MD 355 Over the Monocacy River Emergency Repairs

Collaboration and Innovation in Emergency Response

Presenters:
Rod Thornton, PE – MDOT SHA
Kyle Smith, PE, SE – GPI

MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

GPI

NORTHEAST
BRIDGE PRESERVATION PARTNERSHIP

N

Frederick, MD

+12,000 ADT

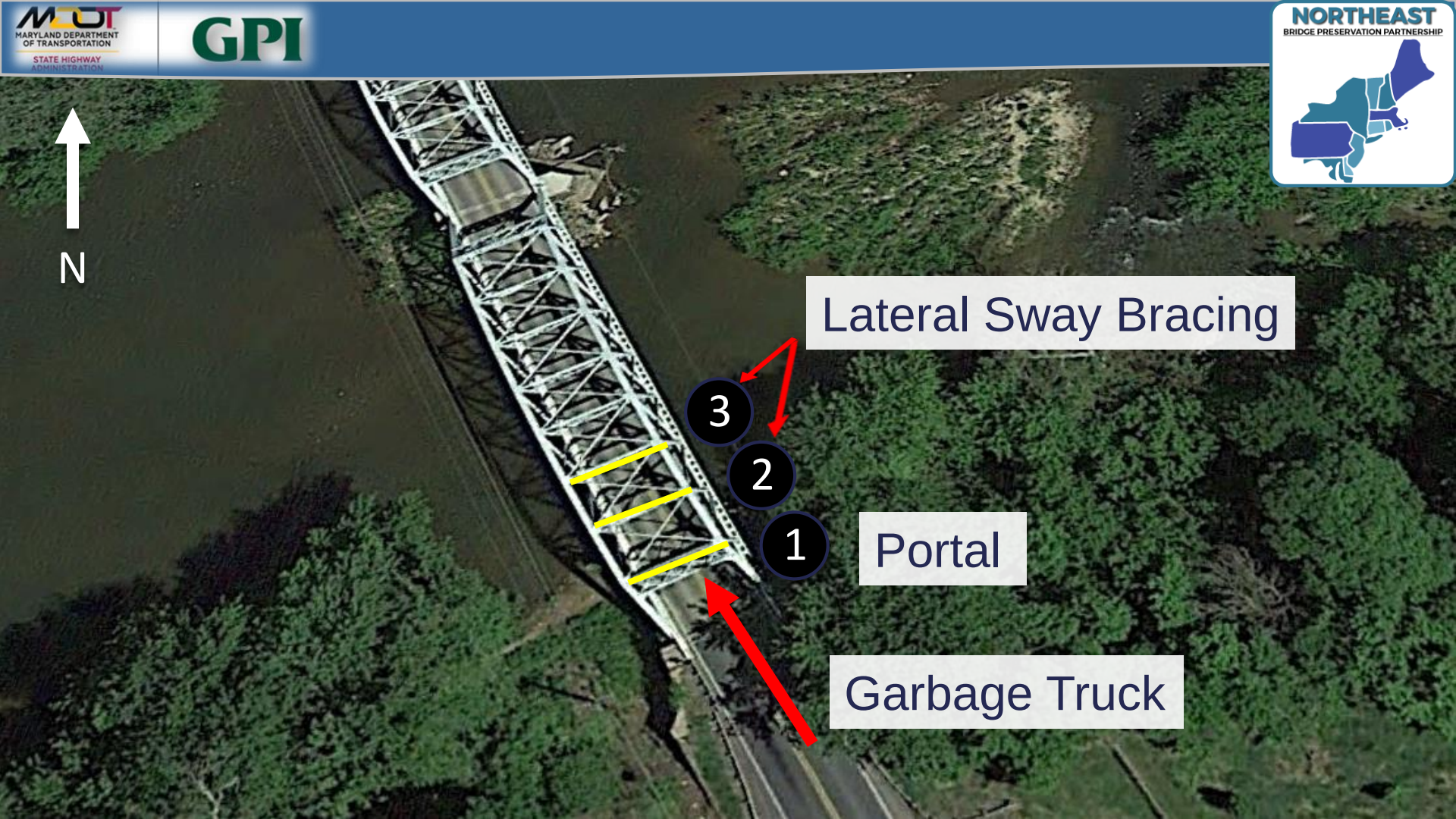
Bridge Location

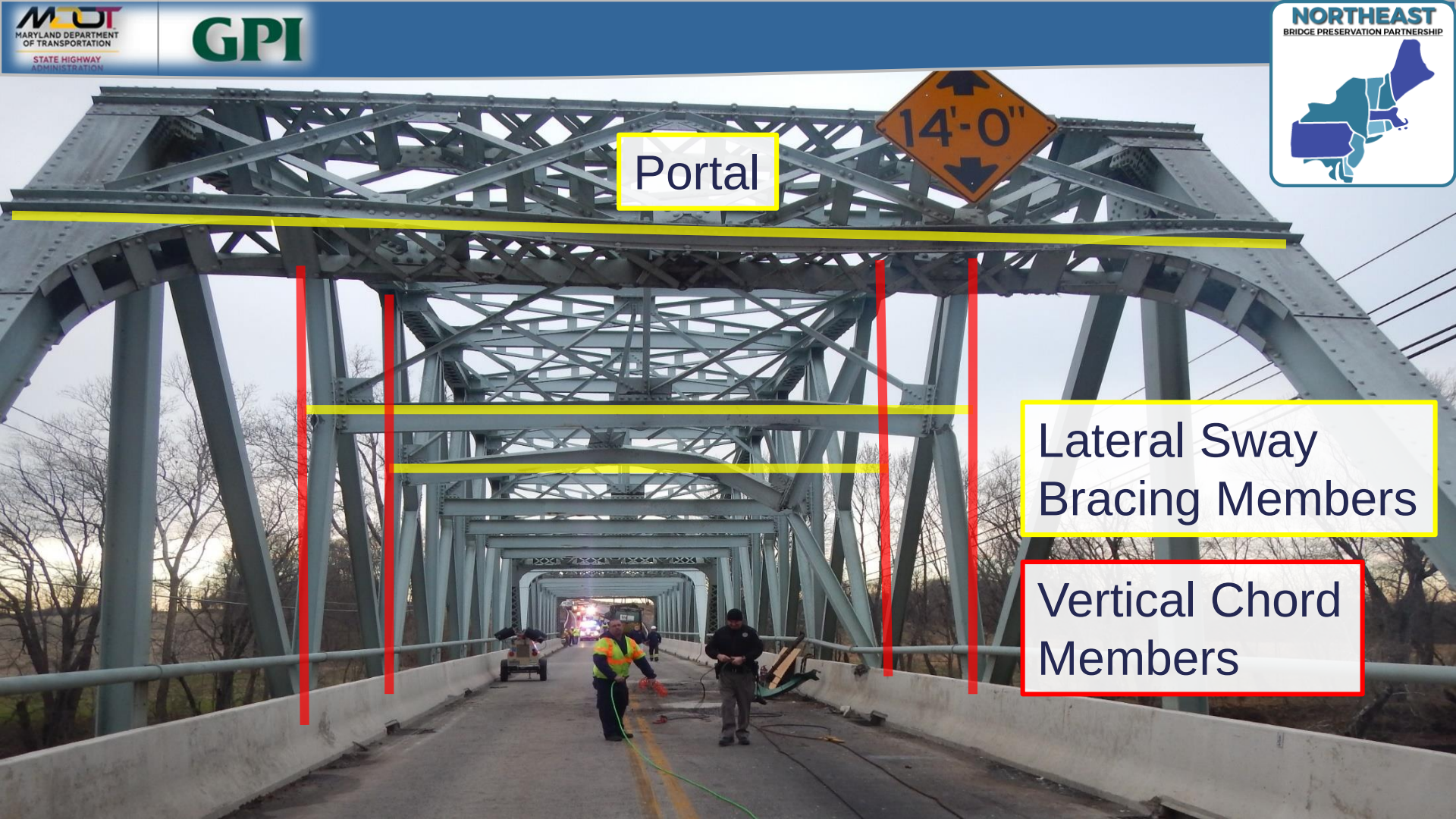
+100,000 ADT

Washington, DC


MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION
GPI
NORTHEAST
BRIDGE PRESERVATION PARTNERSHIP
December 6, 2017


MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION
GPI
NORTHEAST
BRIDGE PRESERVATION PARTNERSHIP
