Design-Build 48-Hour Replacement of LIRR's Post Avenue Bridge Using SPMTs

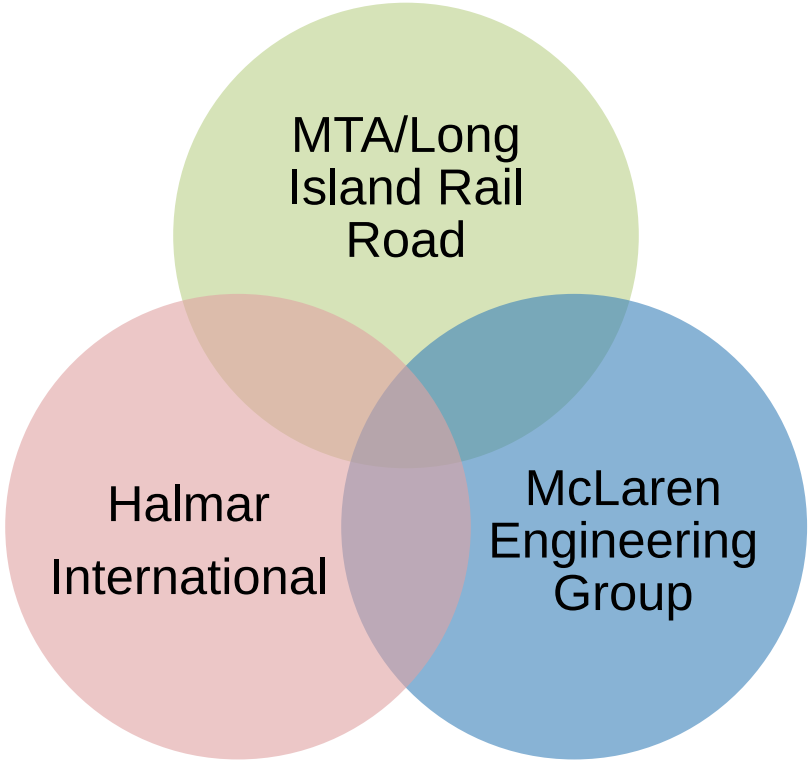
Vicki Christini, PE

June 4, 2019

NYSCHSA
Business Meeting

McLaren ENGINEERING GROUP applied ingenuity

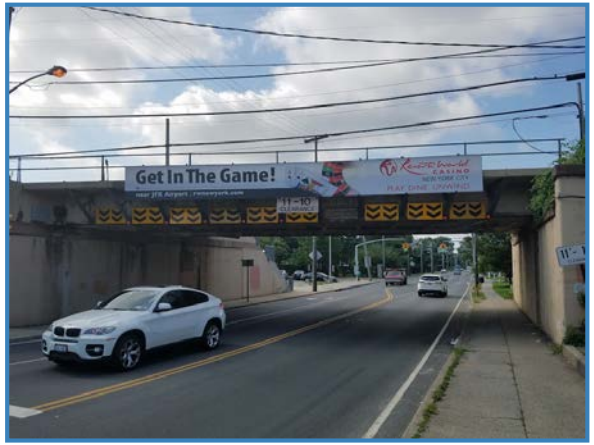
Project Team



Location Map

Project Location

Site Photos



South Elevation

Top of Bridge

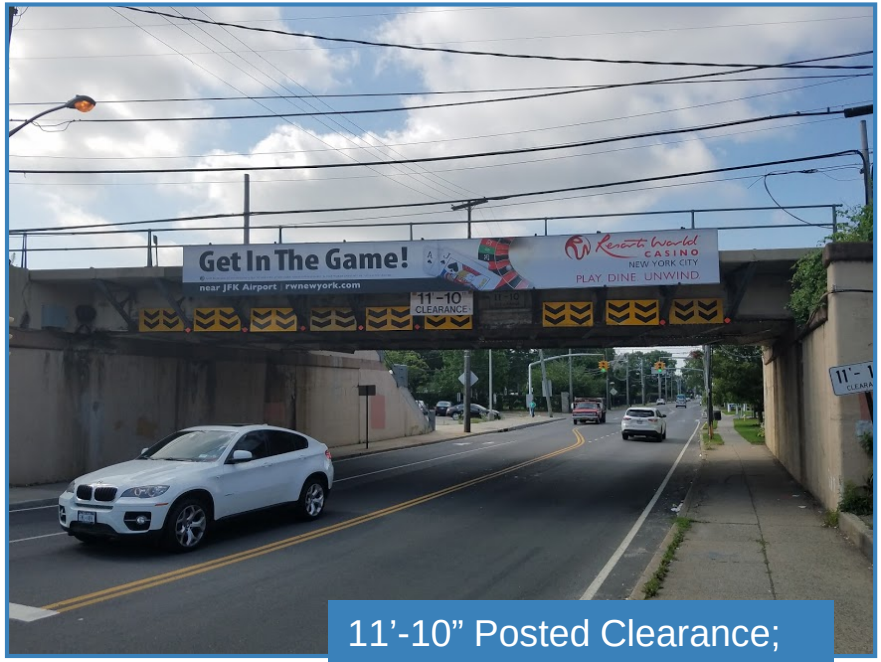
Underdeck

Need for the Project

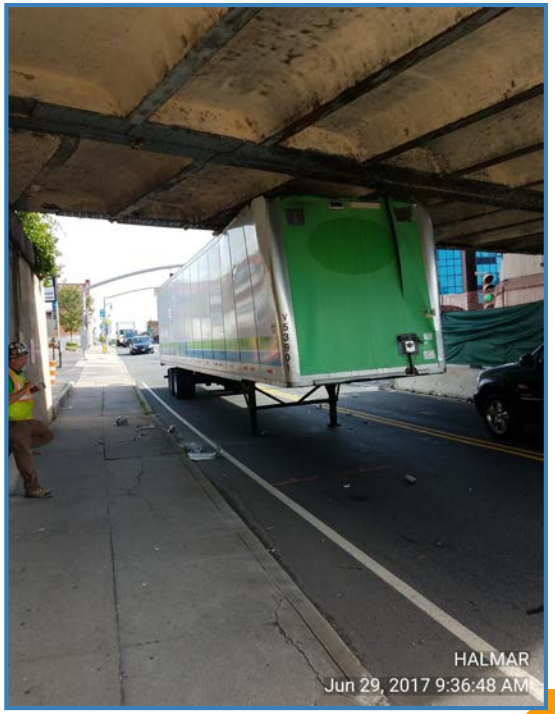
- Age – Bridge was constructed in 1914 - *deterioration*
- Low vertical clearance – *numerous bridge strikes*
- Preparation for LIRR 3rd Track

Bridge Strikes

Bridge Strike June 29, 2017



11’-10” Posted Clearance;
12’-10” Actual Clearance



Recorded:
5 to 9 strikes per year over the last 6 years

Bridge Strikes

Bridge Strike Oct. 5, 2017

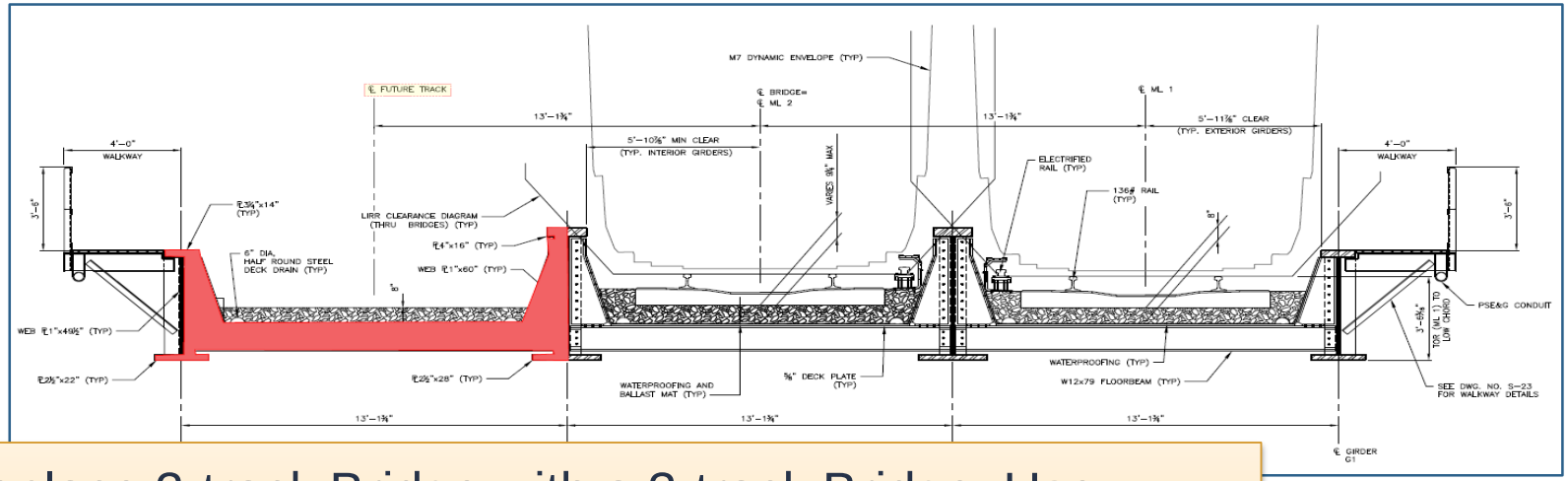
Bridge Strikes

Video

Existing Conditions

- 63’ Span
- Steel Thru-Girder/Floorbeam System
- Concrete Deck
- Concrete Gravity Abutments
- 2-Track Superstructure; 4-Track Substructure
- Vertical Clearance Posted: 11’-10”

Project Scope of Work - Superstructure



- Replace 2-track Bridge with a 3-track Bridge; Use Weathering Steel to Reduce Future Maintenance
- Increase the Vertical Clearance Under the Bridge by Reprofiling Tracks and Minimizing Structure Depth

Project Scope of Work - Substructure

- Rehabilitate and Strengthen the Existing Abutments
- Construct New Retaining Walls

Project Constraints

- Minimize Impact to LIRR Operations and Customers
- Minimize Impact to Surrounding Community

- **48-Hour Weekend Shutdown** - (32-hour Bridge Replacement)

  1 a.m. Saturday morning to 1 a.m. Monday morning

  Designated Weekend: October 21-22, 2017

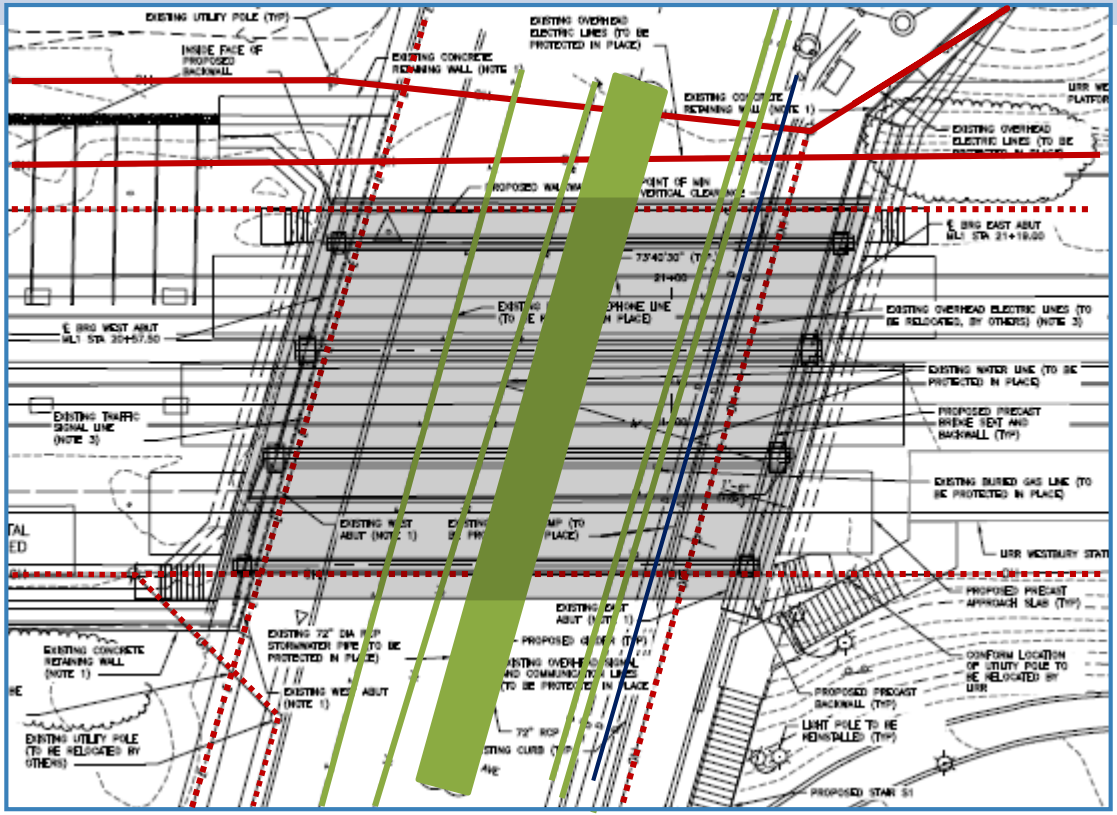
Project Objectives

- Replace the Superstructure using the Weekend Shutdown - Detour
- Rehabilitate the Substructures using Lane Shifts on Post Ave.
- Design New Retaining Walls for Train Surcharge

Design Schedule

- NTP – January 2017
- Steel Mill Order – End of January 2017
- Superstructure Steel & Bearing Design – End of February 2017
- Shop Drawing Approval for Steel and Bearings – May 2017
- Abutment Rehabilitation Design – May 2017
- Detours and Lane Shift Approvals – May 2017
- Retaining Walls – June 2017
- Shop Drawing Approval for Bridge Seats – July 2017

Why a SPMT?



