REPLACEMENT OF THE MBTA FRANKLIN LINE OVER EAST STREET WESTWOOD, MA

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ABSTRACT

The Massachusetts Bay Transit Authority's (MBTA) East Street Bridge carries the MBTA Franklin Line over East Street in Westwood, Massachusetts. The existing bridge was not classified as structurally deficient, but had substandard vertical and horizontal clearance that resulted in many traffic accidents and vehicle collisions with the bridge structure. There were 81 accidents reported between 2009 and 2015 alone.

The Franklin Line is a critical part of the MBTA's rail network and is heavily used by both commuter and freight rail. Likewise, East Street is a heavily traveled roadway, and one of only 4 grade separated crossings within the Town of Westwood. It provides a direct connection between Westwood and Interstate Route 95. To minimize disruption to rail service and East Street traffic, accelerated bridge construction techniques were used to the maximum extent practicable.

INTRODUCTION

The MBTA's East Street Bridge is locally known in Westwood as the "can opener" bridge. It is renowned on YouTube for many accidents caused by the substandard clearances and roadway alignment. The existing bridge was not classified as structurally deficient, however substandard vertical and horizontal clearance and an awkward roadway approach resulted in many traffic accidents and vehicle collisions with the bridge structure rendering the bridge functionally obsolete. The primary goal of this project was to improve the horizontal and vertical clearance of the roadway below, and to improve the safety for both vehicles and pedestrians.

Photo #1: A fireman puts out the fire when an over height truck struck the East Street Bridge

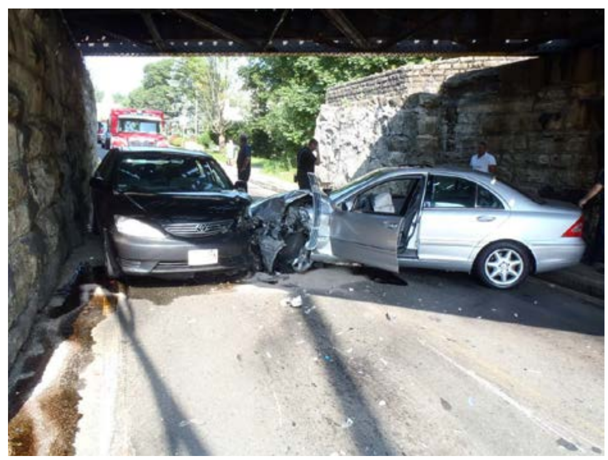
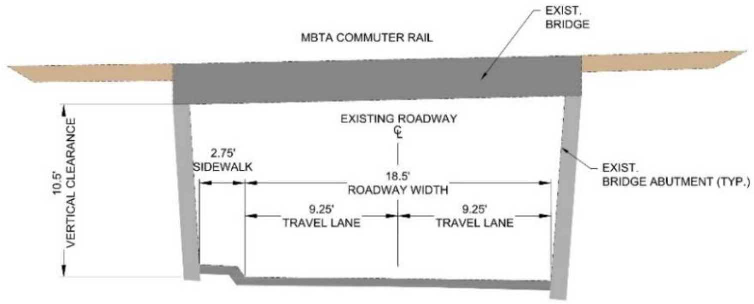


Photo #2: Two cars collide under the East Street Bridge

This section of the Franklin Line corridor is double track and carries both MBTA Commuter Rail and CSX freight. The line is heavily used by both daily. East Street is a heavily traveled roadway, linking Westwood's Islington Village to I-95. For these reasons it was necessary to limit impacts to both vehicle and train traffic during construction.

The existing bridge at East Street was built in 1911 and provided only 10'-6" of vertical clearance over the roadway below. The abutments provided only 18'-5" of lane width plus a 2'-9" sidewalk below the bridge.

The approach roadways were forced to narrow at ‘pinch points’ on either side of the bridge to carry the lanes through. This narrowing caused a large portion of the vehicle accidents under the bridge.



