as the lead designer received the Notice of Award for Contract 1 in mid-2020. With three years to design and construct nine overpass bridges there was little room for delays. During the procurement phase, the design team performed a risk assessment to identify the aspects of the project with the greatest likelihood of causing significant adverse impacts to the project schedule or budget. Two of the most critical risks identified were maintenance of traffic and utility coordination.

The biggest challenge to maintaining traffic was the location of the project, a densely urban Queens neighborhood, with retaining walls flanking both sides of the expressway and service roads running parallel to the Van Wyck Expressway at both ends of the bridges. Due to high traffic volumes, lane closures were only allowed during specific windows, and both vehicular and pedestrian traffic was required to be maintained across the bridges at all times. Mitigation of this risk included the implementation of a complex construction sequence for each bridge and the use of an innovative "top down" construction method for the abutments, which left the existing abutments in place while the new abutments were built behind them. This approach drastically reduced traffic impacts to the Van Wyck Expressway and was a key to the success of this project.

Utility coordination was another critical risk with a high potential to negatively impact the schedule. All nine of the project bridges involved numerous utilities, with up to eleven different utilities being carried across each bridge. Additionally, abundant utilities were present in the service roads at either end of the bridges. In order to mitigate this risk, the Design-Build team's strategy was to coordinate early and often with the various utility companies. To assist the designers and the contractor, comprehensive 3D models were developed to compile utility as-built information and field data along with the proposed modifications to the structures and utilities. This approach allowed the Team to keep track of subsurface utilities relative to the structural elements of each bridge and ensure that the new abutment construction would not impact the utilities.

2.2 *Scope of Work*

The Contract 1 scope of work included the reconstruction and lengthening of nine overpass bridges crossing the Van Wyck Expressway between 133rd Avenue and Hillside Avenue, the relocation of the Linden Avenue ramp, and modifications / widening at Exit 1W to North Conduit Avenue. The bridges were divided into two construction phases (groups) to lessen impacts to traffic and utilities, with construction of the Group 1 bridges beginning in late 2020, followed by the start of construction on the Group 2 bridges about a year later. In addition to the two-phase construction approach, each bridge was further divided into multiple Design Units to allow for timely purchasing of long-lead items and construction of certain critical elements while design was completed on other elements.

Scope items specific to the bridge construction included replacing the entire superstructure at four locations, deck replacement and lengthening existing steel stringers at five locations, construction of new abutments at each bridge, retrofitting of existing abutments at three locations, and pier reconstruction and/or retrofitting throughout. Table 1 below shows details of the structure and scope of work for the nine overpass bridges included in Contract 1.

This document will focus on the design and construction of the 109th Avenue Bridge and the 133rd Avenue Bridge.

Table 1. VWE Contract 1 Bridge Details.

Bridge	BIN	Group	Scope	Spans	Begin Abutment	End Abutment
Rockaway Blvd.	1080570*	1	Reconstruction	2	Fixed Frame	Semi-Integral
109th Ave.	1055660	1	Rehabilitation	2	Fixed Frame	Semi-Integral
Hillside Ave.	1055710	1	Rehabilitation	2	Retrofitted	Fixed Frame
Liberty Ave.	1080590*	1	Reconstruction	2	Fixed Frame	Semi-Integral
133rd Ave.	1055620	2	Rehabilitation	4	Retrofitted	Traditional (New)
Foch Blvd.	1055640	2	Rehabilitation	2	Fixed Frame	Semi-Integral
Linden Blvd.	1080580*	2	Reconstruction	2	Fixed Frame	Semi-Integral
101st Ave.	1080600*	2	Reconstruction	2	Semi-Integral	Fixed Frame
Jamaica Ave.	1055700	2	Rehabilitation	2	Retrofitted	Fixed Frame

*New BINs issued for reconstructed bridges

2.3 *109th Avenue Bridge over Van Wyck Expressway*

The original 2-span 109th Avenue Bridge was constructed in 1948 as part of the construction of the Van Wyck Expressway. The bridge underwent a major reconstruction around 2002 at which time the entire superstructure was replaced and lengthened by twelve feet per span, and both abutments and the center pier were rebuilt. The original footings were incorporated into the new substructure elements during this previous contract.