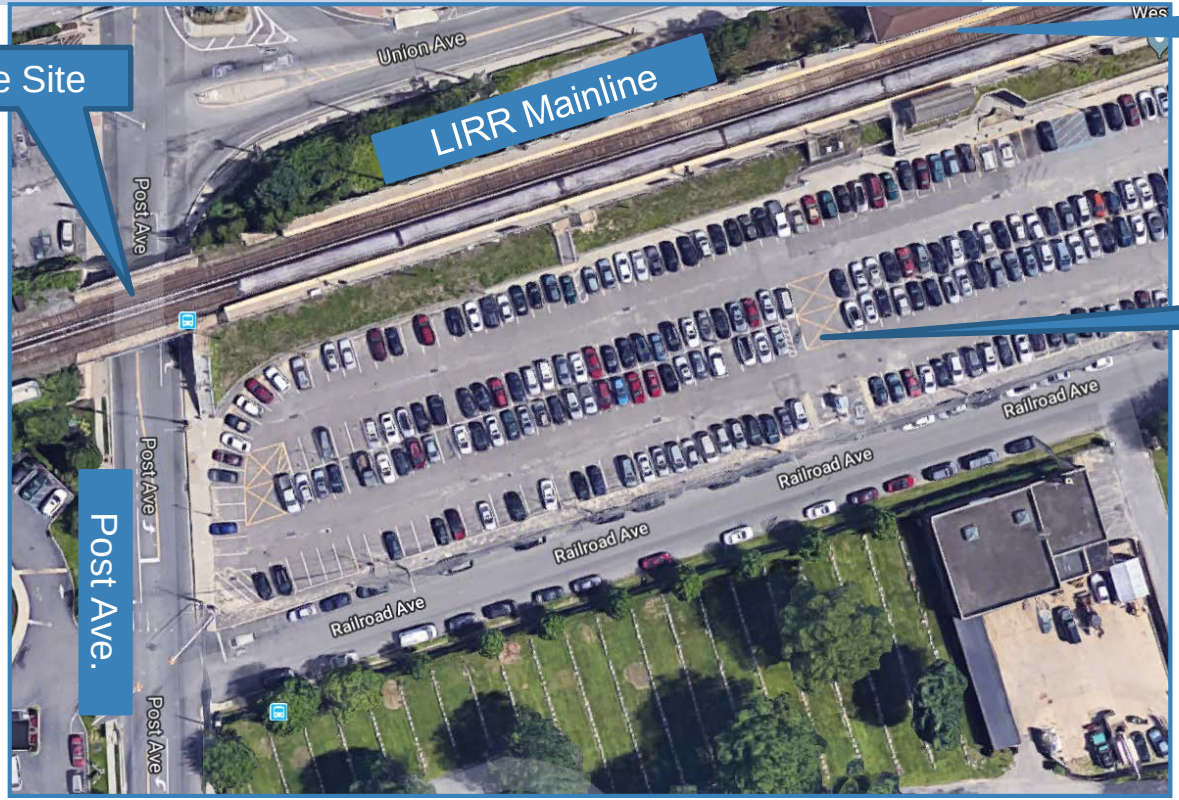
- Numerous Overhead Utility Lines Needed to be Relocated:

Electric
Telephone
Traffic Signals

- Numerous Underground Utilities Needed to be Protected:

Telephone Conduits
4" Gas Main
12" Water Main
72" & 4-24" Storm Sewers

Parking Lot Capture - 1



Bridge Site

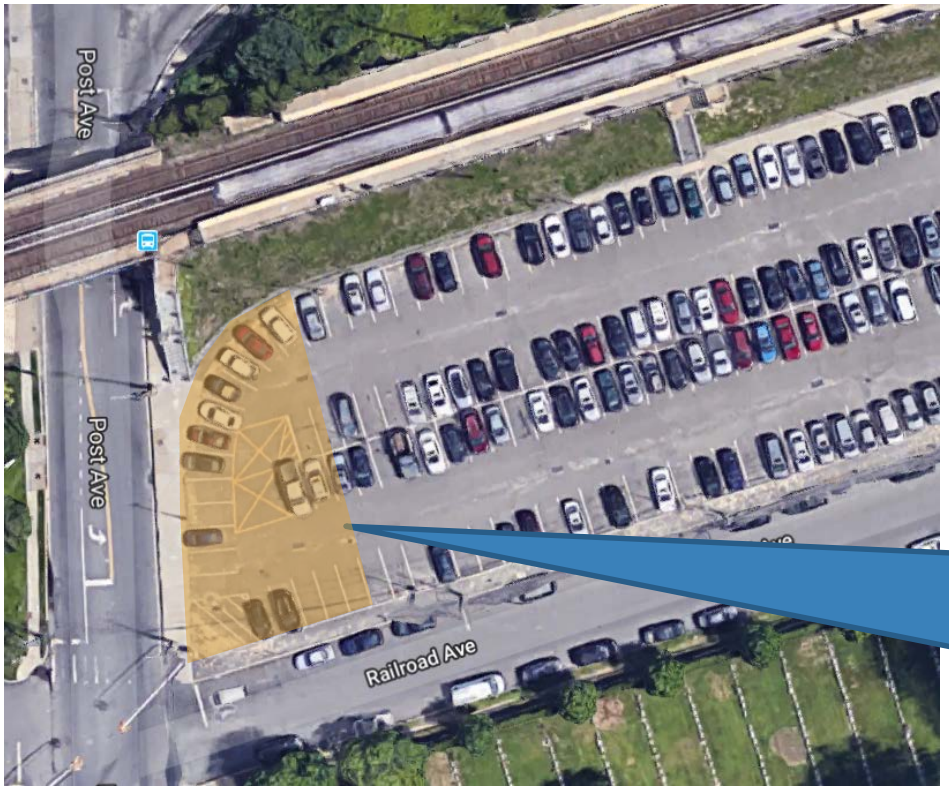
LIRR Mainline

Westbury Train Station

Commuter Parking Lot

Ideal Staging & Laydown Area

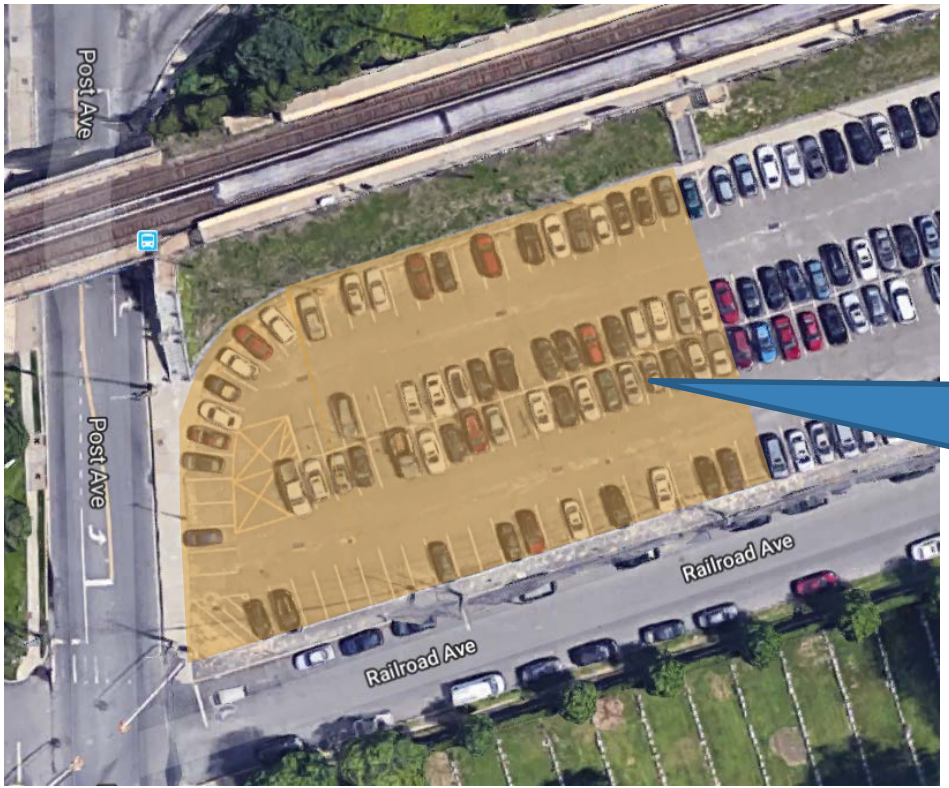
Parking Lot Capture - 2



Phase 1
Capture Zone
20 Spaces
April 2017

Abutment and Retaining Wall Work

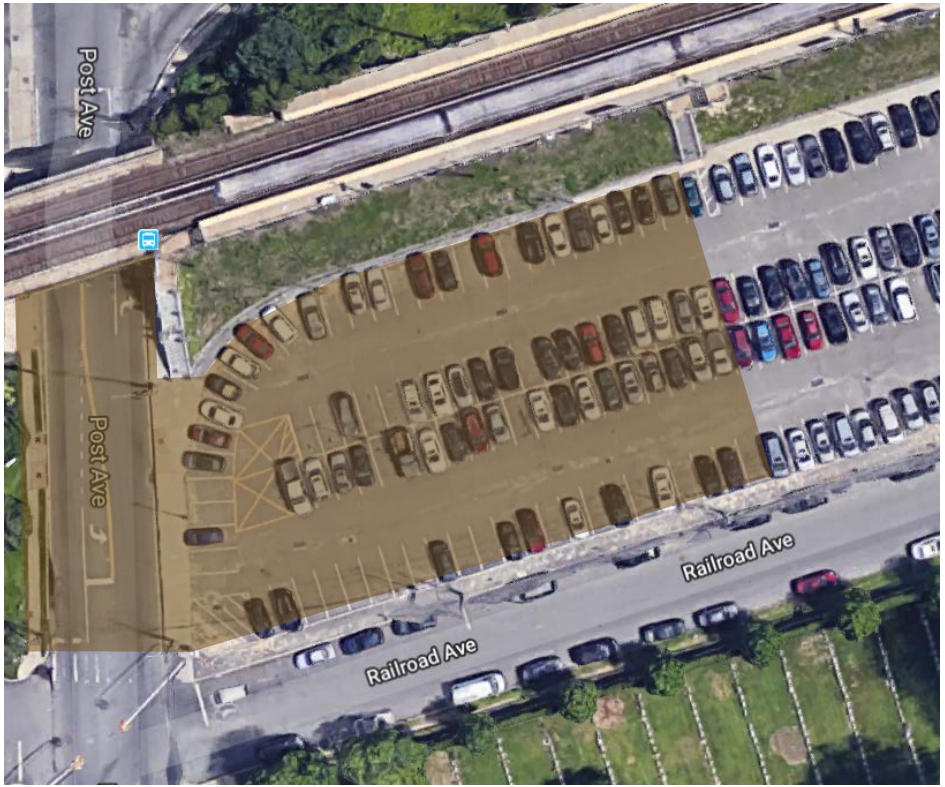
Parking Lot Capture - 3



Phase 2
Capture Zone
80 + Spaces
August 2017

Bridge Erection

Parking Lot Conditions



- Pavement Slope in Lot is 2%
- Grades & Elevation Differences
- Drainage
- Light Poles

Self - Propelled Modular Transporter Path

SPMT Example

Travel Path Slopes < 1% for SPMT Path

Entire Area Covered with Sand Fill & Steel Plates to Create SPMT Path

Accelerated Project Staging

- Relocate existing public utilities and telephone lines (Spring)
- Install soil anchors and retaining walls (May - June)
- Begin assembly of new superstructure (August)
- Create path for SPMTs (October)
- Remove tracks and ballast, relocate LIRR utilities (LIRR – Oct. 21)
- Remove existing superstructure with SPMTs (Oct. 21)
- Remove top of existing abutments and install precast caps (Oct. 22)
- Install new superstructure using SPMTs (Oct. 22)
- Reinstall track and trackbed (LIRR – Oct. 22)

Design Packages

Design Packages:

- Superstructure
- Substructure
- WZTC and Detour
- Trackwork
- Platform and Stairways
- Roadway, Site, Utilities and Demolition

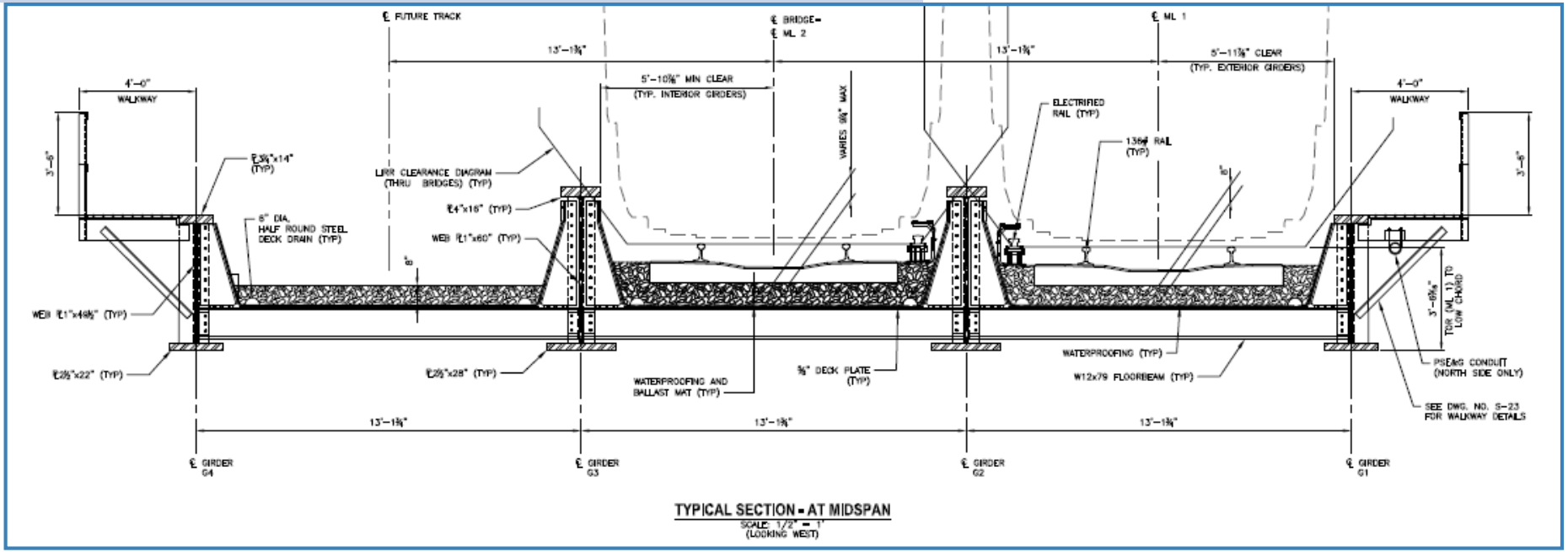
Submissions:

- Steel Mill Order
- 60%
- 90%
- 100%
- RFC – Release for Construction

Weekly Design Meetings / Monthly Project Meetings

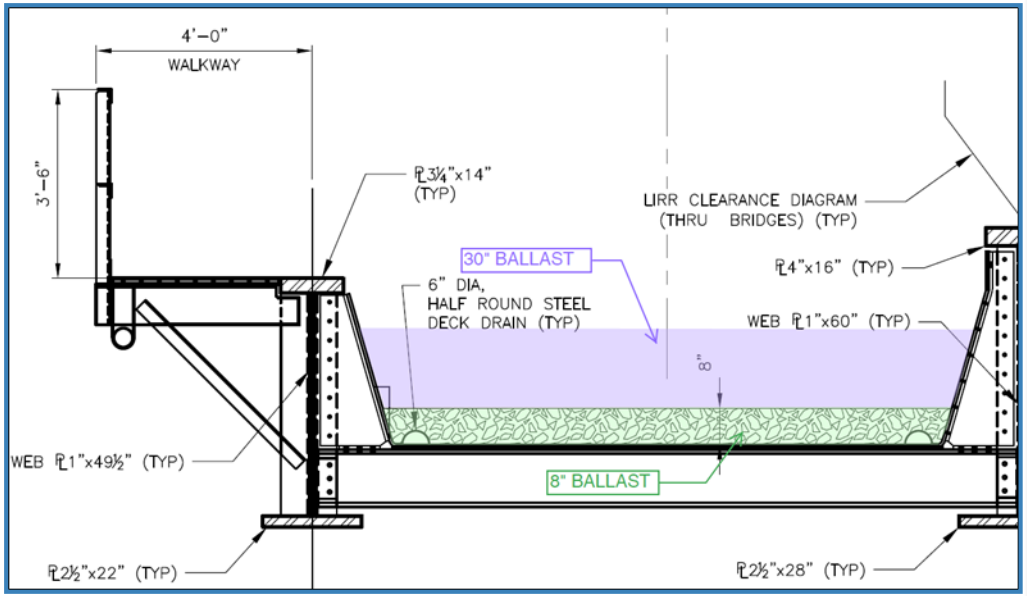
Preparation for the Weekend Shutdown

Superstructure Design Phase



TYPICAL SECTION - AT MIDSPAN
SCALE: 1/2" = 1'
(LOOKING WEST)