EAST STREET
EXISTING CONDITION

PROJECT NEED

Town officials approached the MBTA and expressed concerns that the existing bridge was a safety hazard, citing numerous traffic accidents due to the narrowing of the road as motorists approach and travel under the bridge. The accidents captured by a 24-hour video camera monitoring system, implemented by the Town to document traffic incidents, typically occurred in two scenarios:

1. Vehicles traveling westbound, coming from I-95, strike the sidewalk curb below the Bridge, with their front passenger tire, and are directed across into the eastbound lane, resulting in a head-on collision with oncoming vehicles, or the abutment wall, when the eastbound lane does not contain a passing vehicle.
2. Vehicles exceeding the 10’-6” vertical clearance, strike the bridge and become trapped, often times scattering portions of the vehicle and its contents onto the roadway. In a few instances, vehicles striking the bridge have burst into flames.

These accidents have caused significant impacts to vehicular traffic, backing up vehicles onto I-95 North and South, and Route 1A. Commuter rail traffic has also been affected, with rail traffic being impacted along the Franklin Commuter Line, and ultimately the heavily traveled Northeast corridor from Boston’s South Station to Providence Rhode Island.

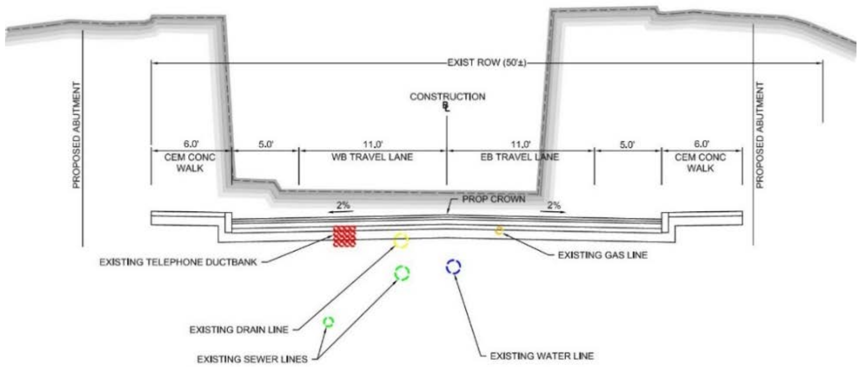
CONCEPT DEVELOPMENT

This project posed many constraints during concept development to evaluate the plausible options for replacement of the bridge. First and foremost was the active railroad traffic that runs through this area. The volume of commuter rail traffic is high, especially during peak hours, and time schedules are inflexible. Additionally, freight traffic added several crossings throughout the day and night. East Street provides a critical link between the Town’s Islington neighborhood, MBTA’s Islington station, and Interstate 95. There were some initial concerns over potential impacts to roadway traffic, and the project team worked closely with Town officials to create a traffic management plan that suited all involved. Accordingly, every effort was made to minimize disruptions to East Street vehicular traffic during construction.

Another major constraint impacting superstructure options, was the necessity to increase the roadway clearance both vertically and horizontally below the bridge. A combination of raising the track profile and lowering the roadway profile was investigated to accommodate the changes and to achieve a balanced design. It was necessary to limit the track profile increase to avoid the need for added costly retaining walls along the right of way. Additionally, Islington Station is only 700 feet (+/-) north of the bridge and could not be changed or impacted as part of this project, so any changes to the track horizontally or vertically needed to tie into the start of the station. MBTA’s Railroad Operations had concerns about any grade increase to the existing tracks, due to train slippage during the fall and winter months. There were also horizontal constraints within the railroad right-of-way to take into consideration, limiting the amount the tracks could move to accommodate new structures.