14'-0"
CONCRETE GENERAL, INC.
(301) 948-4450
12.06.2017


MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION
GPI
NORTHEAST
BRIDGE PRESERVATION PARTNERSHIP
N
Lateral Sway Bracing
3
2
1
Portal
Garbage Truck


MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION
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NORTHEAST
BRIDGE PRESERVATION PARTNERSHIP
14'-0"
Portal
Lateral Sway Bracing Members
Vertical Chord Members


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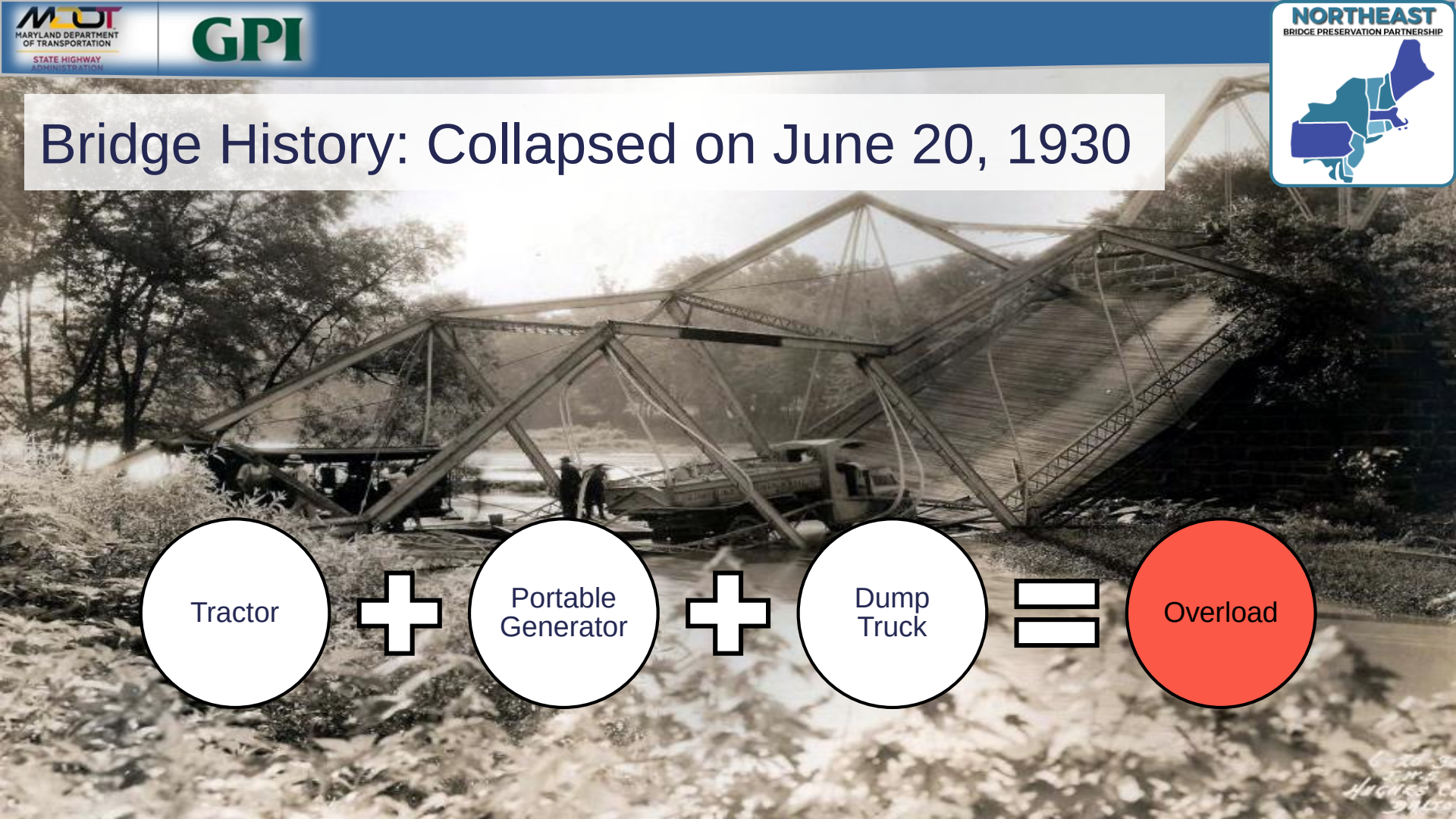
NORTHEAST
BRIDGE PRESERVATION PARTNERSHIP
264520
WASTE MANAGEMENT
CAUTION
VEHICLE STOPS AND BACKS FREQUENTLY