Design Challenges



- Dead Load: Bridge is designed for 8” of ballast & 30” of future ballast
- Live Load: Cooper E80 Live Load as per AREMA
- Geometry Constraints – LIRR Clearance Envelope
- Increase Vertical Clearance under the Bridge to 14 feet
- Seismic Load (Abutment & Bearing)
- Traction/Braking Forces (Abutment & Bearings)

Steel Girder Depth

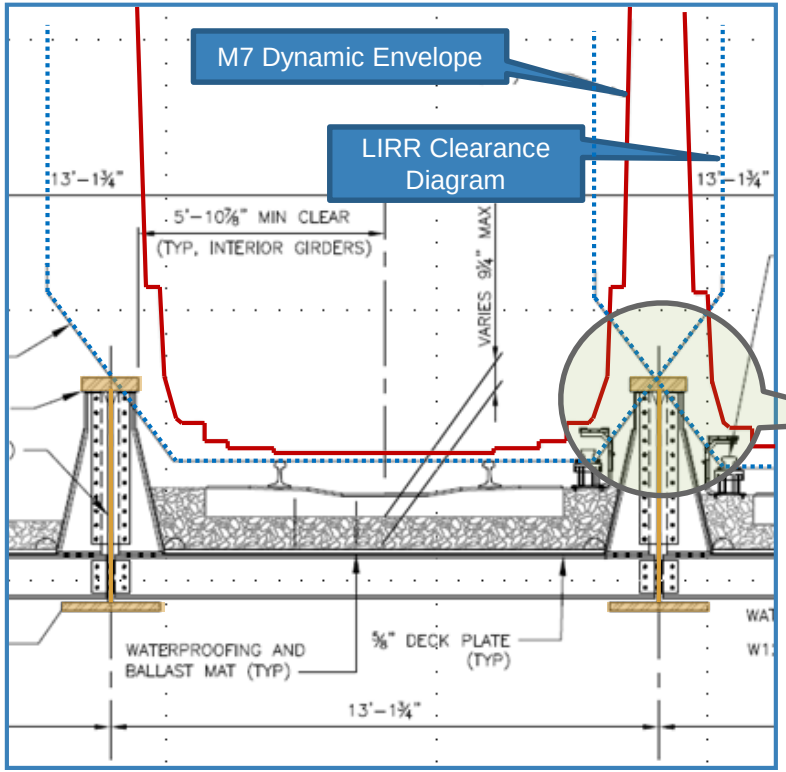
- **Superstructure Design – looking to find a balance**

✓ Limit encroachment into the LIRR Clearance Envelope

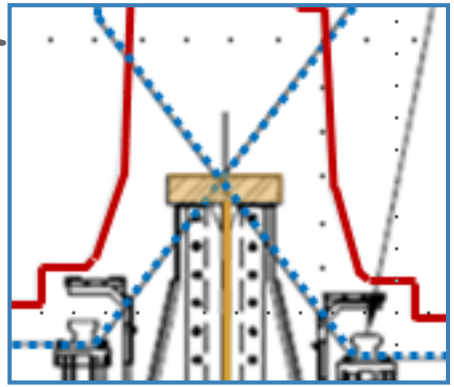
✓ Limit track profile raise

✓ Minimize Structure Depth

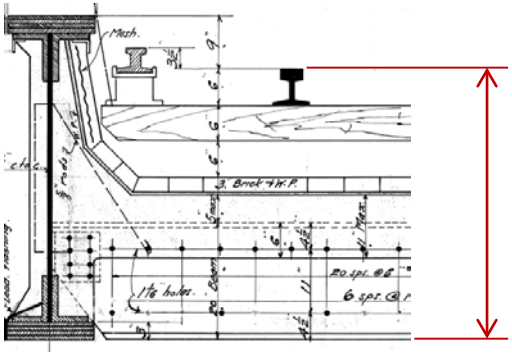
Clearance Diagram



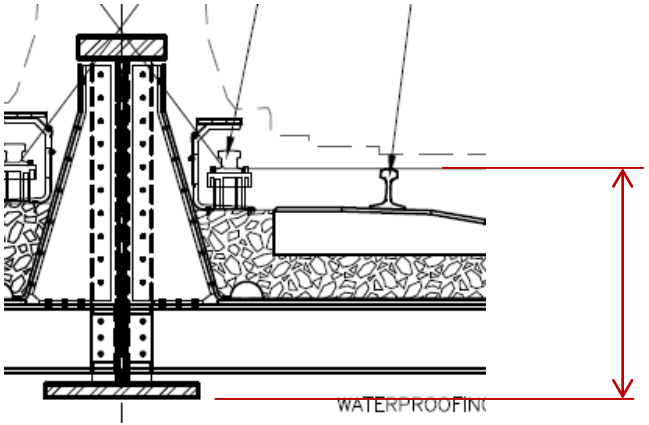
- Standard Track Spacing 14’-0”
- Existing Track Spacing 13’-1 ¾”
- Tops of Girders Encroach Clearance Diagram
- Minimize Depth of Girder: Requested Waiver



Structure Depth



Existing Depth of Structure

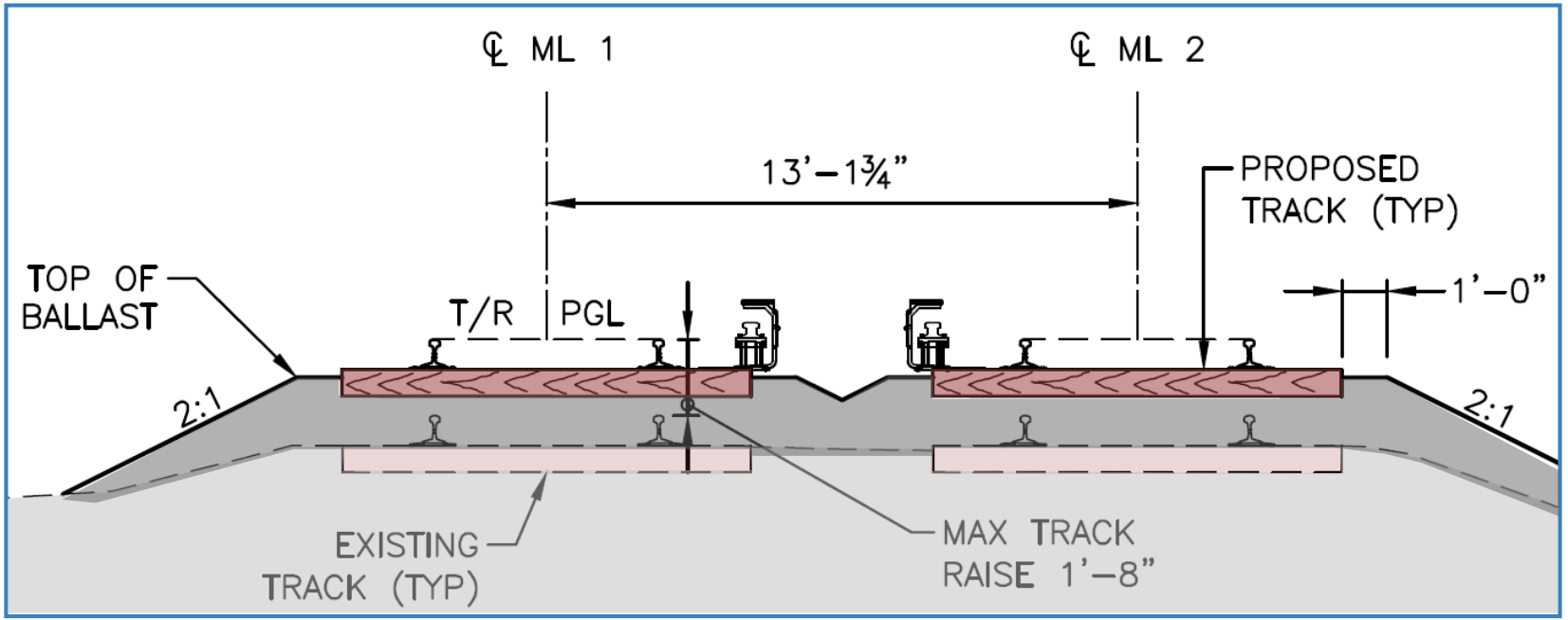


Proposed Depth of Structure

Profile Raise

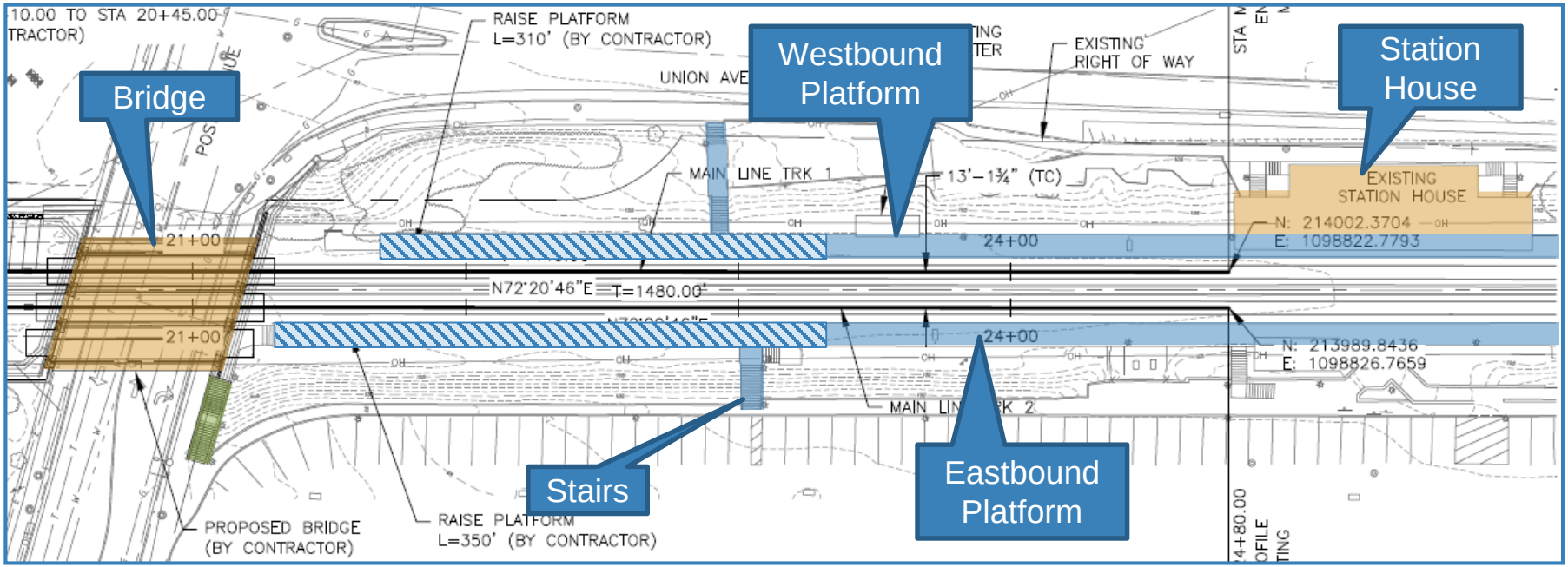
Existing Vertical Clearance =	12’-10”	
Proposed Vertical Clearance =	**14’-1”**	
$\square_{VC}$ =		**1’-3”**
Existing Structure Depth =	3’-10”	
Proposed Structure Depth =	**3’-6’**	
$\square_{SD}$ =		**0’-4”**
Contingency =		**0’-2”**
Raise Profile at Bridge =		**1’-1”**

Reprofile Tracks - Approaches



Length of Track Reprofiling = 3,500 feet

Reprofile Tracks (0.5% to 0.7% grades)



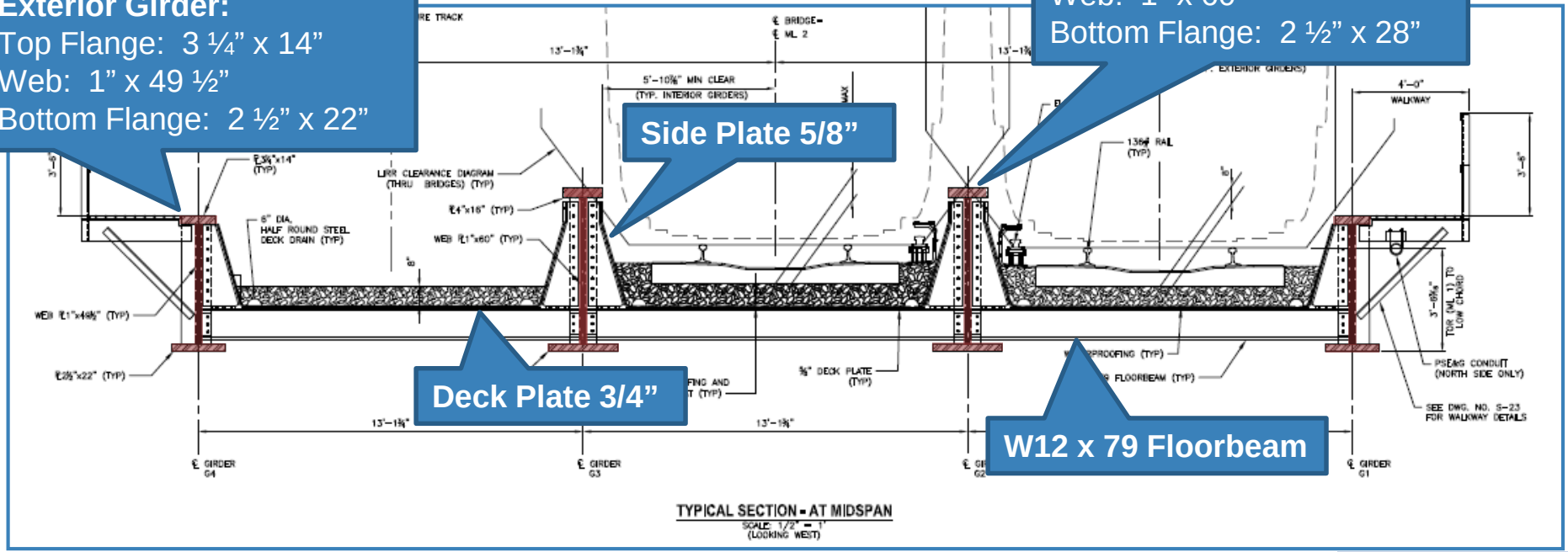
150 ± feet of Platform was Raised to Match New Track Profile

Adjustments Varied from 1” to 8”