In the current project, new abutments were constructed behind the existing abutments in order to again lengthen the structure. At the center pier, the pedestals and bearings were replaced while the pier stem and footing were reused. On the superstructure, the existing structural steel was retained with new steel extensions spliced to the existing stringers, lengthening the superstructure by approximately thirteen feet at each end. The reinforced concrete deck and all deck elements were removed and replaced. Figure 3 shows an elevation view of the proposed configuration of the 109th Avenue Bridge.

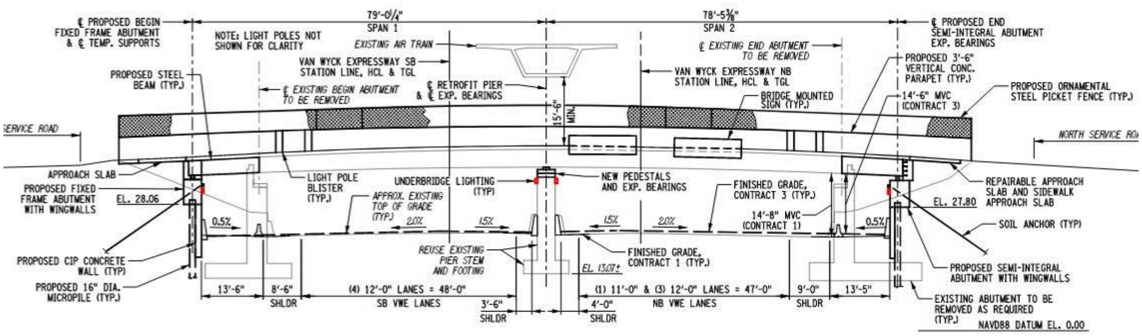

Figure 3. Proposed elevation view of the 109th Avenue Bridge over Van Wyck Expressway.

2.4 *133rd Avenue Bridge over Van Wyck Expressway*

Similarly, the 133rd Avenue Bridge was originally constructed as a 2-span bridge that was part of the same 1948 construction contract as the 109th Avenue Bridge and the Van Wyck Expressway. The structure was completely replaced in 1986 with a longer four-span bridge to accommodate new roadways on either side of the Van Wyck Expressway mainline for traffic moving to and from the Belt Parkway.

Under the current construction contract, the existing west abutment was retrofitted, and a new abutment was constructed behind the existing east abutment to lengthen the overall structure. At Piers 1 and 2, the pedestals and bearings were replaced while the pier stems and footings were reused. Pier 3 was replaced by a new pier located approximately 14' to the east of the existing pier, to accommodate a realignment of the Van Wyck Expressway in Contract 3. For the superstructure, the existing structural steel was retained with new steel extensions spliced to the end of Span 4, lengthening the superstructure by approximately twelve feet at the east end of the bridge. The reinforced concrete deck and all deck elements was removed and replaced, and the deck was widened by 2' on each side of the bridge. Figure 4 shows an elevation view of the proposed configuration of the 133rd Avenue Bridge.

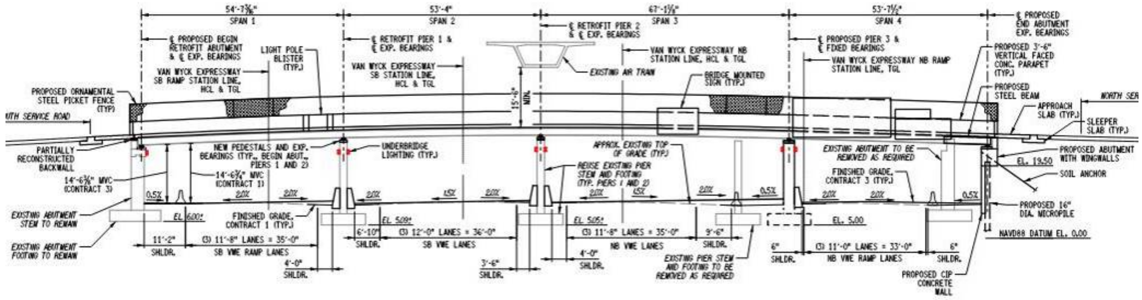

Figure 4. Proposed elevation view of the 133rd Avenue Bridge over Van Wyck Expressway.