History

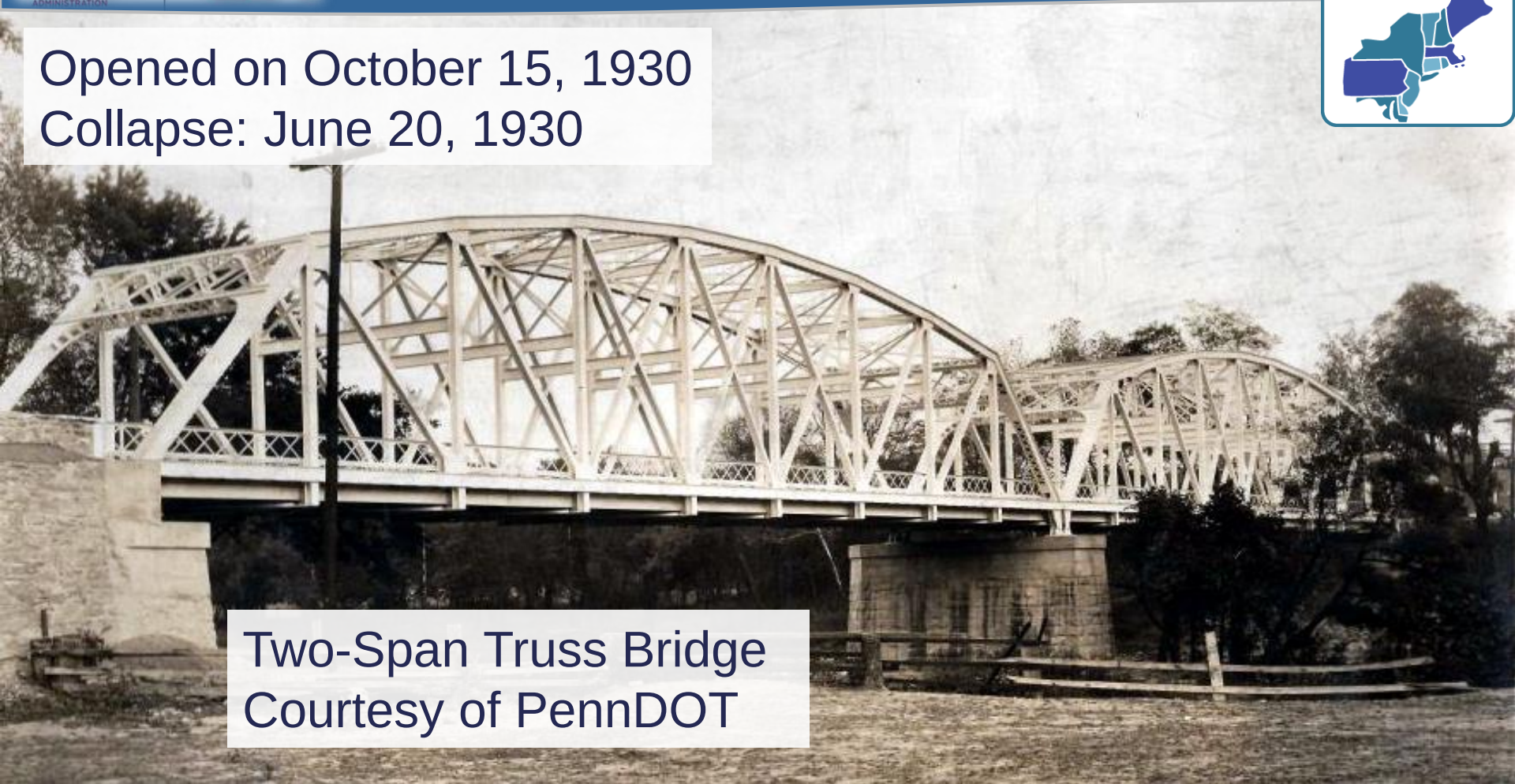
1. Initial Response
2. Stabilize the Bridge
3. Modeling and Instrumentation
4. Repair Procedure
5. Conclusion & Lessons Learned