Steel Design: Thru-Girder / Floorbeam System 1

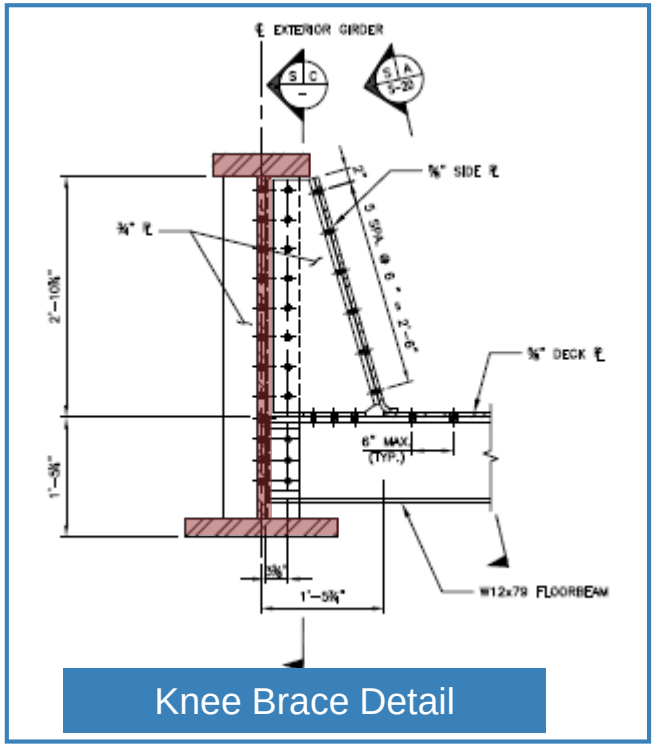
Exterior Girder:
Top Flange: 3 ¼” x 14”
Web: 1” x 49 ½”
Bottom Flange: 2 ½” x 22”

Interior Girder:
Top Flange: 4” x 16”
Web: 1” x 60”
Bottom Flange: 2 ½” x 28”

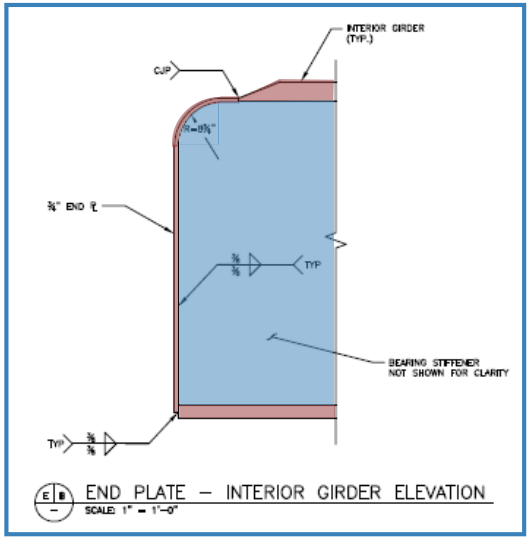


TYPICAL SECTION - AT MIDSPAN
SCALE: 1/2" = 1'
(LOOKING WEST)

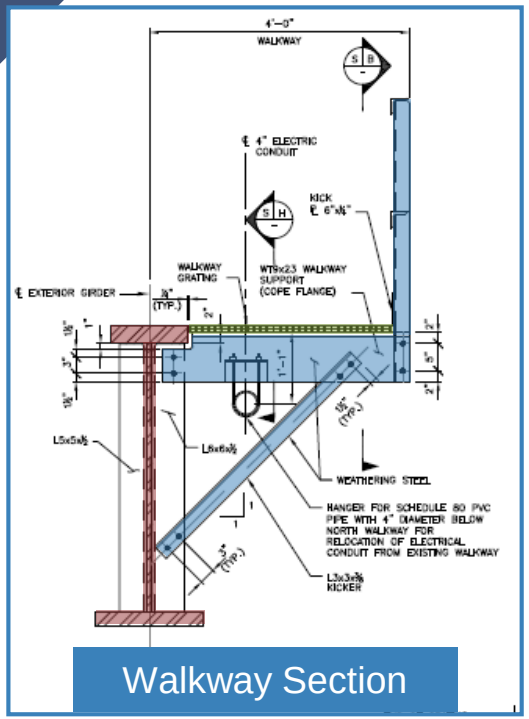
Steel Details: Simple Design, Simple Details, Quick Fabrication



Knee Brace Detail



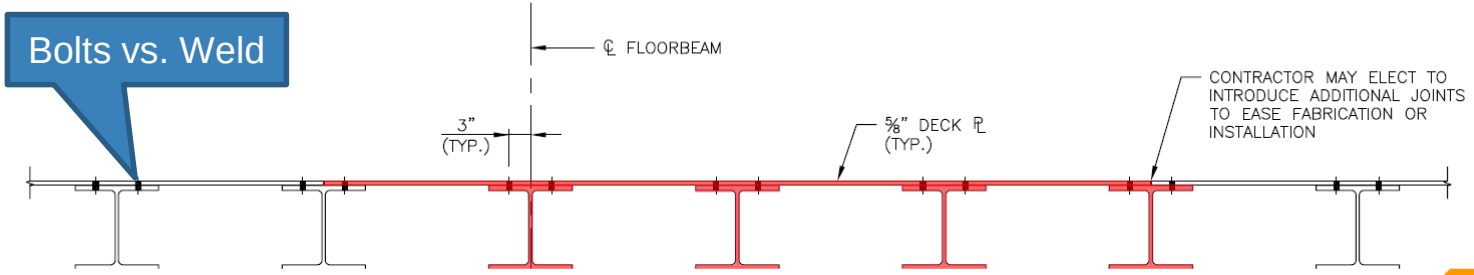
End Plate Detail



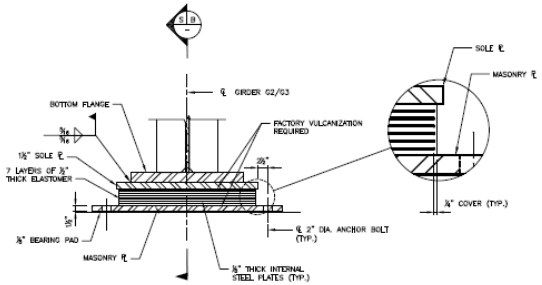
Walkway Section

ABC Applications

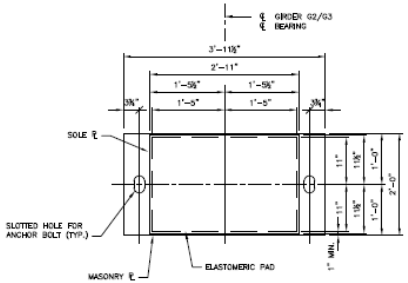
- Superstructure design was fast-tracked to get fabrication of structural steel, bearings, and long lead items started as soon as possible
- Bridge will be partially assembled in the shop prior to transport to the site – floorbeam and deck plate units
- Bolted vs. Welding



Bridge Bearings



Elevation View



Plan View

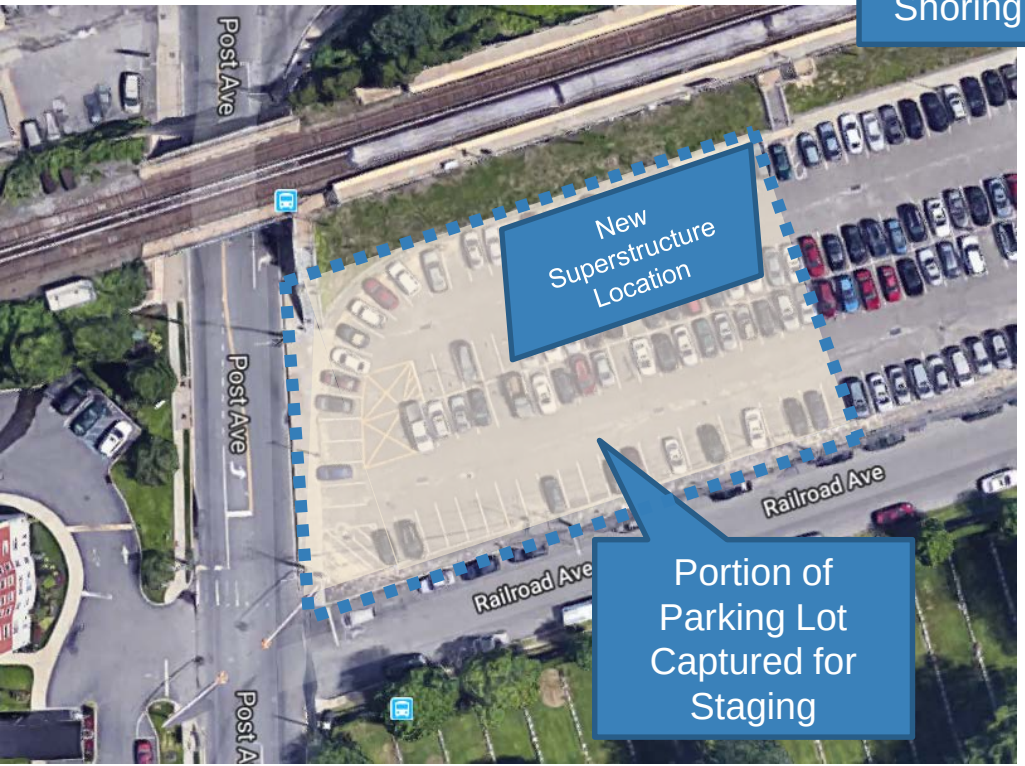
Bearing Type	Expansion & Fixed Bearings (Simple Span)
Number of Bearings	Total 8: ▪ 4 Expansion ▪ 4 Fixed
Design Loads	Reaction from: ▪ Dead Load ▪ Live Load ▪ Live Load Impact ▪ Rocking ▪ Wind Force ▪ Braking/Traction Force ▪ Seismic Force