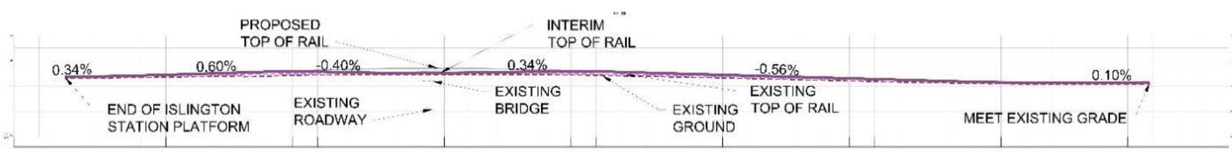
For the roadway profile adjustments, it was necessary to take account of the amount and location of existing utilities, both overhead and underground, which limited the available room to drop and widen the roadway.

The narrow opening between abutments required the roadway to be widened before the utilities could be relocated or lowered. It was also preferred that the lowered roadway not require a complete drainage re-design and replacement, and that it would tie into the existing nearby system without impacts beyond the project limits.

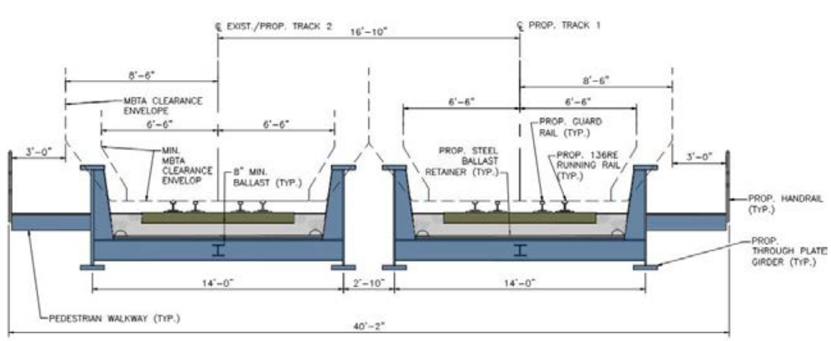


After evaluating several different options for proposed roadway and rail profiles, a compromise between the two was determined to be the best solution. It was decided to raise the rail profile approximately 21 inches and drop the roadway profile 16-18 inches under the bridge. This created a middle ground for the amount of track work and roadway/utility work required to complete the project.

Several different structure and construction alternatives were considered during the preliminary phase of this project. Both traditional and accelerated bridge construction techniques were evaluated. Due to the major constraints relative to the traveling public, particularly the necessity to minimize the roadway and track disruptions as much as possible, the accelerated construction concept was chosen for bridge type selection and design. This option was preferred as it required only night time and weekend shut downs. However, in order to accommodate the amount of track work required to raise the track profile during the allotted time frames, a non-traditional 'interim' profile concept was devised to limit the amount of track work required during the weekend bridge installations. In this interim concept, the approaches to the bridge were partially built up to final grade before transitioning back down to the existing grade at the bridge, creating a 'hump' on each approach. This interim profile significantly decreased the amount of track work required for the contractor on the busy bridge erection weekends.



Once accelerated bridge construction was chosen, the types of feasible superstructures for such a project were limited. The structure type of through plate girders with a ballasted deck was ultimately chosen because it had the shallowest structure depth. A waiver to reduce the amount of ballast was also granted by the MBTA to go from the typically required 12 inches of ballast down to 8 inches. The design team further reduced the structure depth by creating the concept of two separate bridge structures, which not only facilitated the accelerated construction scheme, but also allowed for shallower girder sections due to not having a center girder supporting two tracks. With the two-structure concept came another consideration. The structure layout would require one track (Track 1) to shift approximately 3.5 feet to the west (away from track 2). In order to minimize that shift, it was required to take advantage of the minimum MBTA clearance envelope to lay out the girders. This triggered the need for emergency access walkways on both structures.