Bridge History: Collapsed on June 20, 1930



June 20, 1930

September 20, 1930



Opened on October 15, 1930
Collapse: June 20, 1930

Two-Span Truss Bridge
Courtesy of PennDOT

History

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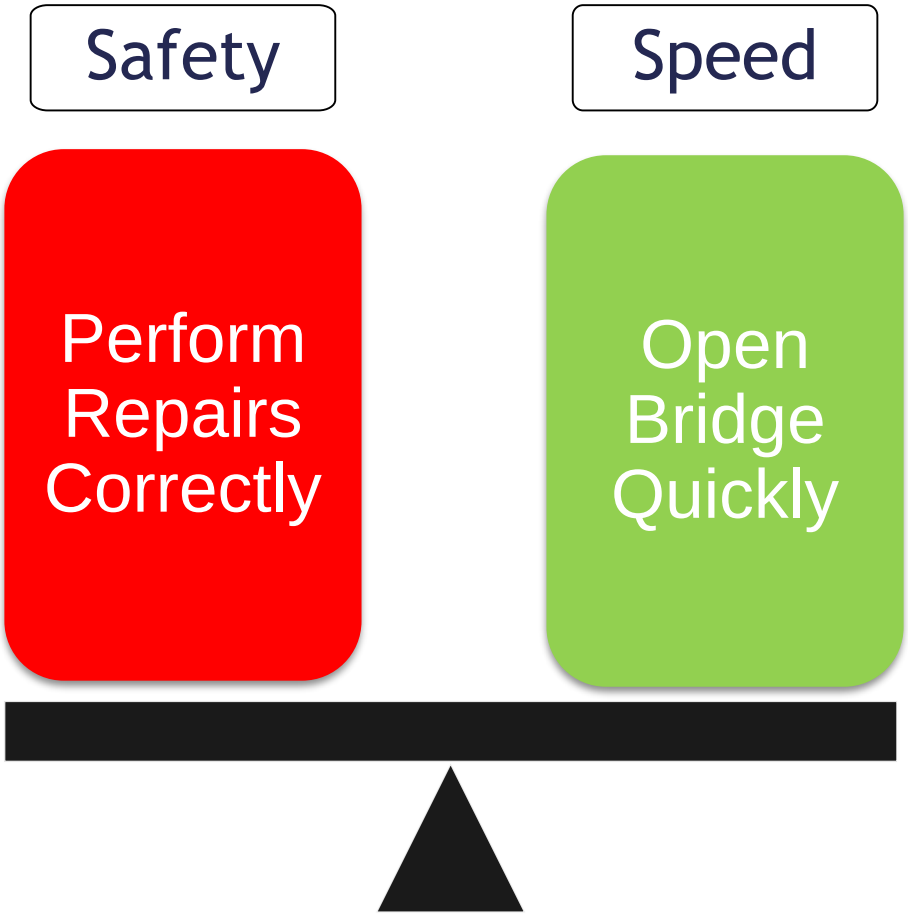
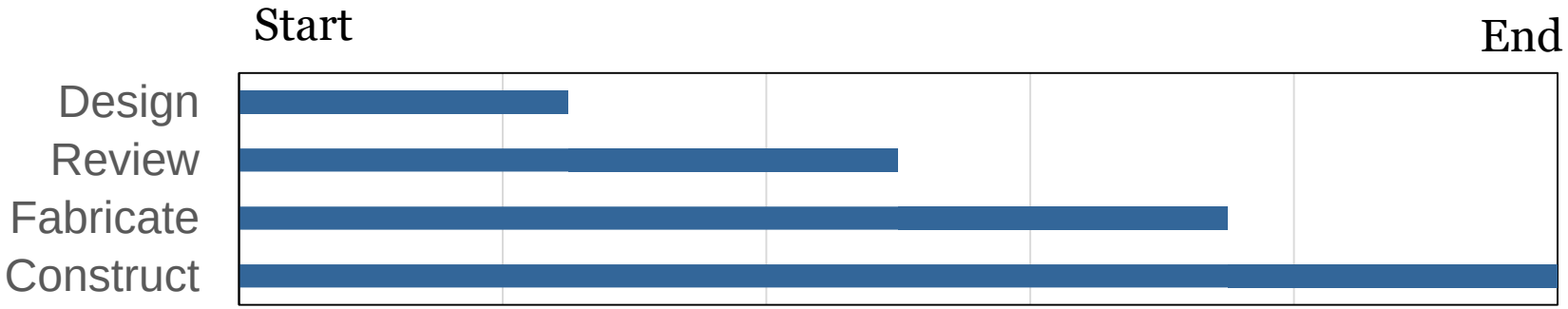
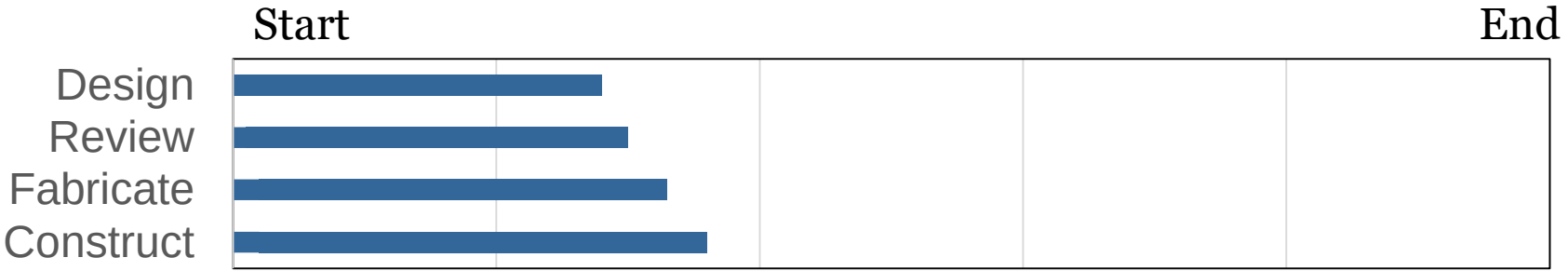
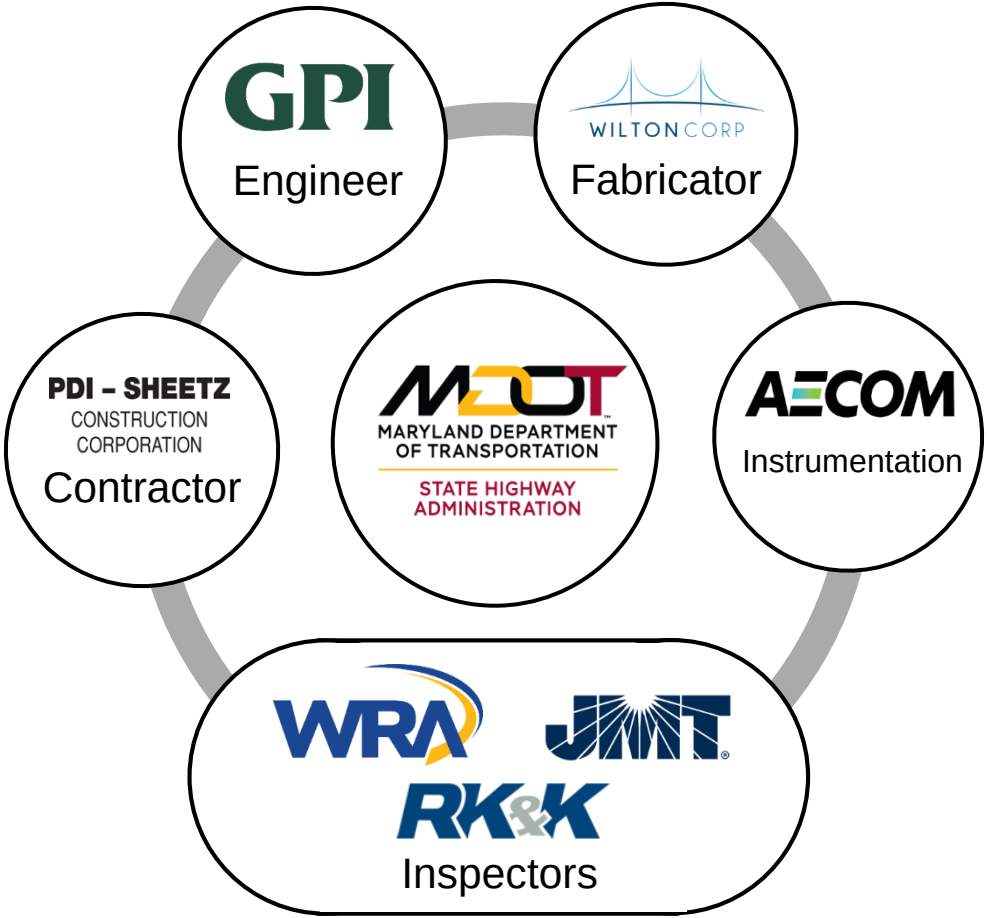