New Superstructure Fabrication

Steel pre-assembled in Fabricator’s yard, disassembled, then trucked to site

Assemble New Bridge in Adjacent Parking Lot for SPMT Operations

August 2017 - 2 Months to Outage



Shoring Towers

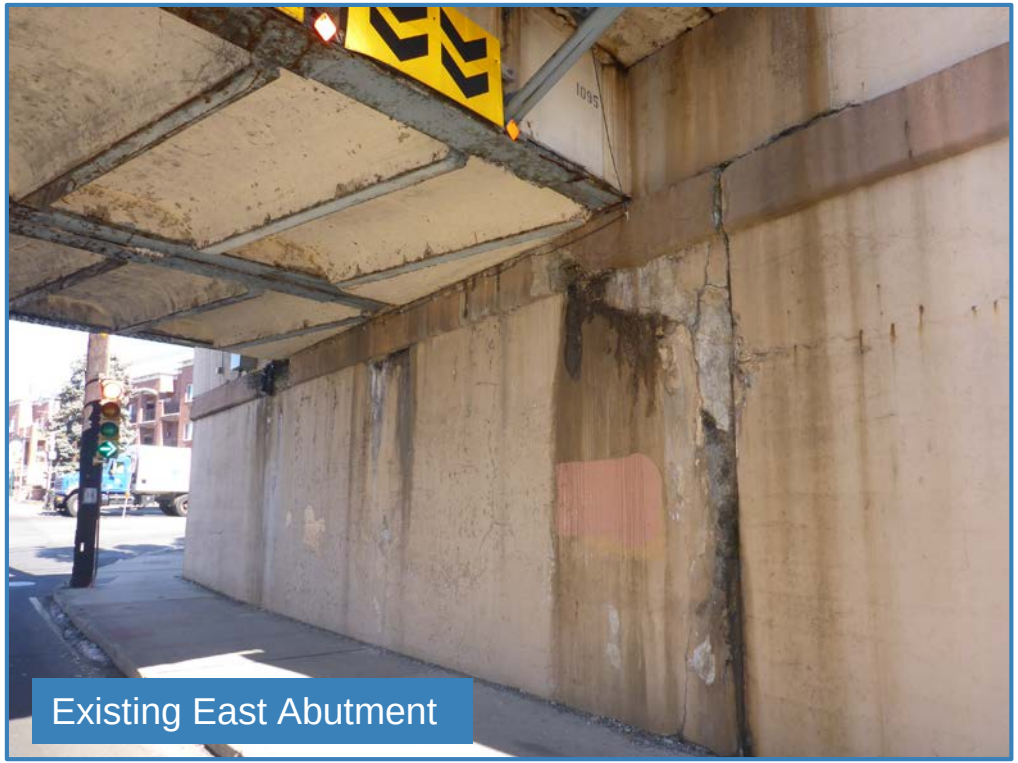
New Girders

Superstructure Erection in Parking Lot

Shoring Tower Height

Temporary Towers

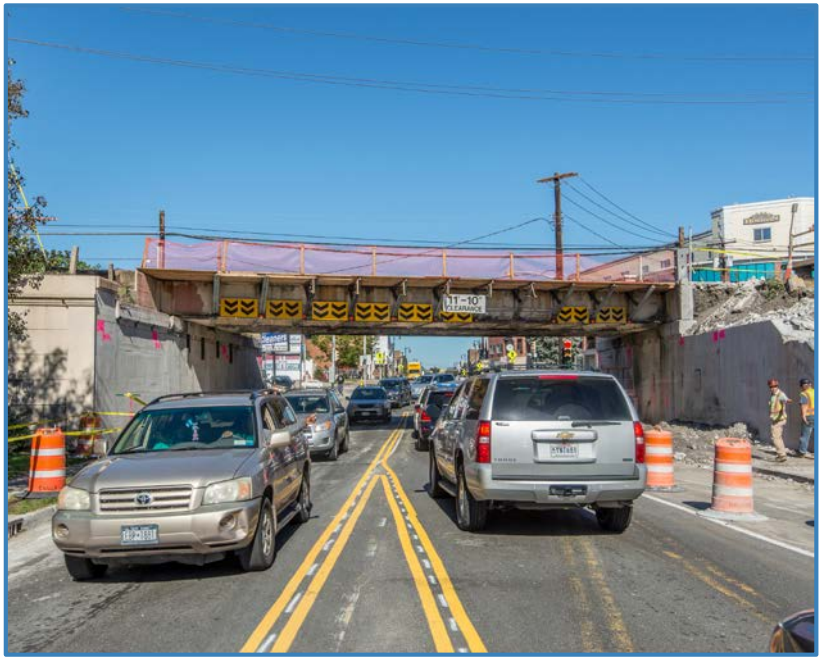
Abutment Rehabilitation Phase



Existing East Abutment

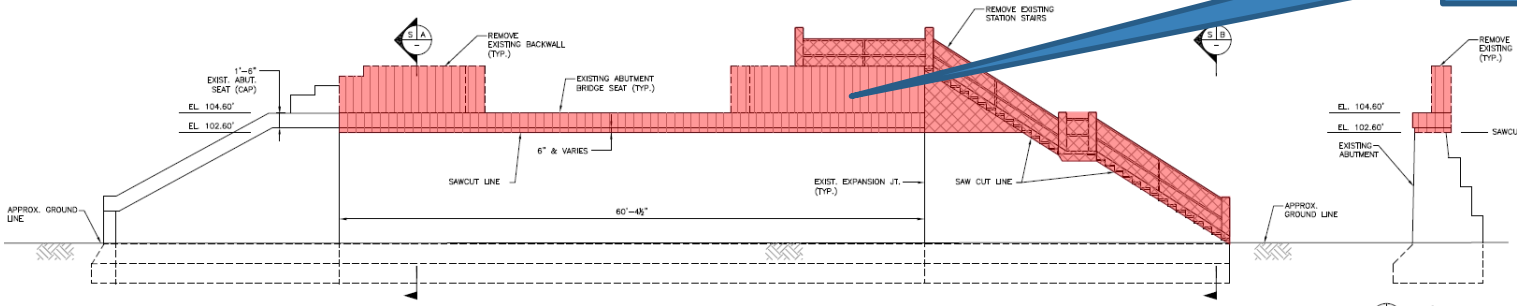
July - August 2017

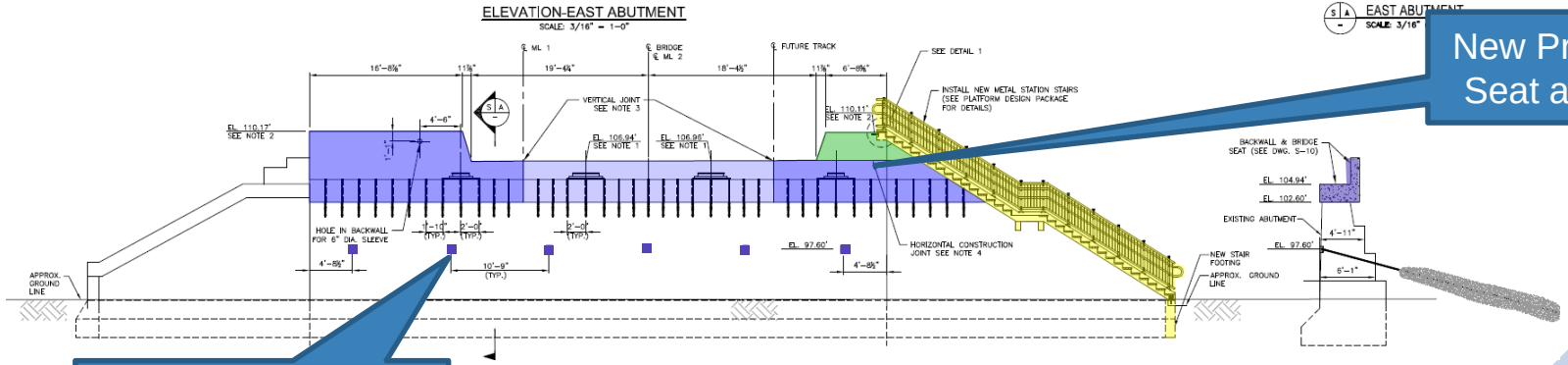
Lane Shifts for Abutment Work



Substructure Rehabilitation – Bridge Seats & Soil Anchors

Removal of Existing Bridge Seat and Backwall





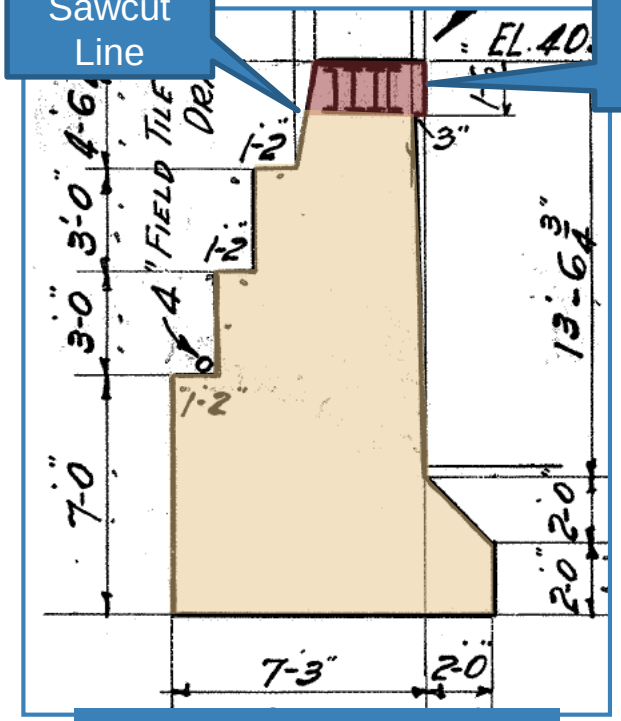
New Precast Bridge Seat and Backwall

New Soil Anchors

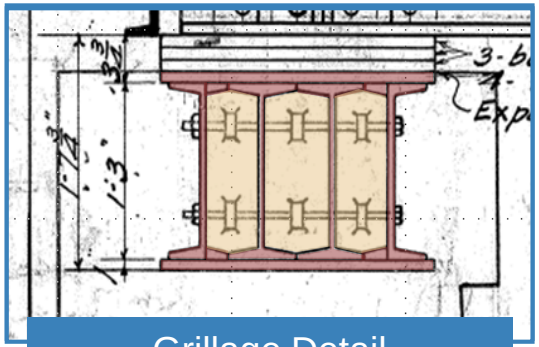
Existing Bridge Seat Removal

Sawcut Line

Removed 1’-6” Bridge Seat Including Steel Grillage



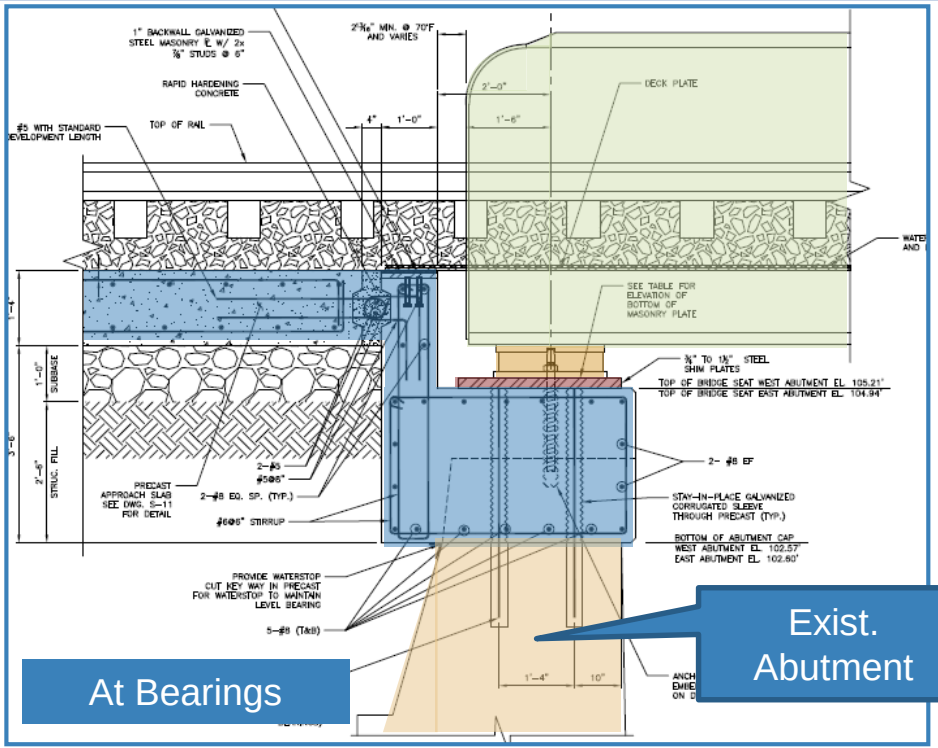
Exist. Abutment Section

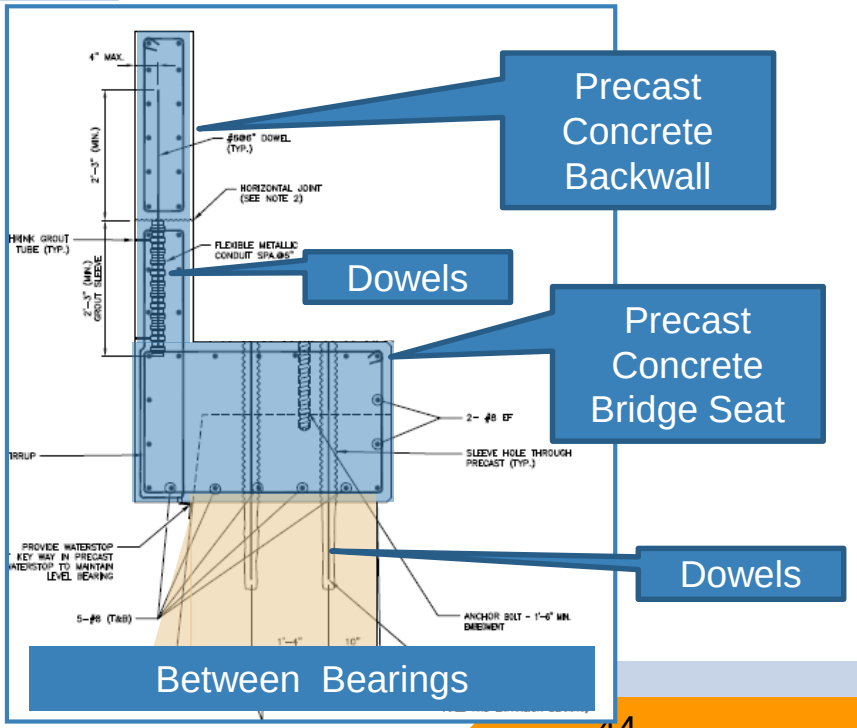


Grillage Detail

August – Sept. 2017

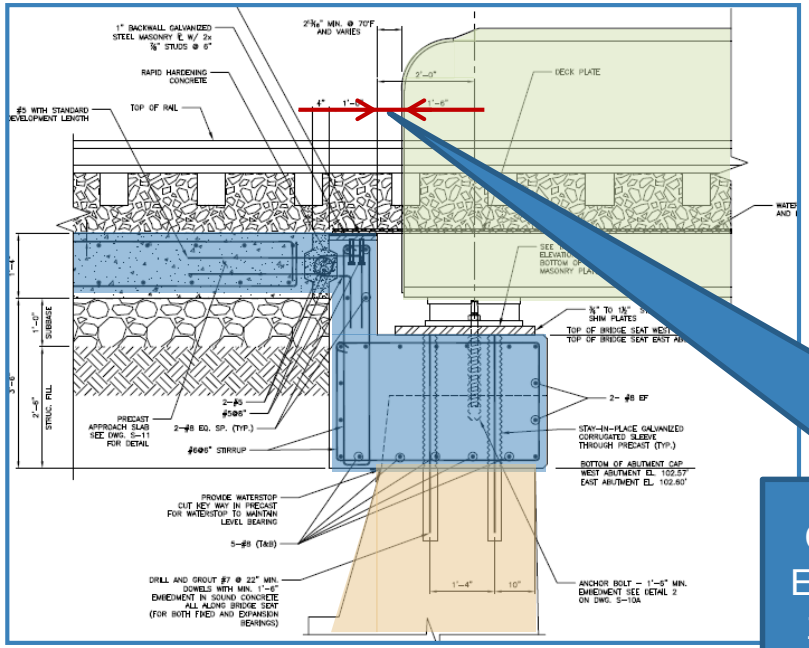
Segmental Precast Concrete Bridge Seats

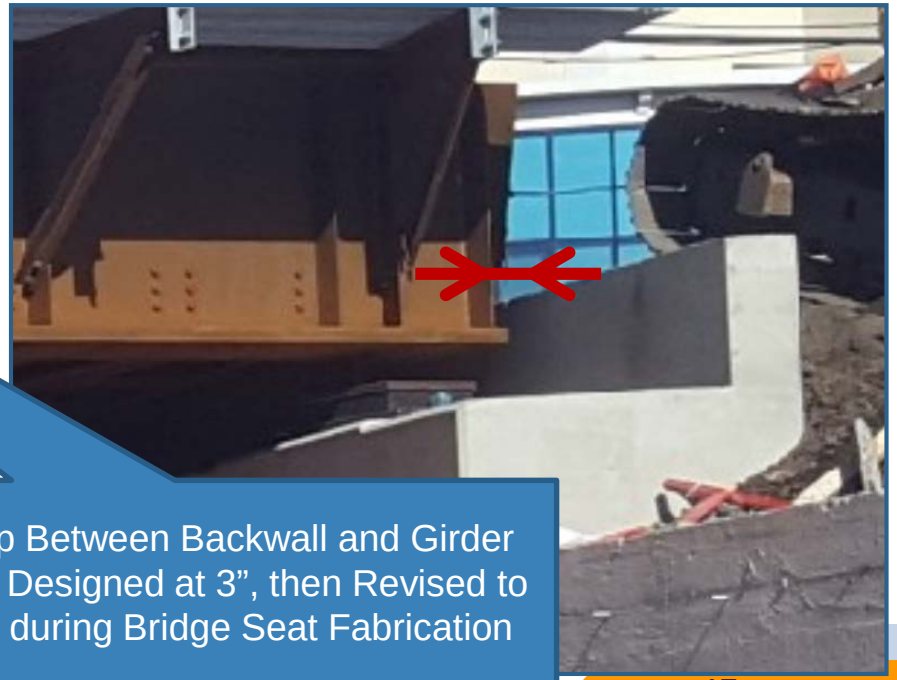




Precast Concrete Bridge Seat - Joint

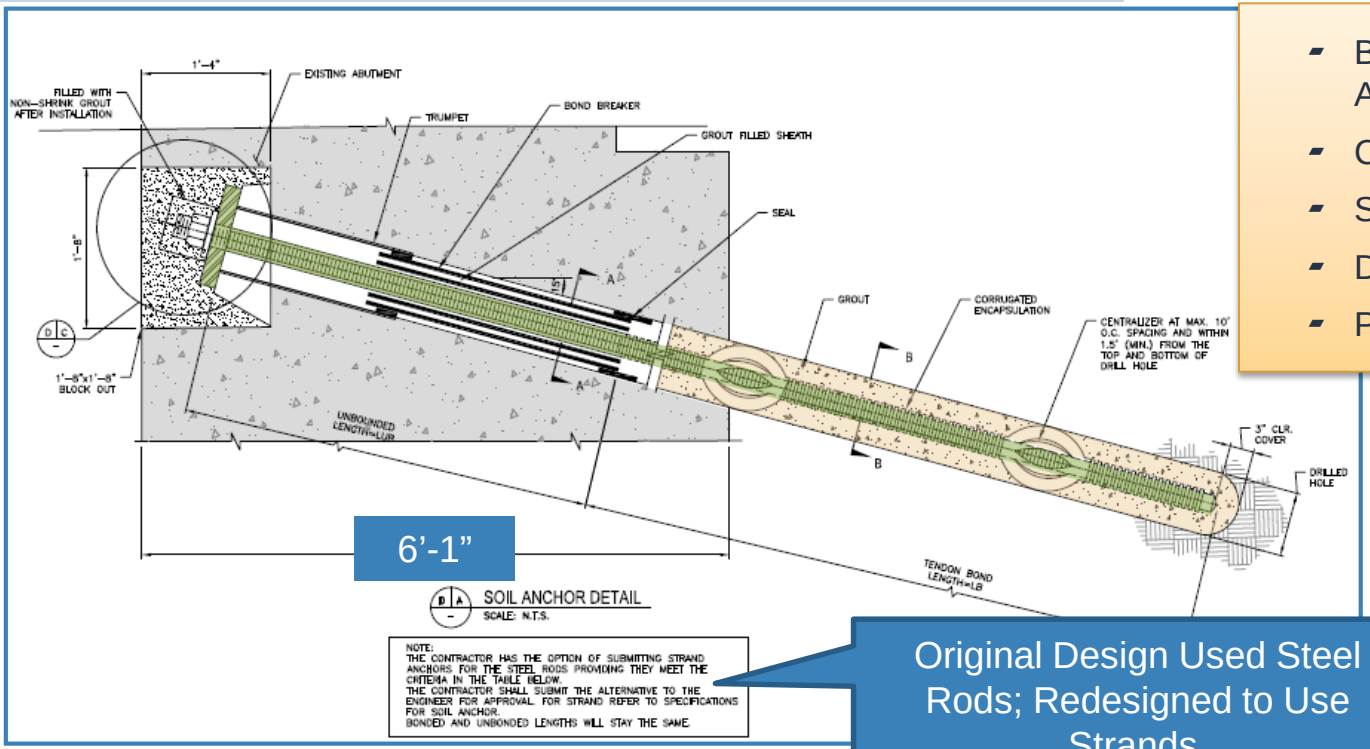
September 2017 – 1 Month to Outage





Gap Between Backwall and Girder End Designed at 3”, then Revised to 10” during Bridge Seat Fabrication