3 ABUTMENTS

3.1 *Overview*

From the perspective of risk management, it quickly became apparent that construction of the bridge abutments would be one of the most critical activities of the project. Abutment construction could have major impacts on the two key project risks: maintenance of traffic and utility coordination. Any misstep would cause major impacts to both the schedule and budget of the project. This meant that a great deal of effort needed to be put into the planning and design of these abutments and how they would be built.

Most of the project bridges contained a new fixed frame abutment paired with a new semi-integral abutment. As part of the proposal, the design team submitted Alternative Technical Concepts (ATCs) for both the fixed frame and semi-integral abutment details. These ATCs, approved by NYSDOT, proposed that all fixed frame and semi-integral abutments would consist of an abutment stem/pile cap supported on a single row of micropiles. The RFP project requirements set a strict limit of ¼" of movement at the end of the approach slabs of the fixed frame abutments under the Service I Limit State (NYSDOT 2019). In order to meet this requirement, additional lateral support would need to be provided by installing drilled and grouted tiebacks through the pile cap at the new fixed frame abutments. Tiebacks were also required on the semi-integral abutments since the micropiles alone would not provide adequate stiffness to allow the abutment to act as a cantilever.

3.2 *109th Avenue: Fixed Frame and Semi-Integral Abutments*

The project requirements in the Contract 1 Request for Proposal (RFP) called for a pair of new integral abutments to be constructed behind the existing abutments, but allowed for the reuse of the structural steel, pier and pier footing (NYSDOT 2019). During the procurement phase, the design team submitted an ATC proposing a fixed frame west abutment paired with a semi-integral abutment on the east side of the 109th Avenue Bridge. Since this was the proposed configuration at many of the other structures, the ATC proposed a consistent configuration wherever possible to maintain uniform structural details across the bridges and streamline design and construction.

3.3 *133rd Avenue: Retrofitted and New Traditional/Jointless Abutments*

Per the RFP project requirements, the existing west abutment was to be left in place and retrofitted as an integral abutment with a new integral abutment constructed on the east side behind the existing abutment. In the procurement phase, the design team proposed a retrofitted semi-integral abutment on the west side of the bridge opposite a new semi-integral abutment on the east side. The existing east abutment stem would remain in place while the backwall would be removed and replaced. A steel plate with shear studs would be field welded to the end of each existing stringer, and the new backwall would be poured up to the stringer ends encapsulating the shear studded plates in the semi-integral backwall. On the east side of the bridge, a new semi-integral abutment would be constructed behind the existing abutment.

During Final Design, the Design-Build team reevaluated the proposed abutment configuration. A Request for Design Exception (RDE) was submitted to NYSDOT proposing a partial reconstruction of the existing backwall at the west abutment with a joint over backwall, matching the details that had already been used at both the Hillside and Jamaica Avenue Bridges. This modification would allow for more streamlined design and construction between the bridges, eliminate the need for field welding, and reduce the amount of demolition and construction required. NYSDOT accepted the proposed RDE on the condition that the new east abutment followed the same joint over backwall details, rather than the originally planned semi-integral abutment.

3.4 *Top-Down Construction*

Constructing new abutments behind the existing abutments needed to be well-coordinated with the construction staging, as both the construction and demolition activities would impact traffic on the expressway, service roads, and local streets carried by each structure. To address this concern, a top-down construction method was developed by PESJV to minimize the impacts to traffic. Using this strategy, construction began by installing drilled micropiles in a narrow trench along the top of the roadway during nighttime closures. At the end of each overnight work window, the trenches were covered with steel plates to allow the bridge to fully reopen to traffic. After the micropiles were in place, a pile cap was poured with cast-in sleeves to allow for the installation of the tiebacks.

The next step in the construction of the abutments was the removal of the existing approach slabs and installation of temporary timber deck panels spanning the gap between the new and existing abutments (Figures 5-6). During overnight closure windows, individual or multiple deck panels could be removed to allow for excavation and other work activities, such as installing the structural steel stringers or extensions, on the newly installed pile caps (Figure 7). At the end of each closure window, deck panels were replaced in time to return the bridge to full service, thus minimizing the time that temporary traffic configurations were required. The final step in the construction of the pile cap was the installation of the tiebacks themselves.

Figure 5. Temporary timber deck panels (above) spanning the gap between the existing abutment (left) and the new abutment pile cap (right). View below deck at the 109th Avenue Bridge east abutment, looking north.