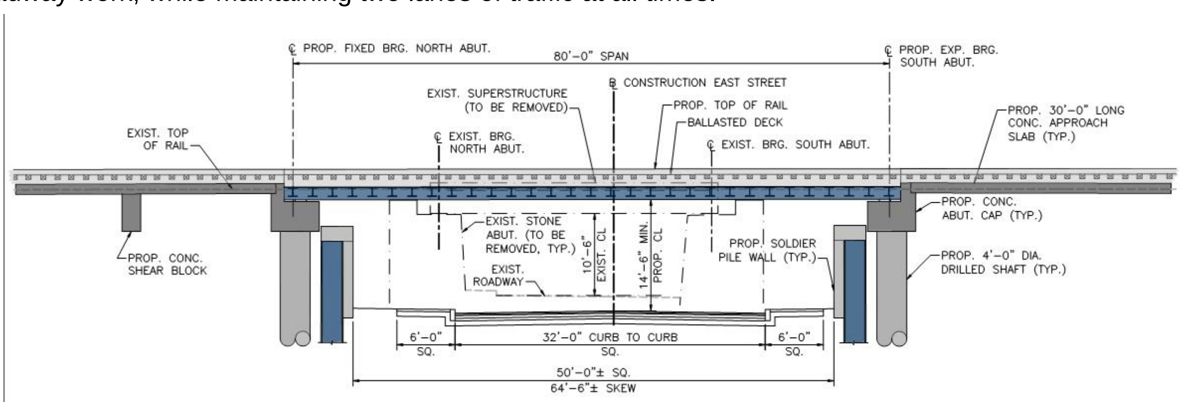
Like the superstructure selection, the substructure type selection was also narrowed down by the decision to use accelerated bridge construction. In order to install the new substructure with the least amount of disruption to the active tracks, constructing deep foundations with precast abutment pieces was preferred to enable the construction sequence.

During the early phases of the project, there were a few concerns from the nearby residents on East Street related to the bridge replacement. Their apprehension was related to a potential increase in truck traffic and vehicle speed on the roadway once the clearance of the bridge was no longer a deterrent. Through several public meetings, the project team worked closely with the Town and residents to explain that the proposed bridge would allow those smaller ‘box trucks’, which were the main source of bridge impacts, to pass safely under the bridge. The increased clearance would still not allow larger trucks to pass through. There was also a truck restriction in place at another bridge along East Street that remains which will continue to limit their presence on the roadway. It was determined that the safety concerns for all users outweighed the perceived negative impacts.

ACCELERATED BRIDGE DESIGN

After the project reached the 30% design level, the MBTA was given the opportunity to bump the project construction start date up by a year. This required the MBTA and VHB to develop an accelerated design schedule by streamlining their typical process, forgoing the standard 60% design submittal, and providing an interim set of plans with 60% specifications while proceeding directly to the 90% plans, specifications and estimate. VHB and the MBTA committed to the updated timeline without sacrificing on the quality of the product.

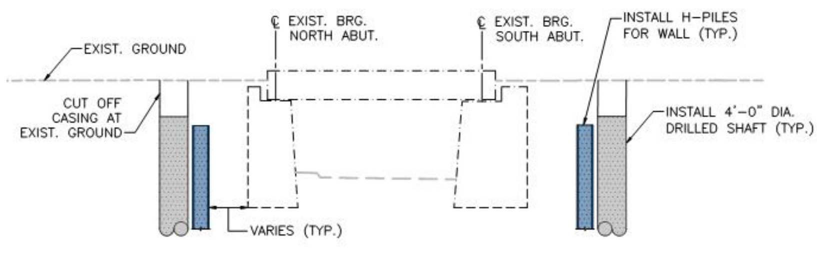
In order to adhere to the project constraints, it was determined that the bridge construction would include Accelerated Bridge Construction techniques to the maximum extent feasible. The proposed design incorporated drilled shaft foundations with precast substructure elements. The best way to construct the new abutments was to place them behind the existing abutments, so the track could remain open while installing most of the proposed elements. The proposed drilled shafts were set far enough back to ensure they would not impact the existing abutments during installation. The location of the existing rails was also taken into consideration when laying out the shafts in order to allow for as much drilling during active rail times as possible. Soldier piles with cast-in-place concrete lagging walls completed the abutment and wing wall support, which were laid out to avoid the existing rails and abutments to the maximum amount that was practical. Concrete deadmen tied back the North (fixed) abutment to limit longitudinal force impacts on the drilled shafts and soldier pile and lagging walls. Using these walls, created the opportunity for the concrete facing to be cast after the existing abutments were demolished and the new bridges installed. This would allow for more space and greater flexibility for relocating the utilities and completing the remaining roadway work, while maintaining two lanes of traffic at all times.