Abutment – Tieback Details



- Braking/Traction Forces (West Abut.)
- Cooper E80 surcharge (1,136K)
- Seismic Forces (East Abut.)
- Design Loads : 63 and 146 K
- PY Wall Software

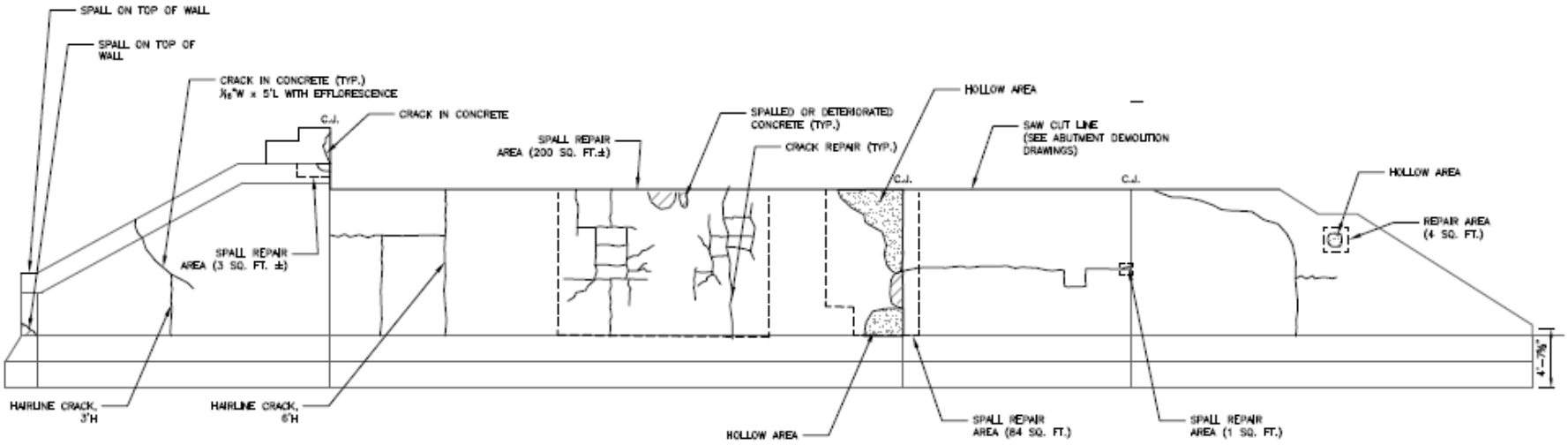
Original Design Used Steel Rods; Redesigned to Use Strands.

Abutment – Tieback Installation - 1

- LUB : 25 feet
- LB : 35 feet & 65 feet
- Post tension: 50% of design load.

July – August 2017

Abutment Crack & Spall Repairs & Refacing



Cracks, Spalls & Hollow Areas Throughout

ELEVATION EAST ABUTMENT

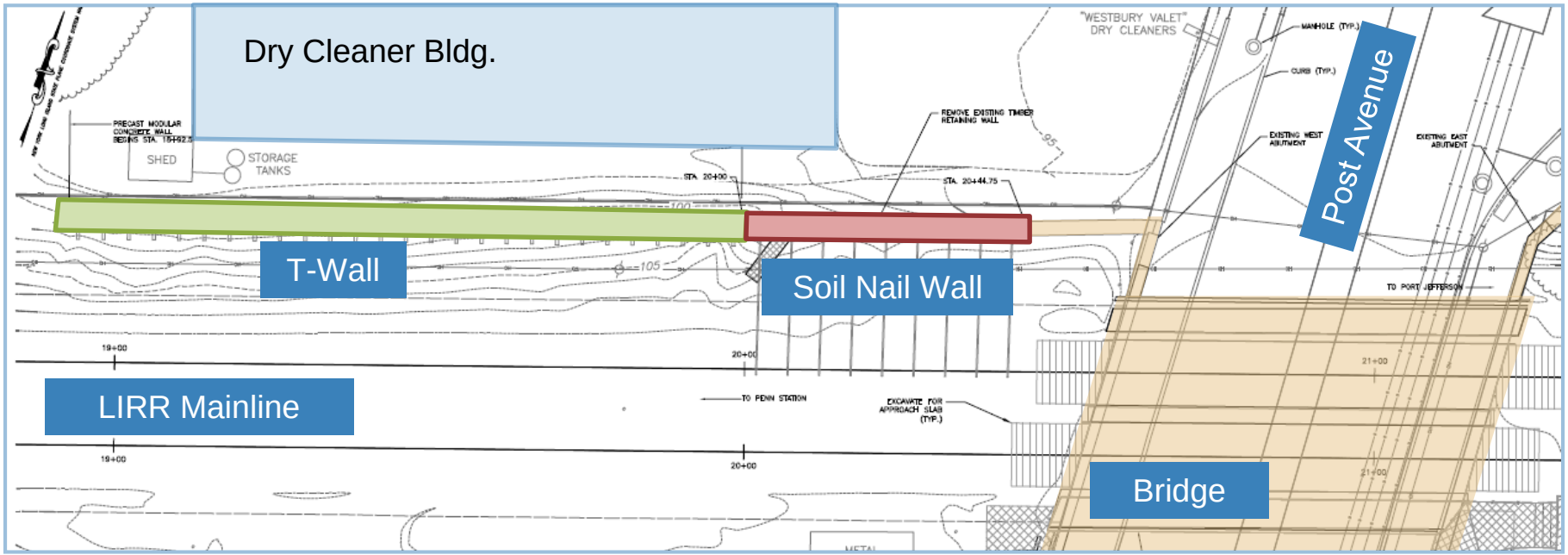
SCALE: 3/16" = 1'-0"

Abutment - Refacing

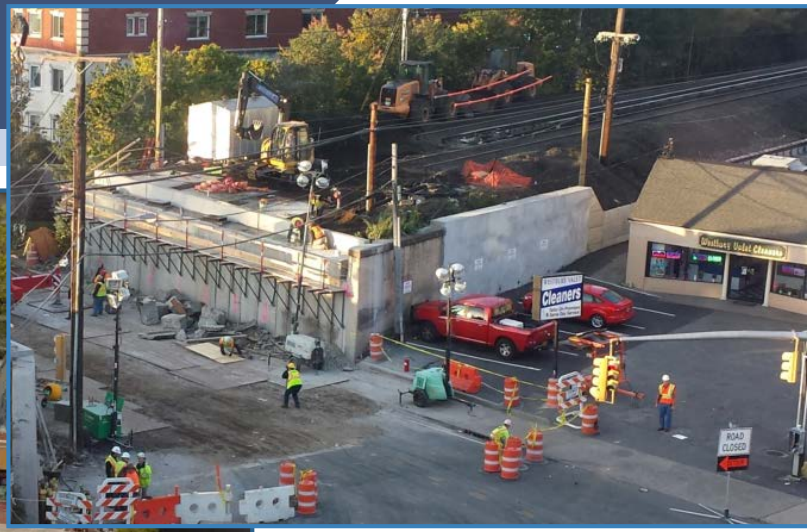
- Repair Cracks & Spalls
- Fill Tieback Anchorage Pockets
- Apply Protective Coating to Entire Surface

June – August 2017

Retaining Walls

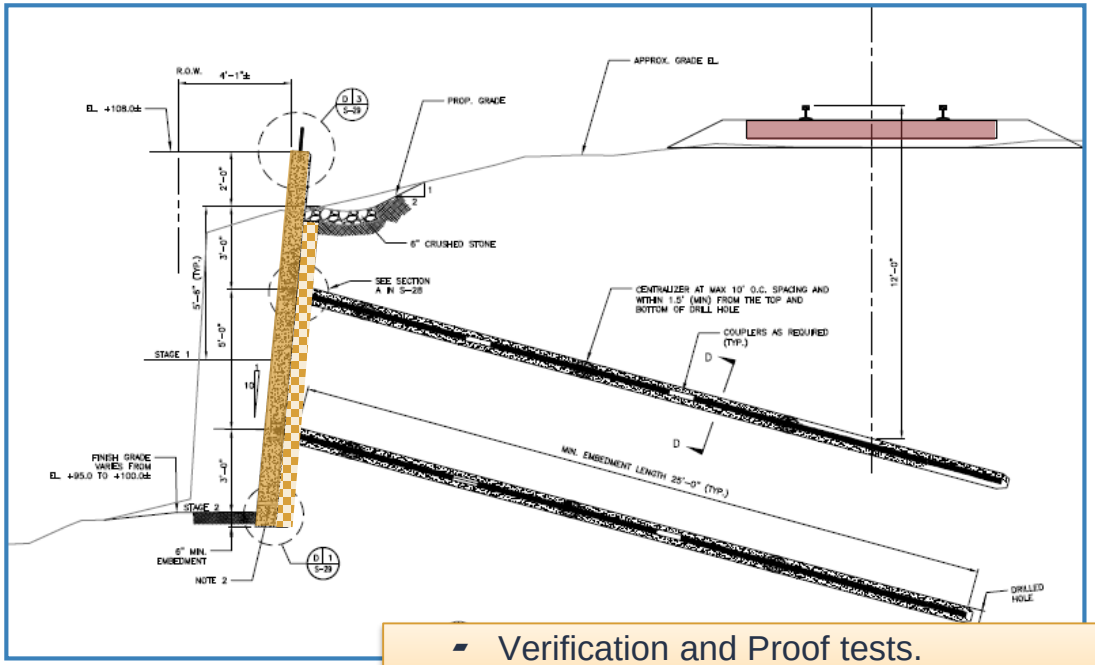


Retaining Walls – Soil Nail Wall

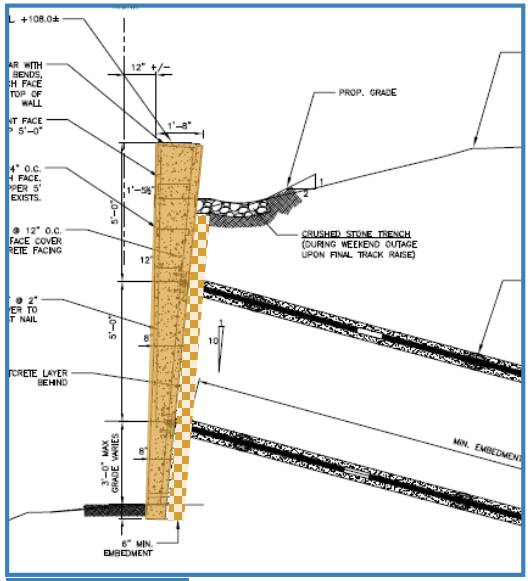


Construction Easement/Agreement Required

Retaining Walls – Soil Nail Wall Sections



As Designed



As Built

- Verification and Proof tests.
- Creep test part of verification test.

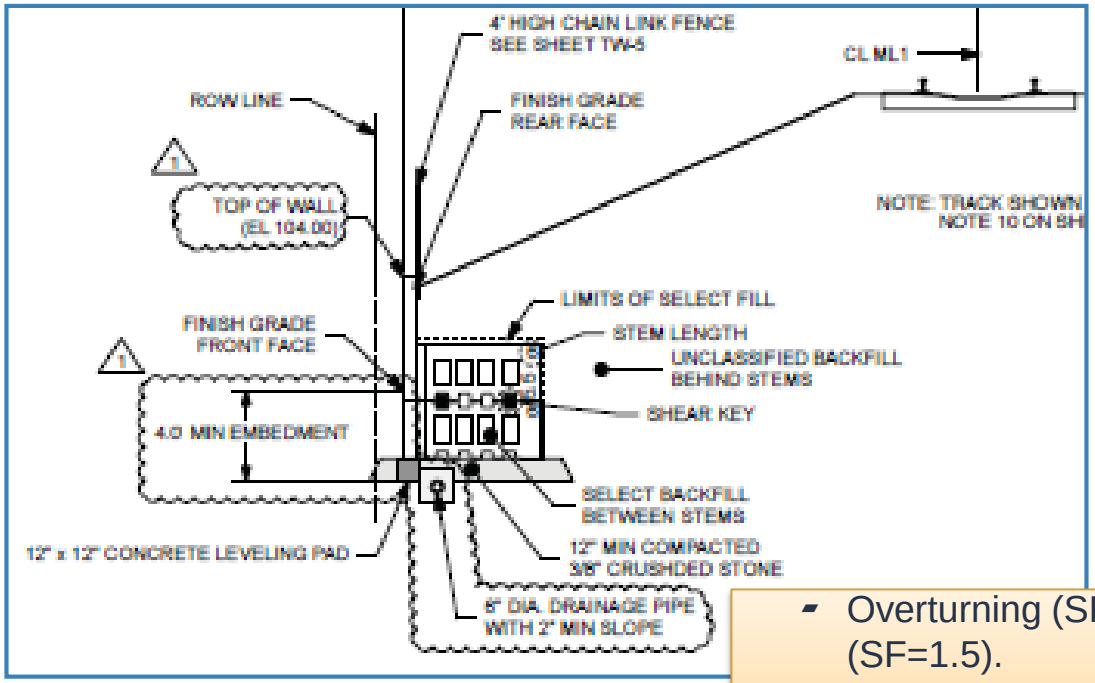
Retaining Walls – Soil Nail Wall - Installation

