Kosciuszko Bridge Project

Construction Protection Plan for Old Calvary Cemetery

PIN X729.77 - BIN 1-07569-9
Kosciuszko Bridge over Newtown Creek
Kings & Queens Counties, New York
February 2013

New York State Department of Transportation
Project Introduction

The Federal Highway Administration (FHWA) in coordination with New York State Department of Transportation (NYSDOT), will be replacing the Kosciuszko Bridge, as defined by Alternative BR-5 in the FDR/FEIS/Final Section 4(f) Evaluation, with a new permanent, parallel structure on the eastbound side of the existing bridge.

The Kosciuszko Bridge carries a 1.1-mile segment of the Brooklyn-Queens Expressway (BQE) over Newtown Creek between Morgan Avenue in the borough of Brooklyn (Kings County) and the Long Island Expressway (LIE) interchange in the borough of Queens (Queens County).

Objective of Construction Protection Plan

Old Calvary Cemetery, along with the Kosciuszko Bridge, was identified within the project Area of Potential Effect as an historic property eligible for listing in the National Register of Historic Places (NRHP)\(^1\) \(^2\).

Old Calvary Cemetery is located north of Newtown Creek and is bounded by Review Avenue to the south, the Kosciuszko Bridge to the east, the LIE to the north, and Greenpoint Avenue to the west within the western half of the borough of Queens.

A Construction Protection Plan (CPP) was prepared to satisfy Stipulation II A-C, Protective Measures for Old Calvary Cemetery of the October 2008 Memorandum of Agreement (MOA) between the Federal Highway Administration (FHWA), the New York State Department of Transportation (NYSDOT) and the New York State Historic Preservation Officer (SHPO) for the Kosciuszko Bridge Project pursuant to Section 106 of the National Historic Preservation Act (36 CFR Part 800.6).

The CPP was developed to protect contributing elements of Old Calvary Cemetery from vibration effects and set forth measures for protection and avoidance of structural and architectural damage from construction activities, monitoring construction activities, and repair in the event of any damage.

Stipulation II. A-C reads as follows:

A. The FHWA and the NYSDOT, in consultation with the NYSHPO, will develop a Construction Protection Plan (CPP) to protect contributing elements of the Old Calvary Cemetery from vibration effects. The CPP will set forth measures for protection and avoidance of structural and architectural damage from construction activities, monitoring of construction activities, and repair in the event of any damage.

B. The CPP will be based on the requirements established in the New York City Department of Buildings Technical Policy and Procedure Notice (PPN) #10/88 regarding procedures for the avoidance of damage to historic structures resulting from adjacent construction. The PPN defines an adjacent historic structure as being contiguous to or within a lateral distance of 90 feet from a lot under development or alteration.

C. The FHWA and the NYSDOT will ensure all conditions of the CPP are carried out by or under the direct supervision of an architectural historian that meets, at a minimum, the

\(^1\) Parsons, Cultural Resource Survey Report for the Kosciuszko Bridge Project (2006).
\(^2\) Hughes, et al., Final Determination of Eligibility: Kosciuszko Bridge (BIN 1075699), Kings and Queens County, New York, New York (2006)
NPS Standards (36 CFR Part 61), and that construction documents indicate he or she will work with the Engineer in Charge of the project with authorization to stop work to prevent any unanticipated damage.

As the project progressed through the planning and design process and from further analysis, it was determined that there will be minimal or no potential to cause affects to the historic cemetery from vibrations associated with construction operations by assigning the vibration limits in the PPN (0.5 in./sec.) to the historic cemetery and monitoring the adjacent construction activities during construction. For this reason, there also is no need for an architectural historian as specified under Stipulation II.C of the MOA.

Historic Cemetery and Appropriate Vibration Threshold Criteria

The following information supports the conclusion that the proposed protection measures for the project will minimize or avoid the potential to generate vibration that would damage the contributing elements of the NRHP-eligible Old Calvary Cemetery. The key elements include assigning vibration limits adjacent to the historic cemetery that are below the established New York City Department of Buildings Technical Policy and Procedure Notice (PPN) #10/88 threshold criteria and monitoring adjacent construction activities during construction. Through these reasonable steps, the potential for damage at the historic cemetery can be minimized or eliminated during construction.

Two types of contributing components to the historic Old Calvary Cemetery are:

- Headstones and other grave markers either directly footed in the ground or on stone foundations with a larger footprint; and
- Mausoleums.

These components have above-ground elements that would typically have a maximum allowable Peak Particle Velocity\(^3\) (PPV) vibration criteria of 2.0 in/s. However, because of the historic status of cemetery, the PPN assigns the maximum permissible PPV vibration criterion of 0.5 in./sec. and a maximum vertical and horizontal movement of ¼ inch.

Underground structures (such as any subterranean burial vaults, etc.) typically have a higher vibration criterion assigned because such structures move along with the ground, and are not free to move and potentially amplify imposed vibration. Criteria to protect any above-ground structures should adequately protect any underground cemetery resources.

Applying the Threshold Criteria

The United States Bureau of Mines (USBM) conducted extensive blast vibration studies from the 1940s onward until the Bureau was disbanded in 1996. This work on blast vibration has been extended and applied to other construction activities, including pile driving.

The USBM determined, from these studies that documented actual blast vibration damage to structures, that the most appropriate criterion is PPV. Particle velocity is how fast a point moves from its rest state as the wave passes by. The most common analogy is that of a fishing bobber on a body of water. As a wave passes, the bobber moves up and down; the velocity of the

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bobber (not the velocity of the wave) is the particle velocity. The PPV is the highest or peak amplitude of the particle velocity (absolute value).