When it came time to develop the superstructure design, several factors went into the design decision. First and foremost was to minimize the structure depth in order to facilitate the improved clearances that were required. The proposed structure required a ballasted deck instead of the existing open timber deck. A ballasted deck would require a slightly deeper structure which limited the options. A steel through plate girder structure was selected to take advantage of the girder-floorbeam system. In order to maintain traffic on and under the bridges, the superstructure would be pre-assembled off site prior to installation. The constructability of installing a large two track structure was not ideal thus, the concept of two identical smaller structures was introduced which allowed half the bridge (one track) to be constructed during each weekend shutdown.

ACCELRATED BRIDGE CONSTRUCTION

To minimize disruption to rail service and East Street traffic, accelerated bridge construction techniques were used to erect precast abutments and to preassemble and erect the through plate girder superstructures. Barletta Heavy Division (BHD) of Canton, MA was the selected contractor through the bid process, and had extensive experience with several similar past ABC projects. Bridge replacement, including associated utility relocations and track realignment, were accomplished during a series of short-duration track and roadway closures, and weekend shutdowns. The project team worked closely with the Town and local police to give ample notice to residents and local emergency services ahead of roadway closures. The detour routes and closure times were coordinated between all parties in order to minimize the impact to the community as much as possible.



STAGE 1

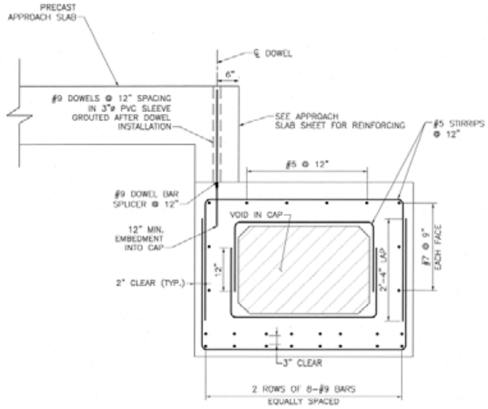
The drilled shafts and soldier piles were simultaneously installed during a series of single and double track weekend shutdowns, while East Street remained open. A number of the soldier piles were installed while both tracks were active due to their distance from the existing tracks, which allowed some of the work to be completed during the week. Four of the six shafts and the rest of the soldier piles were constructed and installed while at least one rail was active during single track weekends. The two center shafts were constructed during a single weekend with a full track closure. With timely scheduling of the drilled shaft installation, the project was able to take advantage of a closure required for the installation of Positive Train Control occurring at the same time. This reduced project costs relative to bussing weekend passengers.


Photo #3: Both tracks active

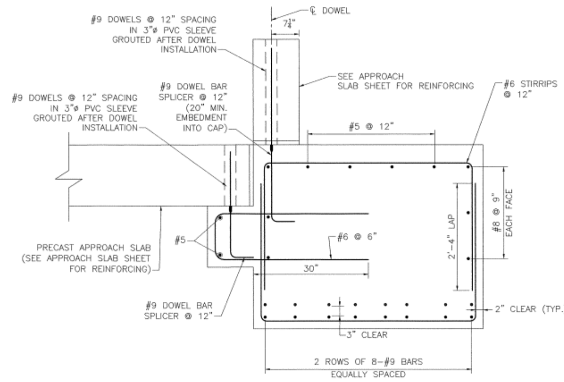

Photo #4: Single track shutdown


Photo #5: Both tracks shutdown

During the construction phase, several design changes were requested by the contractor in order to further streamline construction. The major change involved a change in construction staging in an effort further assure the construction would stay within the two full weekend shutdowns (both rail and roadway) allowed under the contract. Instead of installing one track at a time (both precast substructure and superstructure) in each of the two separate weekend shutdowns, the Contractor installed the entire precast substructure in one weekend shutdown and installed both superstructures in the second weekend shutdown. For this to work, the precast elements were buried in order to re-open the existing track between the precast install and the superstructure install that took place several weekends later. To accommodate this change under the accelerated schedule, the MBTA, VHB and BHD had to expedite a Design Change Request (DCR) in short order to maintain the precast plant's schedule.