Retaining Walls – Soil Nail Wall - Final

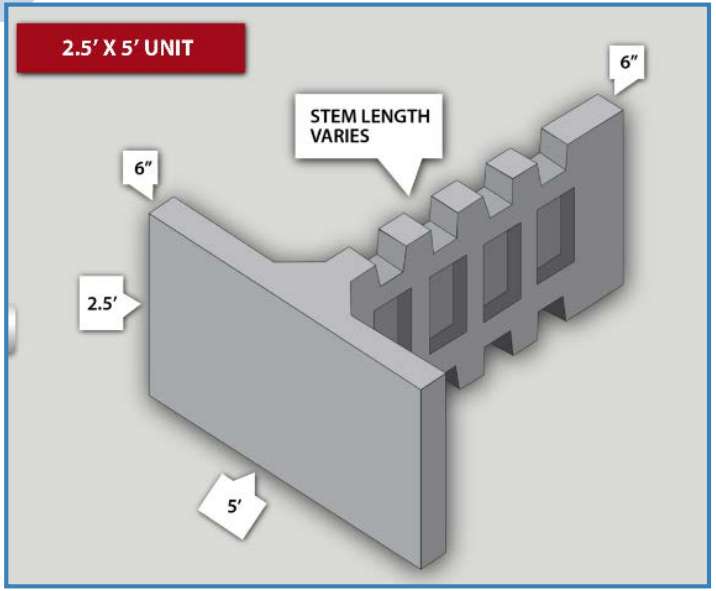
As Built

Retaining Walls – T-Wall 1

Retaining Walls – T-Wall 2



Typical T-wall Unit



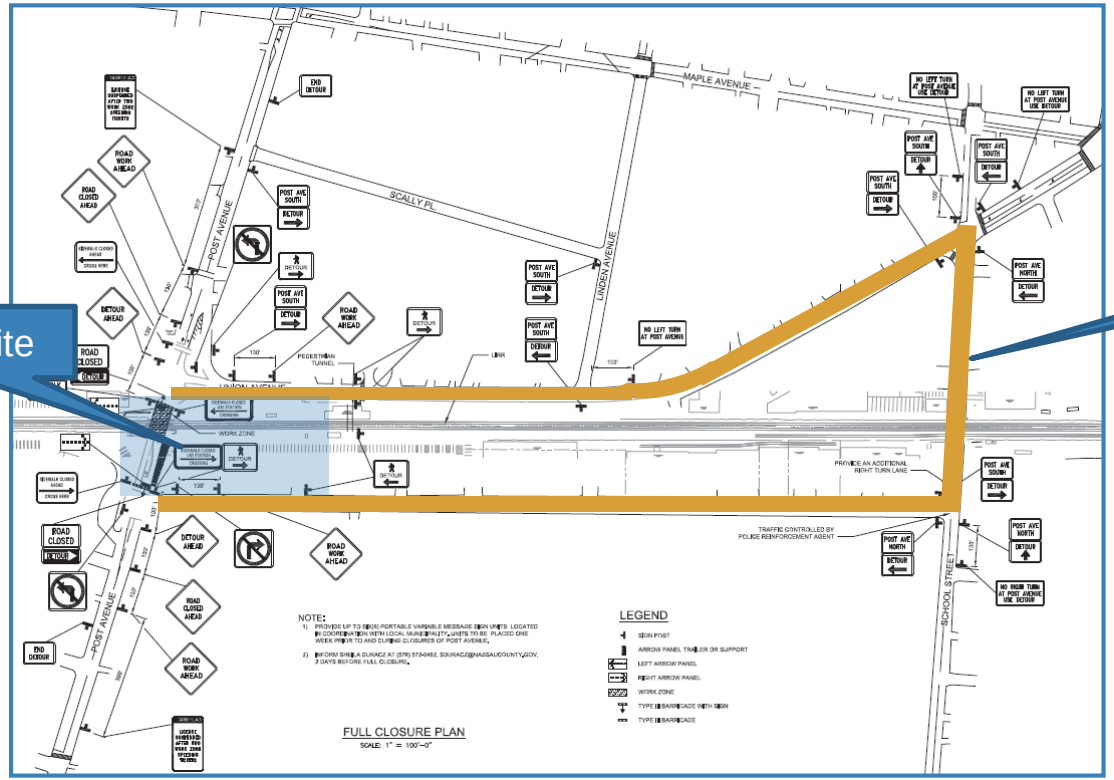
- Overturning (SF=2) and Sliding (SF=1.5).
- Fill Sand with varying amount of Silt and Gravel.

Retaining Walls – T-Wall Installation

Work During the Weekend Shutdown

Detour – Used During 48-Hour Shutdown

Required extensive coordination with the Village of Westbury and Nassau County



Outage Weekend – Sawcut Existing Bridge Seats - 1

10 a.m. Saturday

Wire saw cut 1’-6” below existing seat.

Outage Weekend – Sawcut Existing Bridge Seats - 2

10 a.m. Saturday

Saw cut 1’-6” below existing seat.

5 hour delay

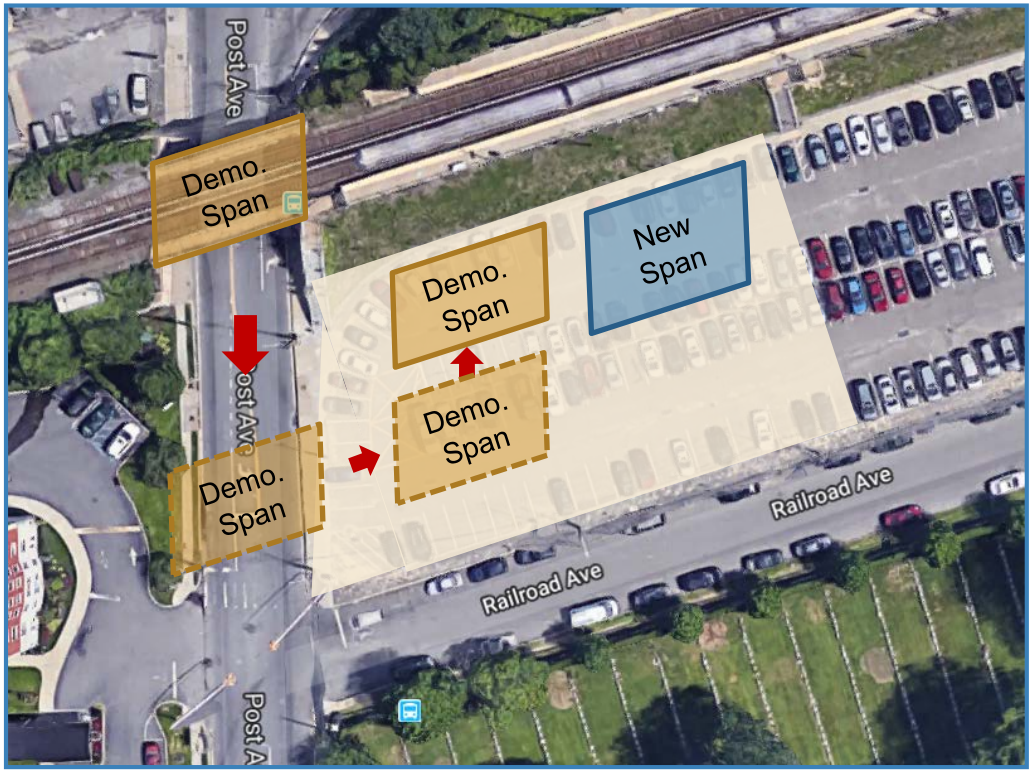
Outage Weekend – Removing Grillage

Outage Weekend – Remove Track, Ballast, Utilities, Etc. – Force Account

Friday Night
Saturday Morning

SPMT Operations for Demolition

Friday Night
Saturday Morning



- Steel Plates on sand fill corrected elevation/grades of SPMT path
- Parking lot slopes 1% down from east to west

Outage Weekend – Remove Existing Superstructure 1

4:00 p.m. Saturday

Preparing Staging Area for Existing Bridge

Existing Superstructure on SPMT

Outage Weekend – Remove Existing Superstructure 2

6:30 p.m. Saturday

Existing Superstructure on SPMT

Existing Superstructure in Parking Lot

Outage Weekend – Remove Existing Superstructure 3

7:00 p.m. Saturday

General Preparation Commences

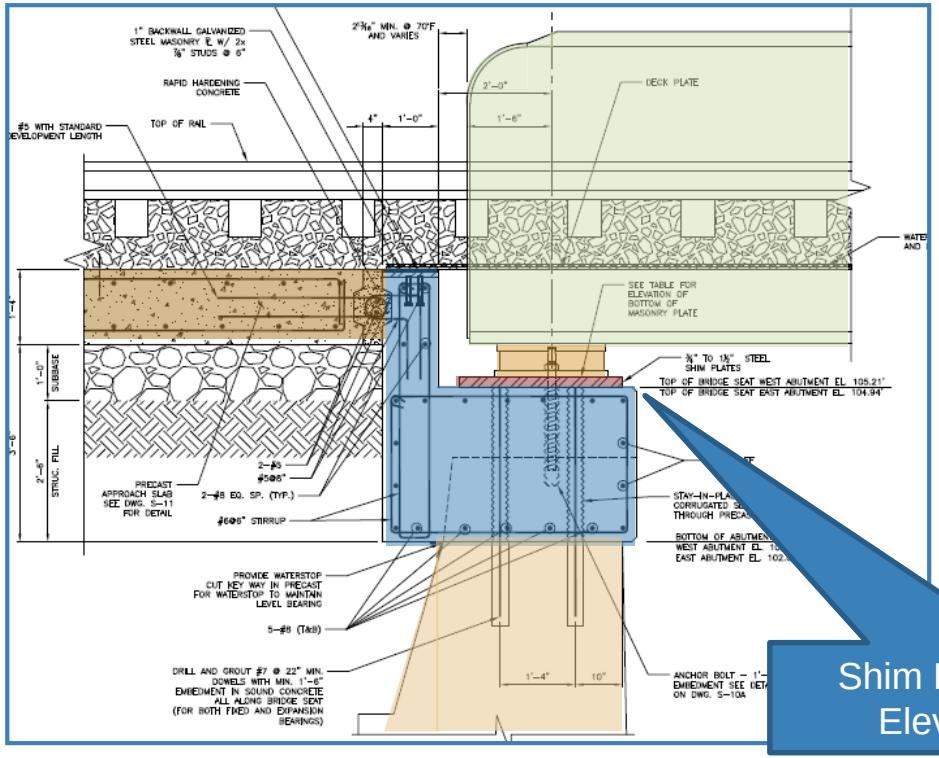
Existing Superstructure in Parking Lot

Outage Weekend – Install New Bridge Seats & Bearings 1

1:00 a.m. Sunday

Outage Weekend – Install New Bridge Seats & Bearings 2

1:00 a.m. Sunday



Shim Plates Were Used for Elevation Adjustments

Outage Weekend – Install New Bridge Seats & Bearings 3

1:00 a.m. Sunday

Completed Bridge Seat/Backwall

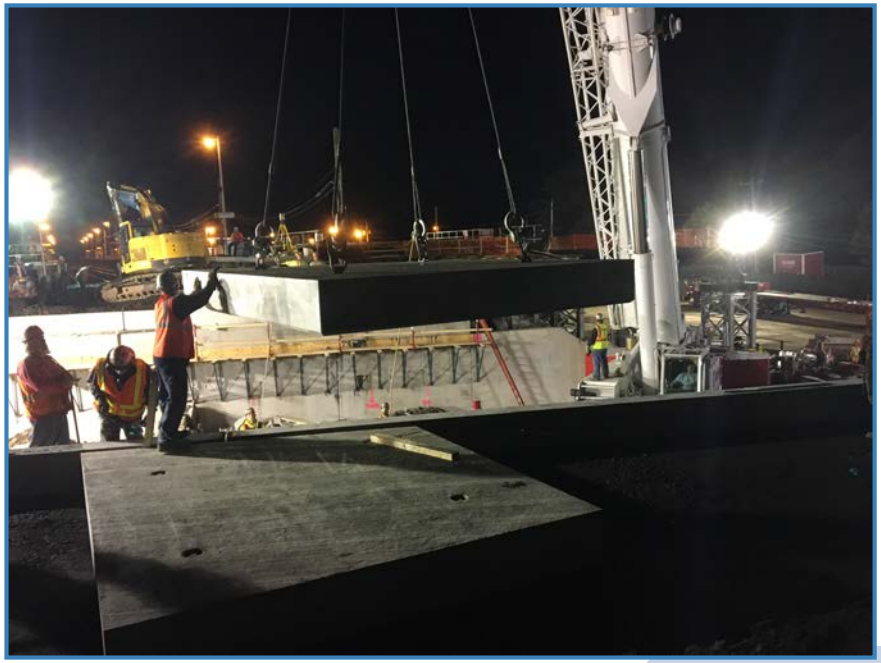
Outage Weekend – Drilling & Grouting Dowels

1:00 a.m. Sunday

Video

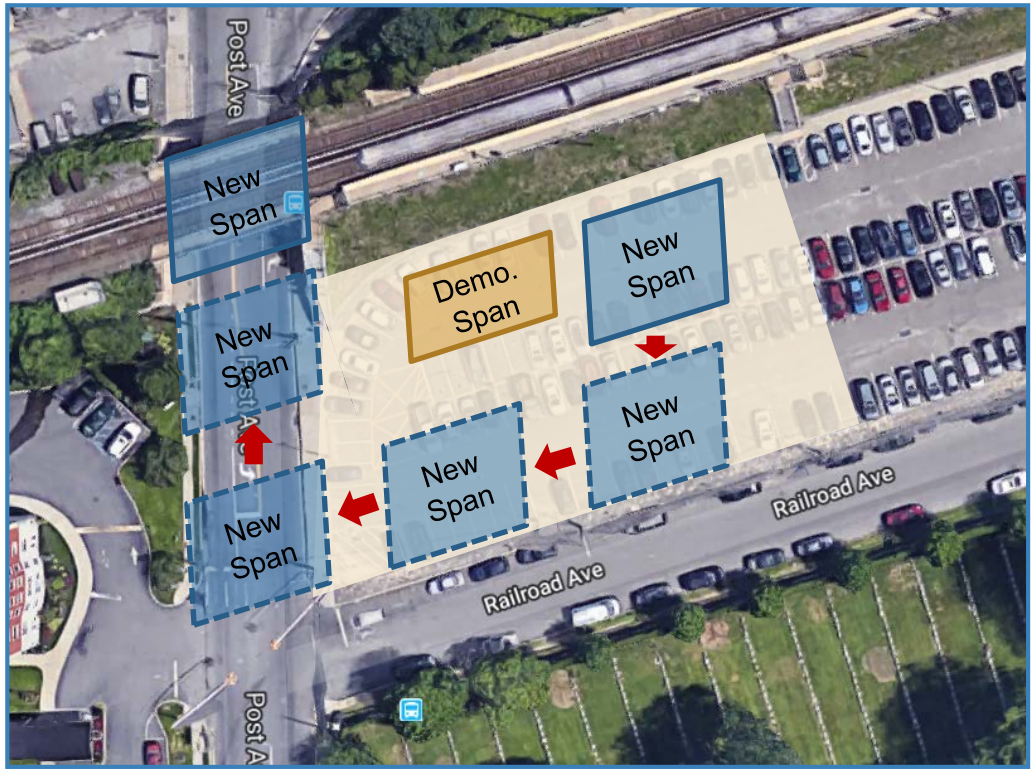
Outage Weekend – Install New Approach Slabs