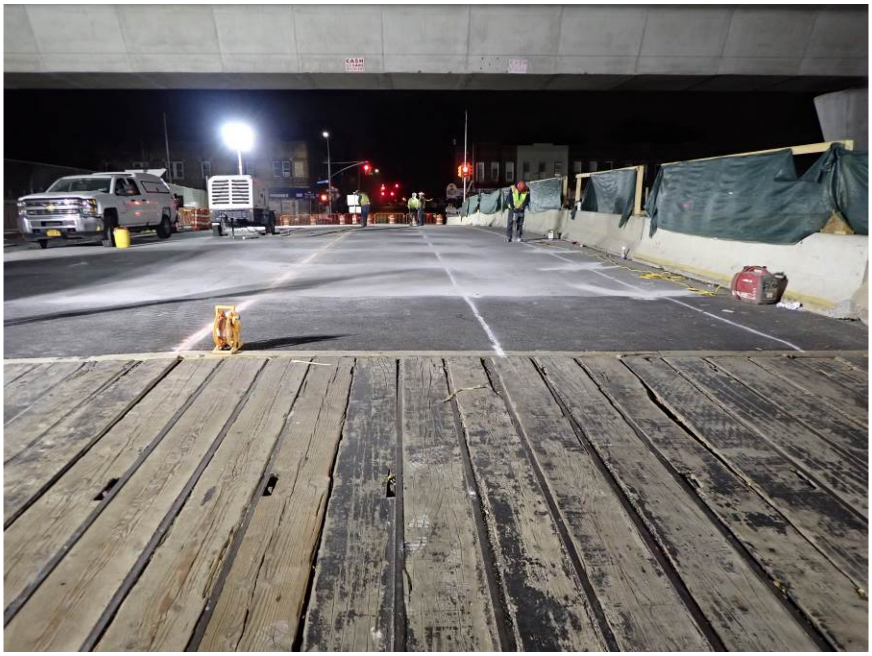

Figure 6. Top of deck view of temporary timber deck panels at the 109th Avenue Bridge east abutment, looking west.

Figure 7. Stringer extensions installed between the existing abutment (right) and the new abutment pile cap (left). View of the 109th Avenue Bridge east abutment, looking south.

After the tiebacks were installed, the area between the new and existing abutments was excavated down to the Van Wyck Expressway grade level using timber lagging and steel plates between the piles. At this point the existing abutments could be demolished with minimal impact to the expressway traffic. In the final step, a cast-in-place reinforced concrete wall facing was constructed below the pile cap down to the expressway grade. Figures 8-10 show the abutment prior to the installation of the wall facing and after the abutment construction was complete.

Figure 8. Excavation between the new abutment pile cap (left) and existing abutment (right). View of the 133rd Avenue Bridge east abutment, looking south.

Figure 9. View of the new Foch Avenue Bridge east abutment, looking south, after the removal of the existing abutment.

Figure 10. Completed new fixed frame abutment with wall facing. View of the 109th Avenue Bridge west abutment, looking south.

3.5 *Micropile and Tieback Layout*

The layout of the micropiles and tiebacks at each abutment underwent several iterations over the course of the design phase. At first, an initial layout of the micropile and tiebacks at each abutment was developed based on the as-built utility information. Micropiles were laid out along the abutment in order to avoid the existing utilities. This initial layout was analyzed from both a structural and geotechnical perspective and confirmed to meet all project requirements.

As field work progressed, PESJV staked out proposed abutment locations and performed test pits and utility surveys at each location. The newly available data was added to the abutment drawings (Figure 11), and the micropile layouts were updated accordingly. Since the micropiles were to be installed prior to the removal of existing utilities, micropile locations were adjusted to avoid interfering with any utilities found during the subsurface investigation with as much clearance provided as possible. Additionally, the micropiles were drilled through the existing spread footings of the abutments to remain but were positioned so that they avoided the wingwall stems and areas of heavy reinforcement between the wingwall stems and footings.