Safety
Speed
Perform Repairs Correctly
Open Bridge Quickly

Typical Procedure:



Procedure Utilized:




GPI
Engineer
WILTON CORP
Fabricator
PDI – SHEETZ
CONSTRUCTION
CORPORATION
Contractor
MDOT
MARYLAND DEPARTMENT
OF TRANSPORTATION
STATE HIGHWAY
ADMINISTRATION
AECOM
Instrumentation
WRA
JMT
RK&K
Inspectors

Day 1 Checklist:

1a. Identify Damaged Components

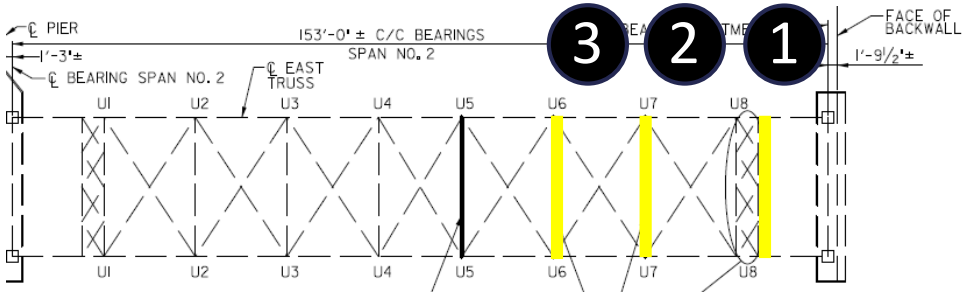
1b. Determine Available Materials

1c. Stabilize the Bridge

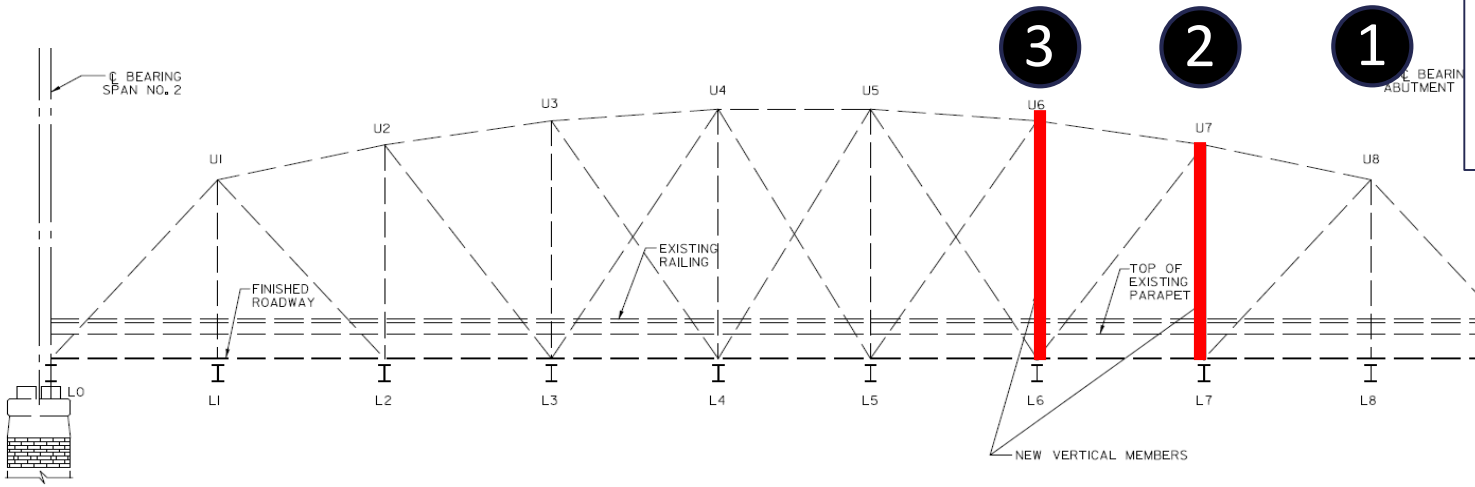
1d. Brainstorm Repair Strategy

1e. Estimate Duration for Public Outreach

1a. Identify Damaged Components:



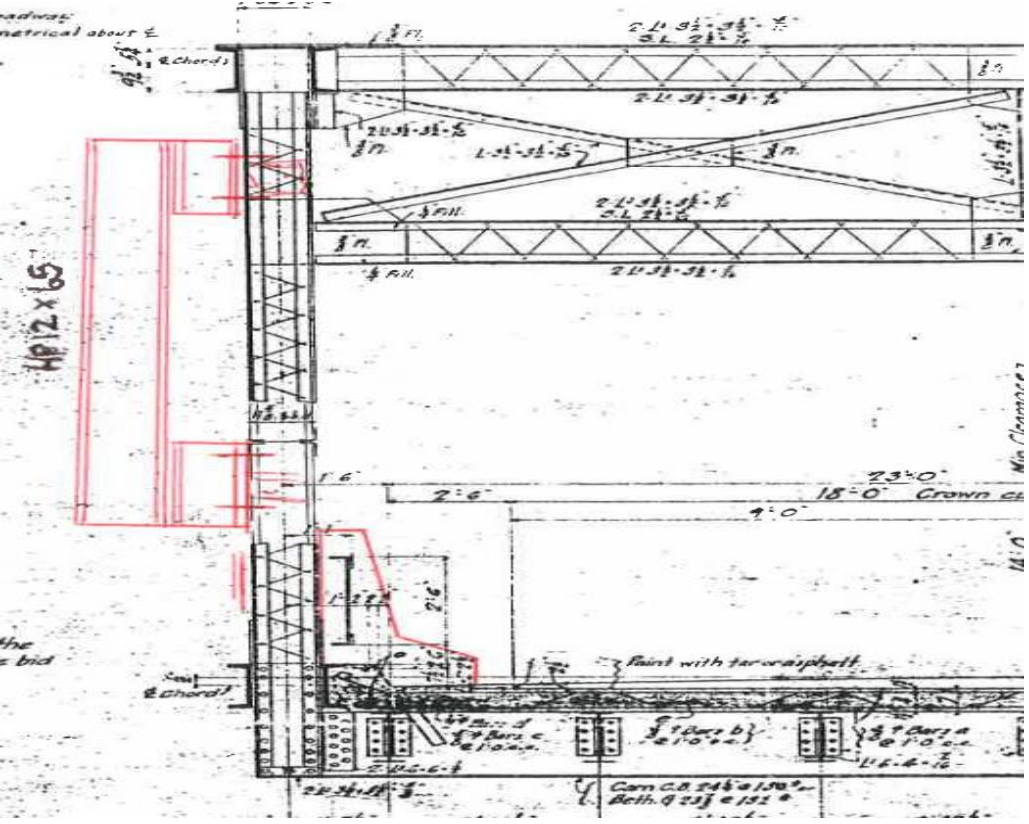
Lateral Bracing



Truss Verticals


MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION
GPI
NORTHEAST
BRIDGE PRESERVATION PARTNERSHIP
1b. Determine Available Materials:
Objective: Eliminate Delays
SHA: W-Beams, H-Piles
Wilton: Steel Plate (1”-2”)