4:00 a.m. Sunday



14 hours remaining

Outage Weekend – Install New Span - 1



Outage Weekend – Install New Span - 2

Video

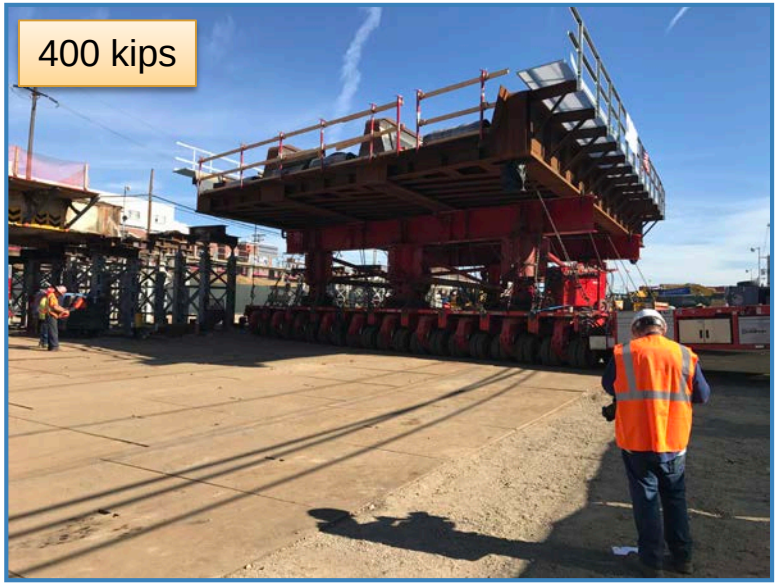
Outage Weekend – Install New Span - 3

SPMT Crew

Video

Outage Weekend – Install New Span - 4

SPMT Surface Path



Cleared Shoring Towers

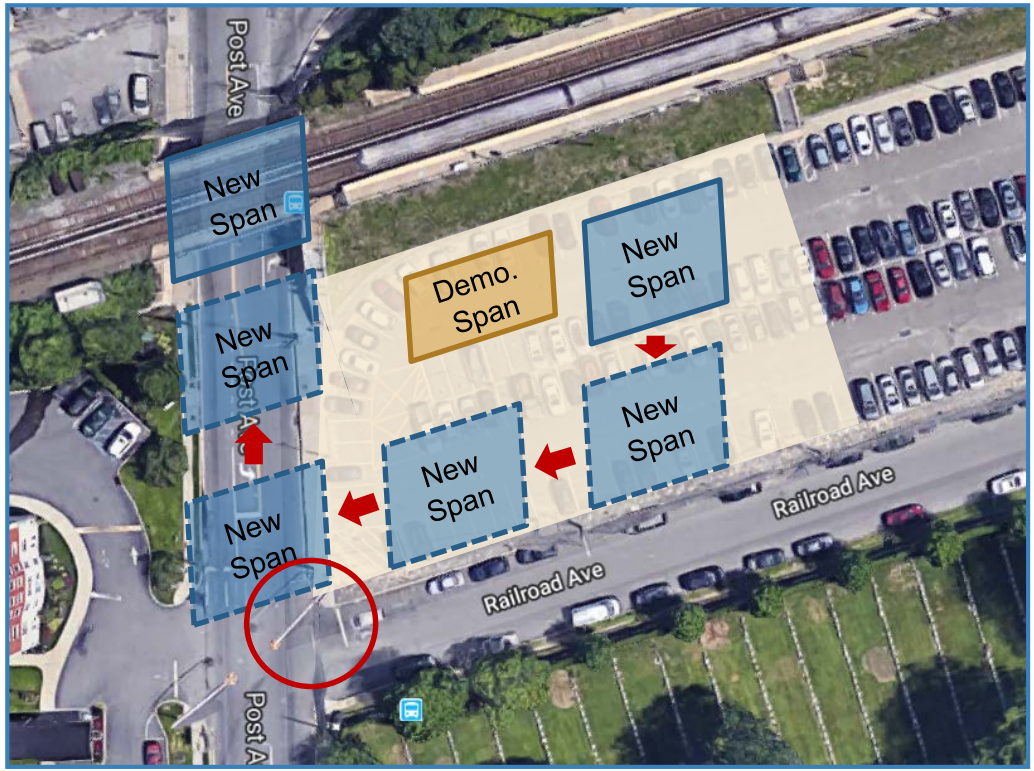
Outage Weekend – Install New Span - 5

SPMT Surface Path

Cleared Curb Line

14 hours remaining

Outage Weekend – Install New Span - 6



Maneuvering Tight Spaces

Traffic and Utility Pole Conflicts

Outage Weekend – Install New Span - 7

Maneuvering
Tight Spaces

Outage Weekend – Install New Span 8

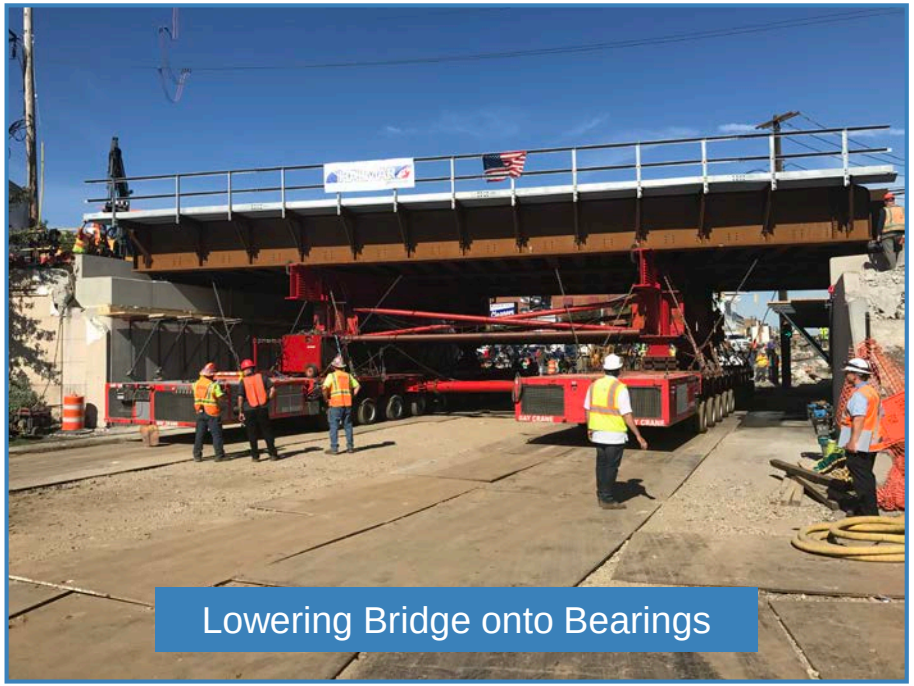
Adding more steel plates for path…

Tree pruning…

Outage Weekend – Install New Span 9

Outage Weekend – Install New Span 10

12 Hours Remaining



Lowering Bridge onto Bearings

Sunday Afternoon 1:00 p.m.

Outage Weekend – Install New Superstructure 11

Sunday Afternoon 4:00 p.m.

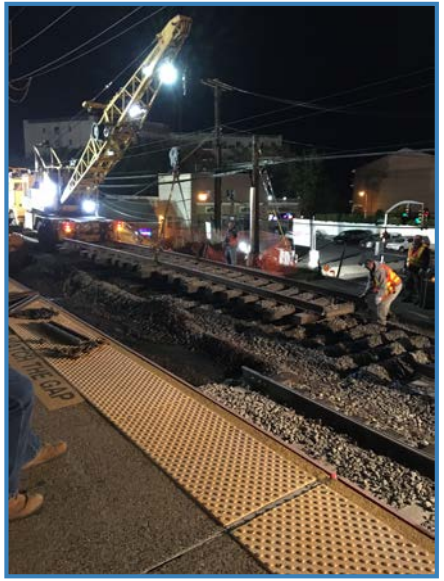
Outage Weekend – Complete Trackwork 1

- Bridge was Rolled-in with Waterproofing, Ballast Mats & Partial Depth Ballast in Place
- Remaining Ballast and Track Sections were Installed After Bridge Was Rolled-in.

Outage Weekend – Complete Trackwork 2

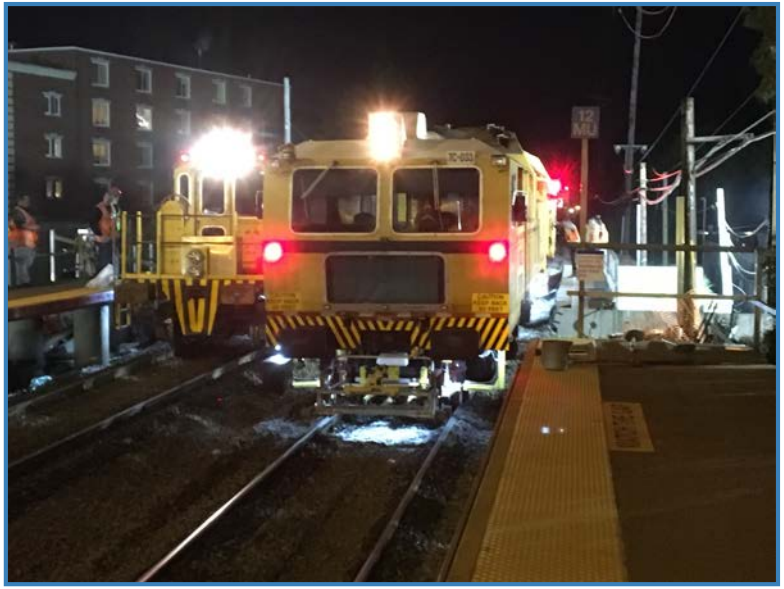
Trackwork Being Completed

Outage Weekend – Complete Trackwork 3



Sunday Night 7:00 p.m.

Outage Weekend – Test Trains 1



Outage Weekend – Test Trains 2

Test Train 12:30 a.m.

Video

Outage Weekend – Test Trains 3

First train to use the bridge was at 1:48 a.m. Monday morning.

Bridge was in service well before the Monday morning deadline.

Video

Post - Outage Weekend – Complete Backwalls

Installation of Precast Backwalls

Post-Outage Weekend - Platform/Stairway Work

Platform Elevation Adjustments

Platform Pier Extensions

Adjustments Varied from 1” to 8”

Post-Outage Weekend – Demolition/Removal Work 1

Dismantling Old Superstructure

Press

Time Lapse - Ground

[redacted]

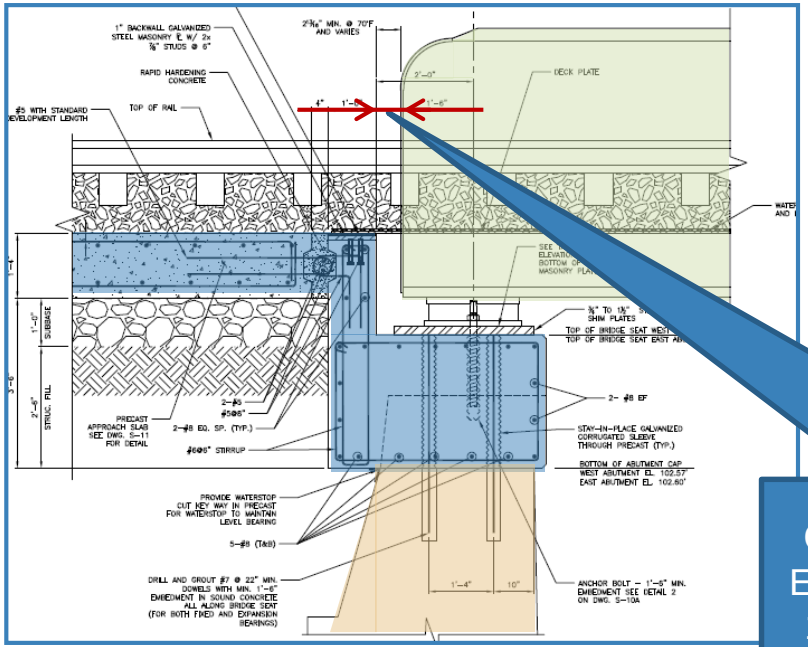
MTA

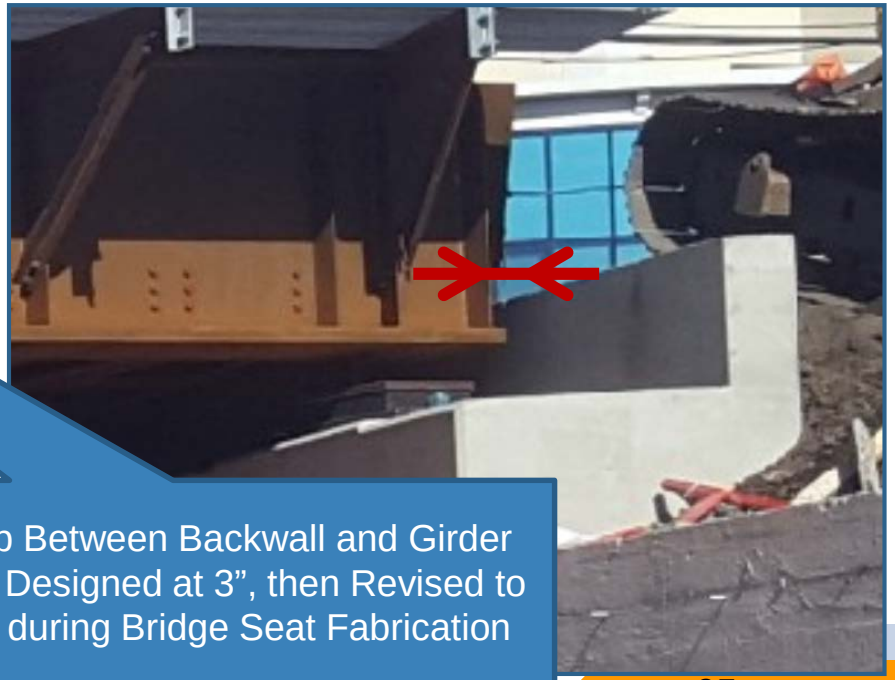
[redacted]

Village of Westbury

Lessons Learned

Lessons Learned: Pre-Construction





Gap Between Backwall and Girder End Designed at 3”, then Revised to 10” during Bridge Seat Fabrication

Lessons Learned: During Construction

- Bearings were designed to fit onto bridge seat
- Longitudinal adjustment through slotted holes
- Oversized hole provision for transverse adjustment
- Make sole plate longer than necessary

Assessment of Learning

Questions

1. What is the Design Life of the Bridge?
2. What is the maximum slope of the SPMT Path?
3. What was a Key Design Lesson Learned?
4. Name one Critical Design Milestone.
5. What was a Key Design Challenge?
6. What was a Key Construction Challenge?

Answers 1

1. The bridge design life is 75 years.
2. The slope of the SPMT path is 1% or flatter.
3. The key design lesson learned was to oversize the sole plates of the bridge bearings to better seat the girders when landing the bridge on a skew.

Answers 2

4. The critical milestone was either the submission of the Steel Mill Order by February 2017 or the approval of the steel shop drawings by May 2017.
5. The key design challenge was to find the balance among the structure depth, track clearance diagram and the track profile raise to achieve the 14’-1” vertical clearance.

Answers 3

6. A key construction challenge was aligning the new bridge both vertically and horizontally, so that it could be erected on shoring towers in the parking lot and driven to the abutments with minimal adjustments using the same SPMT that removed the old bridge.

Questions & Answers

McLaren ENGINEERING GROUP
40 YEARS 1977–2017