Proposed Precast Cap Design



As-Built Precast Cap Design

The precast cap was re-designed to include a corbel to support the approach slab, allowing both the cap and approach slabs to be low enough below existing grade that the existing tracks could be re-installed and run over the buried pieces.

During the first full weekend shutdown of both the roadway and tracks, the contractor installed four precast caps, four precast approach slabs, and two precast deadmen. The existing bridge structure was not touched during this weekend. After the precast pieces were in place, flowable fill was pumped below to fill any voids and the pieces were buried. The existing tracks were then reinstalled and opened back up with plenty of time ahead of the first train early Monday morning.

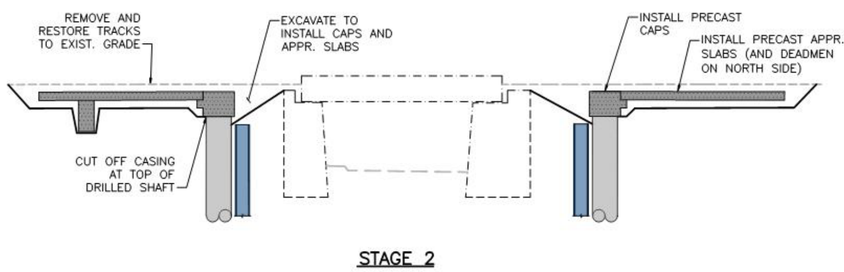


Photo #6: Drone view of substructure installation

Photo #7: A precast cap is lifted into place on the drilled shaft foundation

The two superstructures were pre-assembled off site in a nearby MassDOT maintenance yard. The yard provided plenty of staging area for delivery and assembly of the various steel components. This also helped to minimize impacts to the roadway and rail traffic at the site, and to reduce the amount of work required during the final weekend closure. The waterproofing and protective boards were installed while the bridges were in the yard, further decreasing the work required at the site.

Photo #8: A girder is lifted into place in the MassDOT yard off site

Photo #9: A floorbeam and deck plate section is lifted into place with the braced girder

The two separate smaller superstructures also allowed for more maneuverability and easier transporting of the structures to the bridge site. The contractor used self-propelled modular transporters (SPMT) to move the preassembled superstructures to the site for erection during the second full weekend track and roadway closure. The SPMT's drove each structure through the local neighborhood, down the street to the bridge site on the Friday before the weekend installation.

Photo #10: The project team 'walks' a bridge through the local neighborhood on SPMTs

Photo #11: The SPMTs maneuver around a tight corner on the way to the bridge site

Once both the tracks and roadway were closed, and prior to the bridge installation, the existing superstructure was cut into large chunks and removed to an offsite location to be fully dismantled. The existing substructure was then demolished down to a point where the superstructure could be installed, and the remaining precast backwall and wingwall pieces, as well as the bridge bearings, were installed.