1c. Stabilize the Bridge:

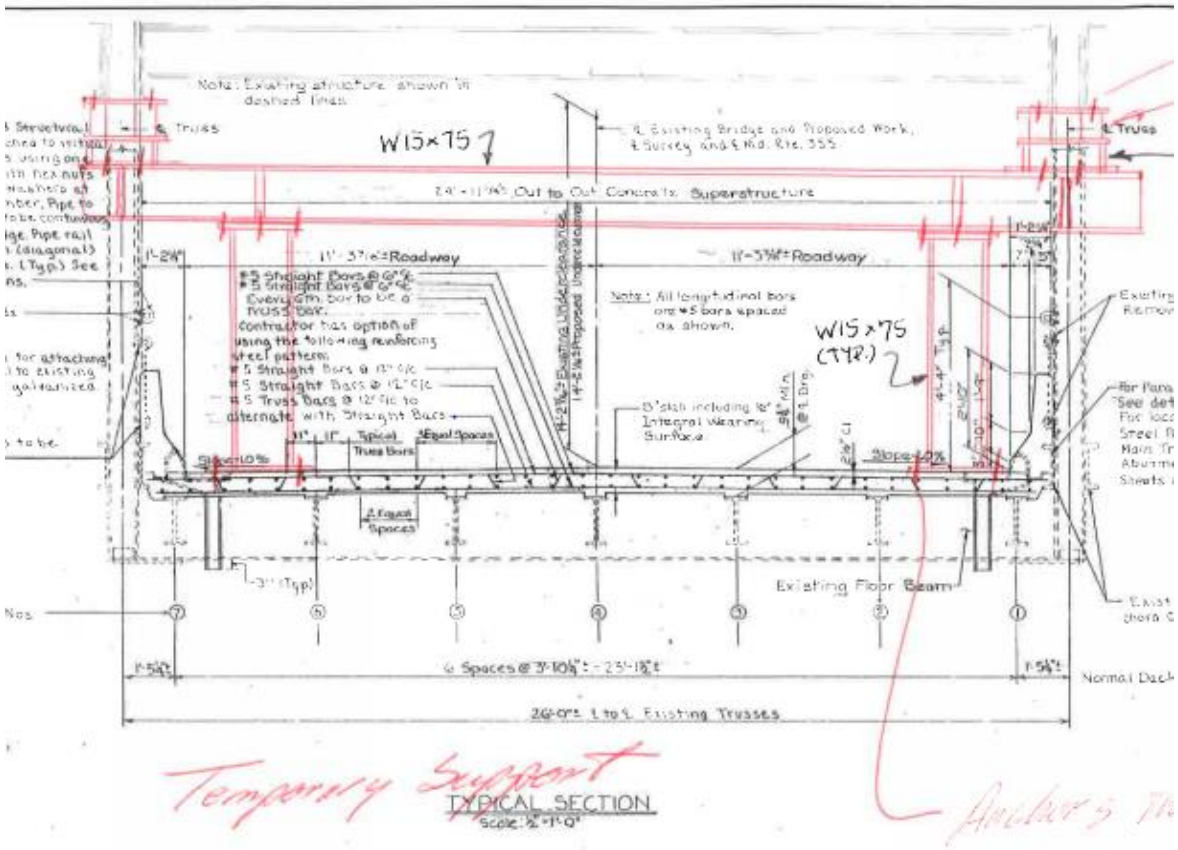


Install stabilization to provide safe access for repairs.

Solution:

"Sister Beam"

1d. Brainstorm Repair Strategy:



- **Lift Top Chord**
- **Remove & Replace Damaged Members**

Challenges:

- Safety
- Access
- Control

Solution:

Jacking Frame

1e. Public Outreach:

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Md. 355 bridge repair could take up to 60 days, officials say

By Jeremy Arias jarias@newspost.com Dec 7, 2017 26

The Md. 355 bridge over the Monocacy River could remain closed until February or early March while structural damage is repaired, according to the State Highway Administration.

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FRIDAY, DECEMBER 8, 2017

MD. 355 BRIDGE

Officials: Repair could take up to 60 days

By JEREMY ARIAS
jarias@newspost.com

The Md. 355 bridge over the Monocacy River could remain closed until February or early March, according to the latest estimates from the State Highway Administration.

"We're trying to expedite it, but some of the beams were so damaged that, when the engineer got out there to take a look at it, they were unusable," said Charlie Gischlar, an SHA spokesman. "So what's happening here is, because that bridge is so old, we don't have spare parts lying around so the pieces have to fabricated in a shop."

As of Thursday, the SHA was estimating repairs would take up to 60 days.