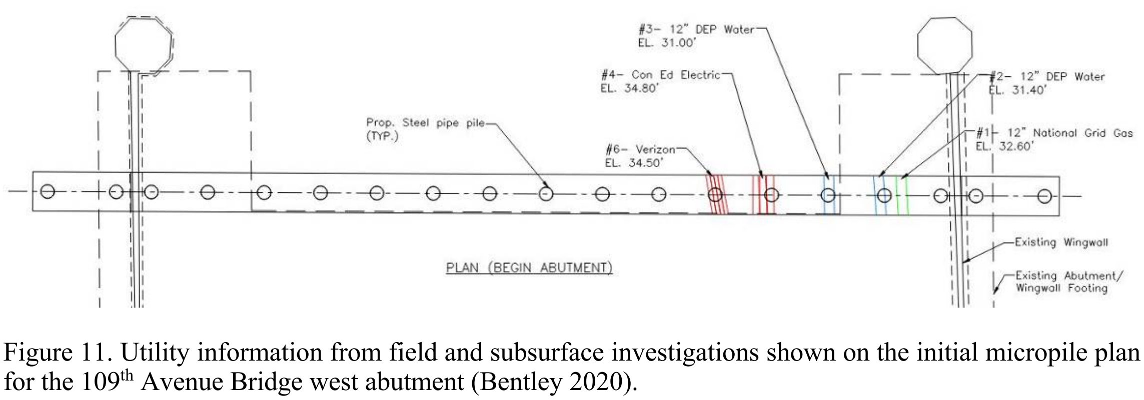

Figure 11. Utility information from field and subsurface investigations shown on the initial micropile plan for the 109th Avenue Bridge west abutment (Bentley 2020).

The initial layout of the tiebacks followed a similar procedure. In addition to the horizontal position along the pile cap, the installation angle of the tiebacks, both vertically and horizontally, needed to be considered. At seven of the nine project bridges, including both 109th and 133rd Avenues, the AirTrain to JFK Airport ran along the median of the Van Wyck Expressway crossing over the bridge. The specifications of the installation equipment used was evaluated in conjunction with the tieback angles to determine the proximity to the AirTrain and to ensure that required clearance envelopes were maintained (Figure 12). Based on preliminary calculations, both geotechnical and geometrical, a tieback angle of 30º was initially established. After further evaluation it was determined that at several locations, including the 109th Avenue Bridge, an installation angle of 30º would cause an interference with the top of the existing abutments. The angle was modified to 35º at these locations to clear the existing abutments.

Figure 13 shows the tiebacks being installed at the 109th Avenue Bridge.

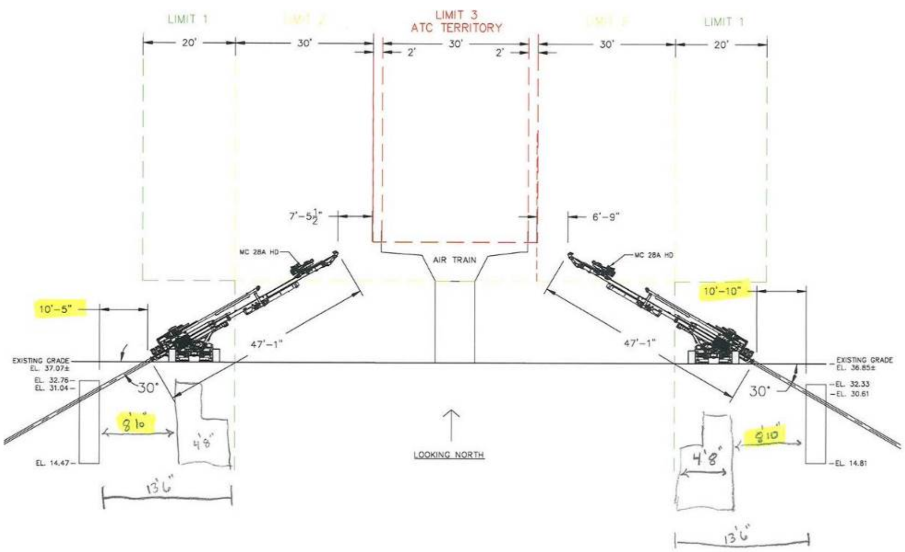

Figure 12. Tieback installation equipment was evaluated at each location to determine the ideal tieback angle and confirm clearances to the AirTrain above. Pictured is the 109th Avenue Bridge, looking north.

Figure 13. Photo of tiebacks being installed during overnight operations at the 109th Avenue Bridge west abutment, looking south. Note the temporary deck panels which have been partially removed to allow for the work to take place during overnight closure windows.