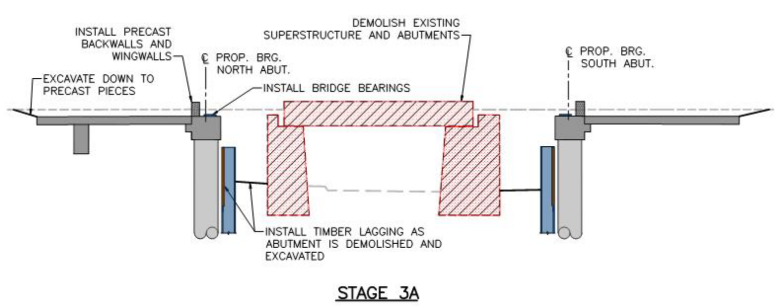


Photo #12: Existing abutment demolition

Photo #13: Precast backwall and bearing installation

Once the bearings were set, two 600 ton cranes were used for a heavy lift bridge installation for each superstructure. Because of due care taken during design and control measures taken during construction, the fabrication and assembly of the many pieces involved went together without any fit-up issues. The steel superstructures were placed within very tight tolerances on the precast backwalls. In addition to these construction activities, the track bed needed to be raised approximately 21” at the bridge, which included new subgrade, ballast and track.

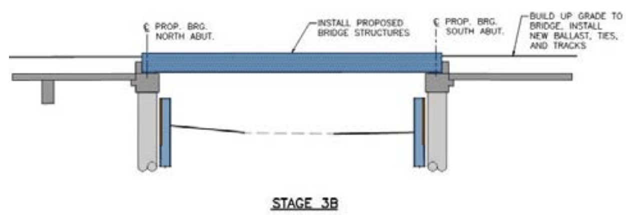


Photo #14: Bridge superstructure erection

Photo #15: Drone view of superstructure erection

Once the superstructures were set in place, the remaining track work over the bridge was completed as well as the rest of the existing substructure removal. The roadway was not lowered down to its final grade at that time, but was smoothed out so traffic could run over it in an interim condition. All weekend work was completed ahead of schedule to re-open the track and roadway early Monday morning.

Photo #15: Final track work on bridge

Photo #16: Roadway open to morning traffic

Once the existing substructure and bridge were fully removed and replaced, almost double the staging space was available for the replacement of the utilities in the roadway and for lowering the roadway grade to its final profile. It also created the ability to use lane shifts in order to construct the CIP concrete facing on the soldier pile walls, to install the new sidewalks and pavement, and to facilitate the tie-ins to existing private properties, all while maintaining East Street traffic. The walls were able to remain in a temporary condition with the timber lagging, until the utility relocation and traffic patterns allowed for the permanent concrete facing to be cast. The final lowering and paving of the roadway were completed with single lane closures.

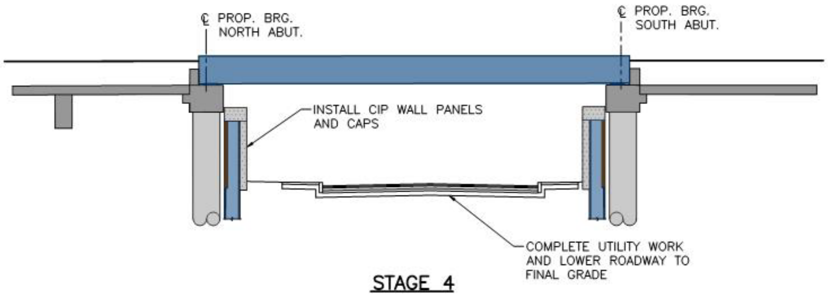


Photo #17: Final utility and roadway work around active traffic

Photo #18: Installation of C.I.P. concrete facing on the soldier pile and lagging walls

CONCLUSION:

The ‘can opener bridge’ presented an on-going danger to pedestrians, roadway and rail traffic. The need for un-interrupted commuter rail traffic required accelerated bridge construction techniques be used throughout the project. Work was concentrated during off peak and weekend time in order to facilitate the continued access for traffic below and on the bridge. The timing for construction funding required the design team to accelerate the design process without sacrificing on the quality of the project. With proper planning, extensive teamwork between the Owner, Designer, Contractor and Town, the result was a successful high profile bridge project completed on schedule and under budget.

PROJECT TEAM

MBTA – Owner

VHB – Lead Engineer and Designer

Nobis Engineering – Geotechnical

Green International Affiliates – Survey

Keville Enterprises – Project Controls, Estimating and Scheduling

Barletta Heavy Division – Contractor