The measurement of the PPV is appropriately made on the ground surface immediately adjacent to the structure of concern. Structures can have complex responses to induced vibration, and the amplitudes from one part of the structure to another can vary significantly. Therefore, the Bureau’s approach was to measure the ground vibration, and then use that as a statistical basis for relating the input vibration to reports of damage. This approach has been continued over the years, and is documented in most regulations derived from the Bureau’s recommendations⁴, and the International Society of Explosive Engineers Field Practice Guidelines⁵.

The criterion, then, for limiting the potential for vibration damage is PPV measured on the ground surface adjacent to a structure of concern. In the United States, this measurement is in units of inches per second, or in/s. The criterion for a specific type of structure is then based upon either statistics that relate PPV to probability of damage for actual damage studies, or application of presumably appropriate criteria based upon other information.

Based on the available literature, there does not appear to have been any direct damage studies to funerary monuments from vibration, other than qualitative indications of damage to monuments from earthquakes. Therefore, a generic criterion for “historic” structures of 0.5 in/s has been adopted as noted in the PPN.

Vibrations decrease, or “decay”, with distance from the source, and generally increase with applied energy at the source, whether this is due to explosive detonation, impact or vibratory pile driving, or other construction activities. The USBM determined that vibrations are related to distance and energy according to a power law formulation:

\[ PPV = A \times SD^B \]  

Where \( A \) and \( B \) are site-specific constants, and \( SD \) is the “Scaled Distance”, the Scaled Distance incorporates both the distance from the source as well as the applied energy. For example, for blasting the Scaled Distance takes on the form where \( D \) is the distance from the blast and \( W \) is the charge weight per individual detonation.

\[ SD = \frac{D}{\sqrt{W}} \]  

For pile driving, the typical form is where \( E \) is the driving energy of the pile driver⁶.

\[ SD = \frac{D}{\sqrt{E}} \]  

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In both of these cases, the exponent $B$ is negative, so that the vibration decreases with increasing distance (and thus increasing Scaled Distance), and increases with increasing applied energy.

A somewhat different formulation is used to assess the likely vibration from other construction activities such as jackhammers, bulldozers, etc. This formulation, based upon the Federal Transit Administration Guidance Manual\textsuperscript{7} is as follows:

\[ PPV = PPV_{ref} \left( \frac{25}{D} \right)^{1.5} \]  

(4)

In this case, $A$ is represented by $PPV_{ref}$, which is an estimated vibration level (independent of any specific energy level), measured at a distance of 25 feet. Note also that since the distance $D$ is now in the denominator, the exponent $B$ is positive, and is taken as a constant of 1.5 rather than being site-specific.

Because most construction activities (other than blasting or pile driving) do not have high energy levels, and therefore do not generate high vibration, the use of the FTA Guidance Manual approach is appropriate.

**Construction Activities**

General construction activities adjacent to the cemetery include:

- Construction of a temporary bridge over Laurel Hill Boulevard with foundations along the sidewalk adjacent to the cemetery;
- Reconstruction of the BQE/LIE Interchange ramps east of the cemetery, including retaining walls;
- Demolition of the existing bridge; and
- Construction of the new Queens approach and connector structure with foundation on the southeast side of Laurel Hill Boulevard.

There are three primary sources of vibration from these construction activities that include:

- Installation of piles, either by vibratory or impact pile driving;
- Ancillary construction activities such as bored-in piles, mechanical excavation, material movement and removal, jackhammers, etc.; and
- Blasting used during the demolition of the existing bridge foundations.

Construction activities for the duration of the project that have the potential to cause vibration including pile driving, blasting, etc., will have an active remote vibration monitoring program, including the use of up to three seismographs to keep the Peak Particle Velocity (PPV) at the project limits adjacent to the cemetery within the established criteria of 0.5in/sec.

**Drilled Piles and Ancillary Construction Activities**

For these activities, the estimated vibration is often based on an approach documented in Chapter 12 of the FTA Guidance Manual, and calculated Equation (4) above. The reference vibration levels for various equipment types as well as bored-in piles (given as “Caisson Drilling”) are as follows:

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It can be seen that for all vibration activities other than Clam Shovel Drop (which is not anticipated), vibration levels are less to much less than the criterion 0.5 in/s.

Aside from pile-drivers, most other types of construction equipment can be assumed to have vibration similar to or less than one of the types shown in this figure.

**Driven Piles**

In contrast to other vibration-generating construction activities, pile driving has the potential for generating more significant vibration levels. The FTA Guidance Manual also includes PPV values for both vibratory ("sonic") and impact pile driving.

Anticipated vibration can be estimated as shown in the following figure, which shows the vibration levels that are anticipated for the closest approach of pile driving to the cemetery fence line (80 feet) to beyond the furthest distance during first construction (180 feet):
Blasting

The demolition of the existing bridge may use explosives to remove the bridge piers, which are reinforced concrete. This work will primarily involve the above grade portions of the piers and is typically accomplished by drilling small diameter holes in the concrete and then using stemmed explosive charges. By limiting the size of the charges, hole pattern, use of stemming and delays, the vibration level can be controlled. In addition, above grade the piers can be wrapped to minimize debris. If blasting is permitted, the use of a test blast series can be used to determine the appropriate measures, in accordance with equations (1) and (2), to keep the PPV within acceptable 0.5 in./sec. threshold to protect the cemetery features.

Vibration Monitoring

When there are construction activities that have the potential to create vibration near the cemetery, the contractor will be required to continuously monitor vibration to verify that these activities do not exceed the PPV vibration limits.

If it is determined that there is a potential for vibration damage based on this monitoring, the NYSDOT Standard Specification ITEMS 634.99010017 and 634.99020012 will be followed. These will be included as Special Notes in the Contract Documents. The NYSDOT’s standard contract protocols will outline the contractor’s responsibility in case damage to Old Calvary Cemetery occurs.