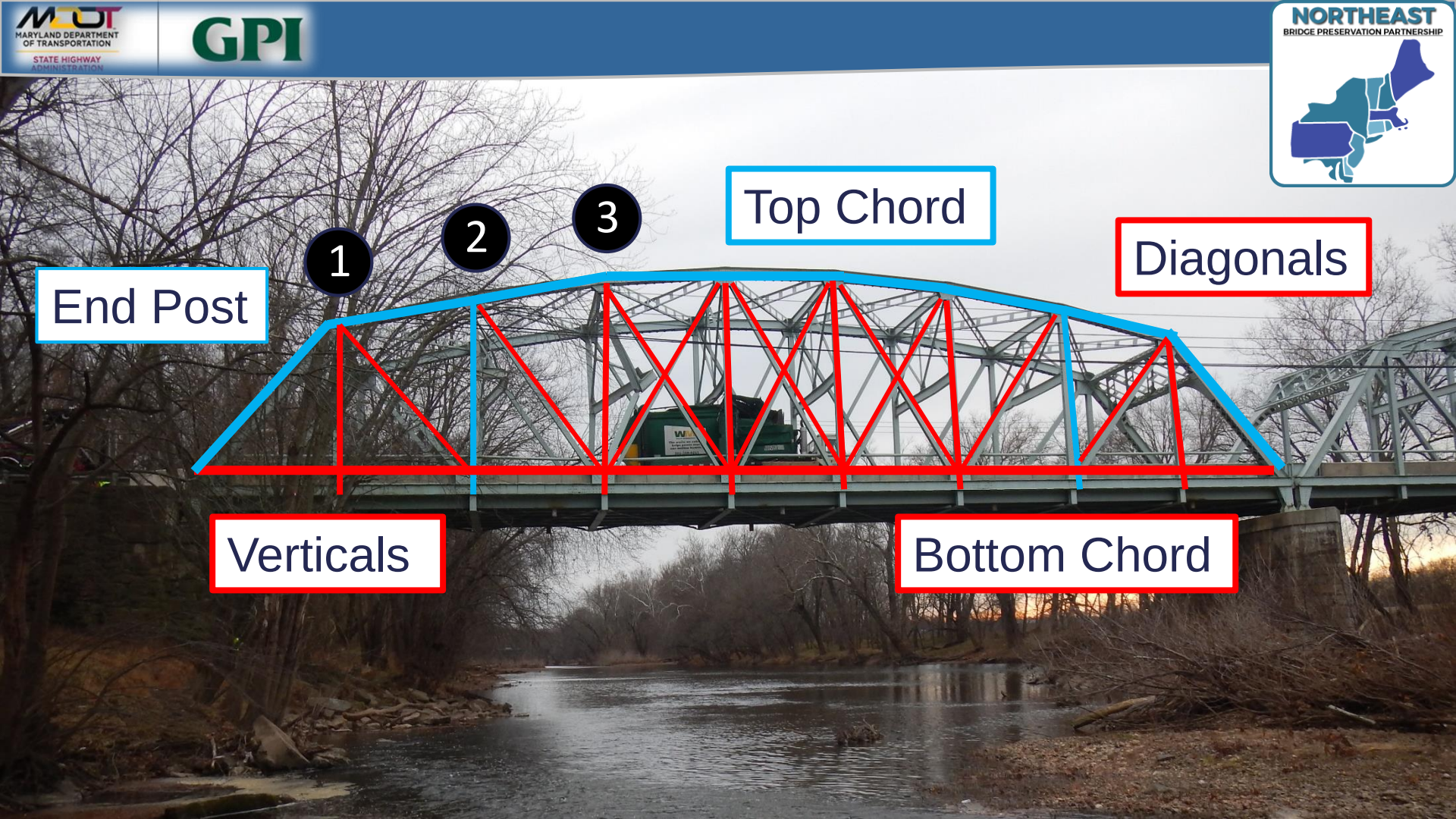
The Maryland Department of Transportation closed the bridge early Wednesday afternoon after several of the steel support beams over the bridge were struck by a garbage truck being towed across the deck, according to the Frederick County Sheriff's Office and a representative from the waste management company.

No injuries resulted from the crash, but debris was left in the road. First responders called the SHA so that an engineer could survey the

(See BRIDGE B2)

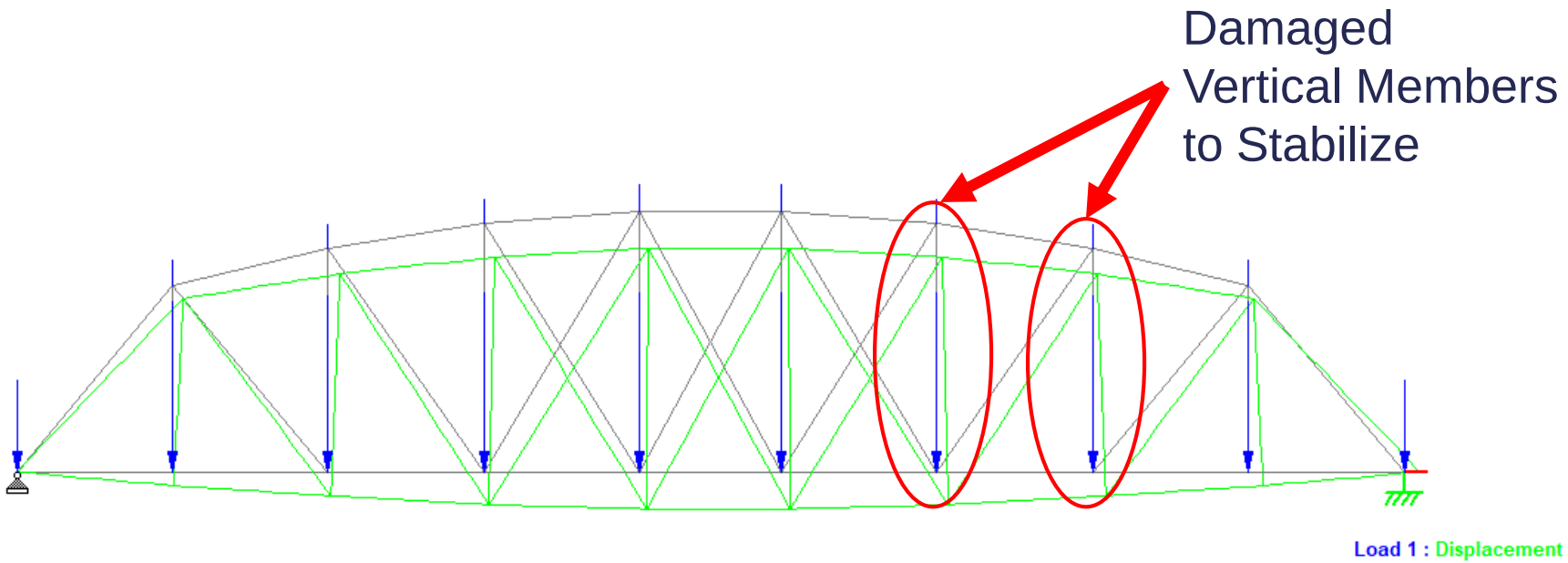
History

1. Initial Response
2. Stabilize the Bridge
3. Modeling and Instrumentation
4. Repair Procedure
5. Conclusion & Lessons Learned


MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION
GPI
NORTHEAST
BRIDGE PRESERVATION PARTNERSHIP
1
2
3
End Post
Top Chord
Diagonals
Verticals
Bottom Chord