3.6 *3-D Models*

Several 3-D models were prepared for the bridge abutments over the course of the project. The primary model was a Finite Element Method (FEM) model for each fixed frame abutment as required by the RFP (NYSDOT 2019). This model was developed using CSiBridge (CSI 2020) and incorporated each micropile and tieback in order to ensure that the deflection at each fixed frame abutment was below the 0.25” of movement allowed in the project requirements. Due to the sensitivity of this model and the small amount of movement allowed, each iteration of the micropile and tieback layout needed to be adjusted in the FEM model and then reanalyzed to confirm that the design would not exceed the maximum allowable deflection (AASHTO LRFD 2017).

In addition to the FEM model, a 3-D utility model was also prepared for each bridge to be able to visualize the location of each utility on the bridge and under the adjacent service roads relative to the locations of the structural elements. These comprehensive models included information from various sources including as-built information, utility plates received from the utility companies, information from test pits and other field investigations, and proposed design information. Compiling this information into a single model allowed the design team to avoid potential conflicts with existing and proposed utilities, which could have caused extensive construction delays. Once the 3-D utility model was complete, the proposed abutments and tiebacks were added to the model (Figure 14). This enabled the design team to carefully evaluate each location for any potential conflicts between the tiebacks and utilities, while ensuring that clearance envelopes required by the various utility companies were maintained (Figure 15). Throughout this exercise, conflicts were discovered at several locations and the tieback locations and/or angles were adjusted accordingly to avoid any issues during construction.

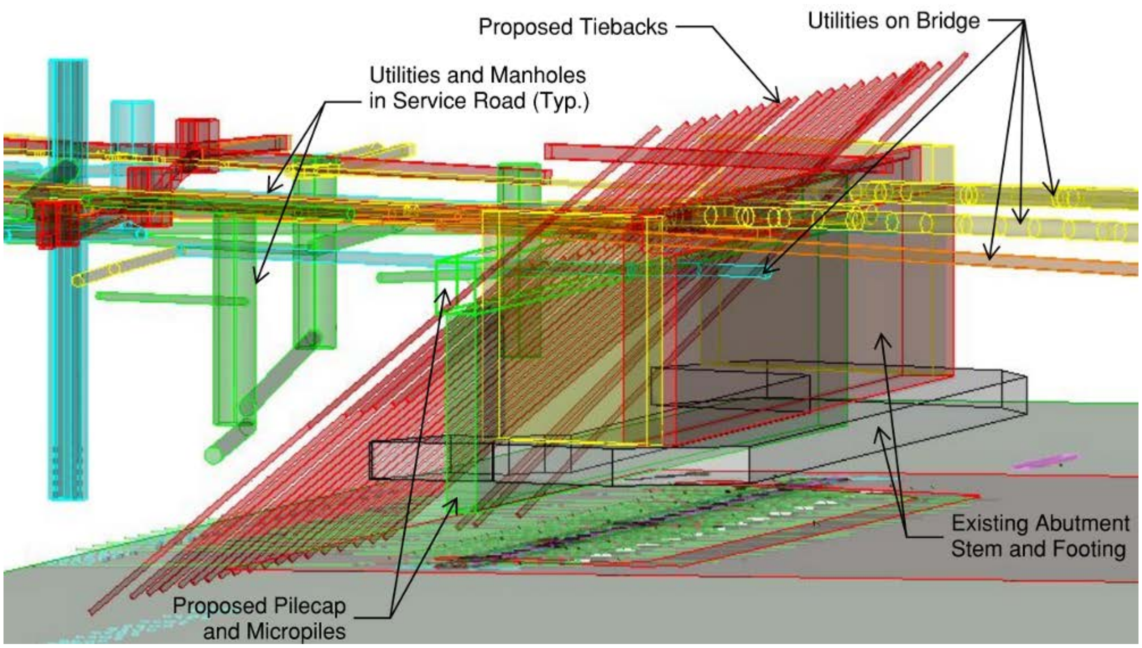

Figure 14. A 3-D model showed the location of utilities crossing and in the service road of each bridge along with the proposed abutment and tiebacks to minimize construction issues and ensure that utility company requirements were met. Pictured is the Rockaway Boulevard Bridge model as an example (Bentley 2020).

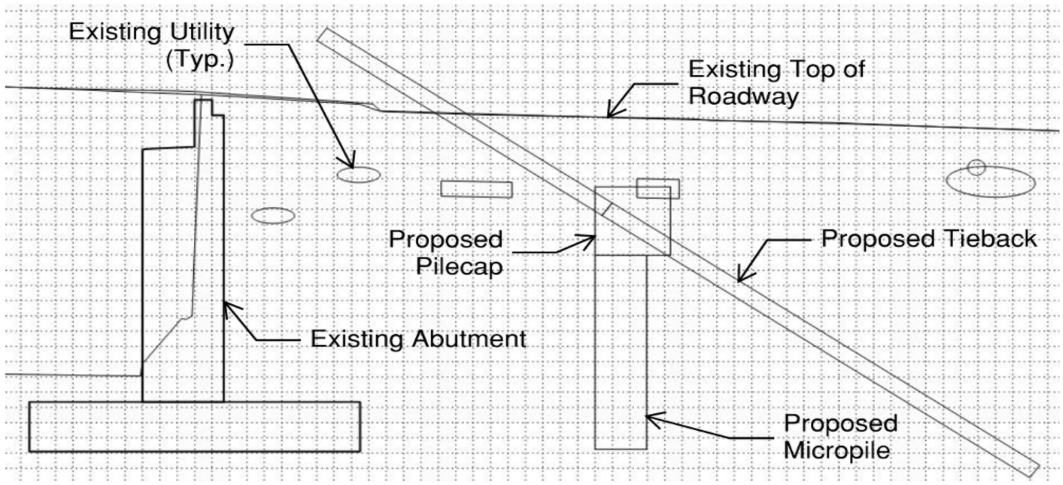

Figure 15. A cross-section cut from the 3-D model shown in Figure 14. A similar section was cut at each tieback to identify potential conflicts and determine clearance envelopes (Bentley 2020).

4 CONCLUSIONS

The key to the success of any major construction project, Design-Build or otherwise, is in the ability to accurately identify potential risks early and implement effective mitigation strategies throughout all phases. This project provides an excellent example of the advantages of the Design-Build delivery method where a high level of collaboration between the contractor, designer, owner and other stakeholders allows for a high-quality finished product while minimizing the chance of deviating from the proposed schedule and budget. The development of the abutment construction concept discussed herein is an example of an innovative solution that could not have been developed without such a high level of collaboration. As a result, this project was constructed with minimal delays and impacts to the surrounding community and traveling public, despite a multitude of challenges.

REFERENCES

American Association of State Highway Transportation Officials (AASHTO) 2017. *LRFD Bridge Design Specifications, 8th Edition.* Washington, D.C.: AASHTO.

Bentley Systems, Incorporated. MicroStation V8i (SELECTseries 10). Computer Software. 2020.

Computers and Structures, Inc. (CSI). CSiBridge v22. Computer Software. 2020.

New York State Department of Transportation (NYSDOT) 2003. *EB 03-040 NYSDOT Standard Specifications for Highway Bridges – 2003 Update*. Albany: NYSDOT.

New York State Department of Transportation (NYSDOT) 2019. *EI 19-001 NYSDOT LRFD Bridge Design Specifications – 2019*. Albany: NYSDOT.

New York State Department of Transportation (NYSDOT) 2019. Part 3, Project Requirements. *Van Wyck Expressway (VWE) Capacity and Access Improvements to John F. Kennedy (JFK) Airport Project – Contract 1, DB Contract Documents, Request for Proposals*. https://www.dot.ny.gov/main/business-center/designbuildproject48

New York State Department of Transportation (NYSDOT) 2019. Part 6, RFP Plans. *Van Wyck Expressway (VWE) Capacity and Access Improvements to John F. Kennedy (JFK) Airport Project – Contract 1, DB Contract Documents, Request for Proposals*. https://www.dot.ny.gov/main/business-center/design-buildproject48

New York State Department of Transportation (NYSDOT) 2019. *Van Wyck Expressway Capacity and Access Improvements to JFK Airport*. https://www.dot.ny.gov/VWE

New York State Department of Transportation (NYSDOT) Office of Structures 2019. *Complete US Customary Bridge Manual - 2019 Edition including Addendums with EB 19-019*. Albany: NYSDOT.