Sister Beam Design

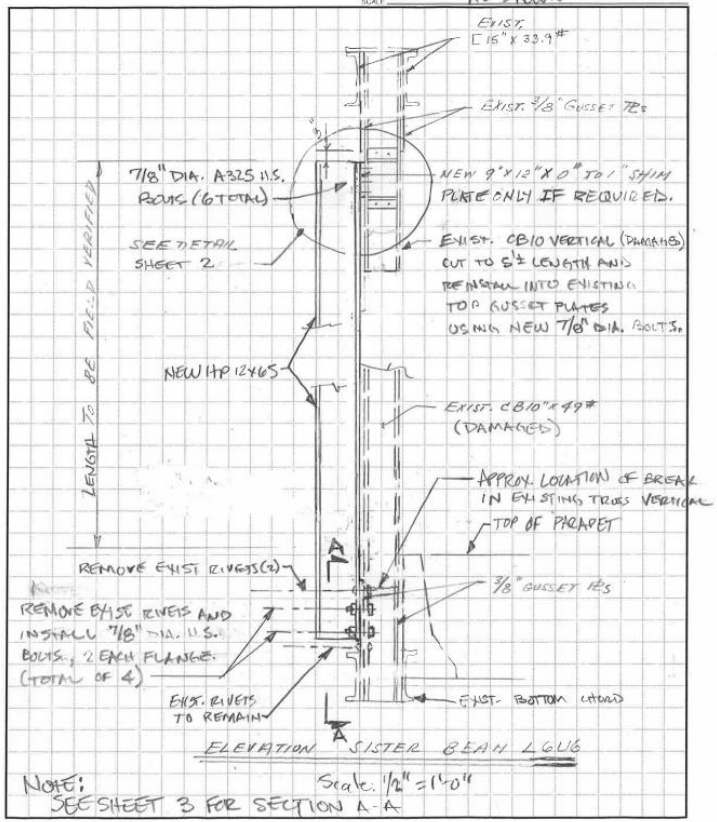
<u>Starting Point:</u> Model As-Built Condition

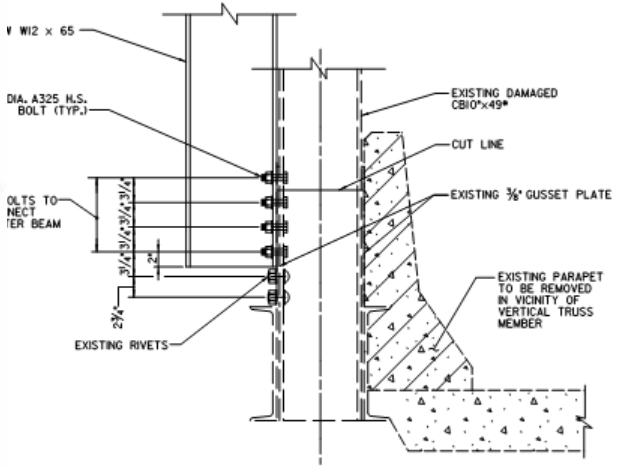


Initial Sketches Provided to Field

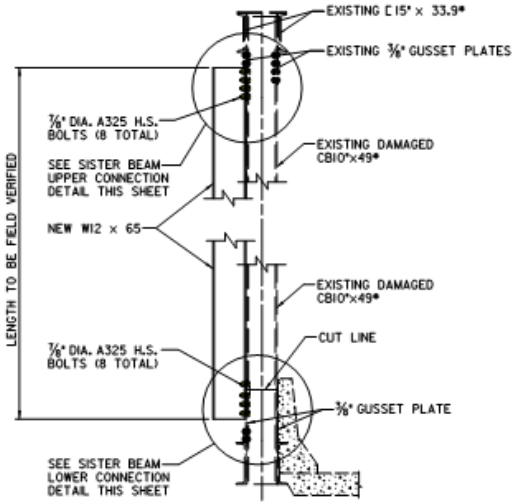
GREENMAN-PEDERSEN, INC.
10977 Guilford Road
Annapolis Junction, MD 20701
(410) 880-3055 Fax (301)490-2649

JOB MD 355 Emergency Repairs
SHEET NO. 1 OF 3
CALCULATED BY MAM DATE 12/9/17
CHECKED BY CSN DATE 12/9/17
SCALE AS SHOWN





SISTER BEAM LOWER CONNECTION DETAIL AT L6
SCALE: 1 1/2" = 1'-0"



ELEVATION
SISTER BEAM L7U7
SISTER BEAM L6U6 SIMILAR
SCALE: 1/2"=1'-0"

Final Plans

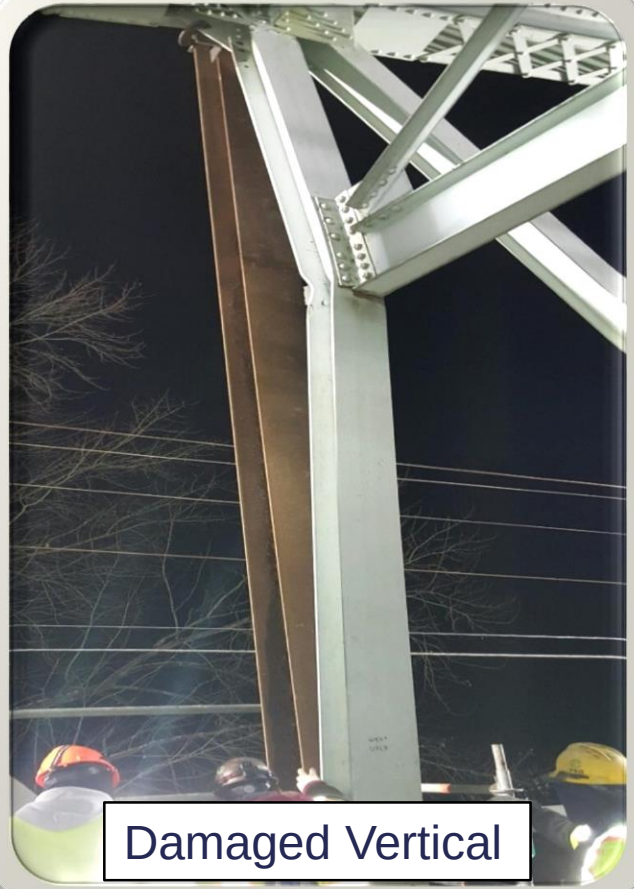
Install Sister Beams

Begin Stabilization on 12/09/17

Limited Access Due to:

Light Equipment

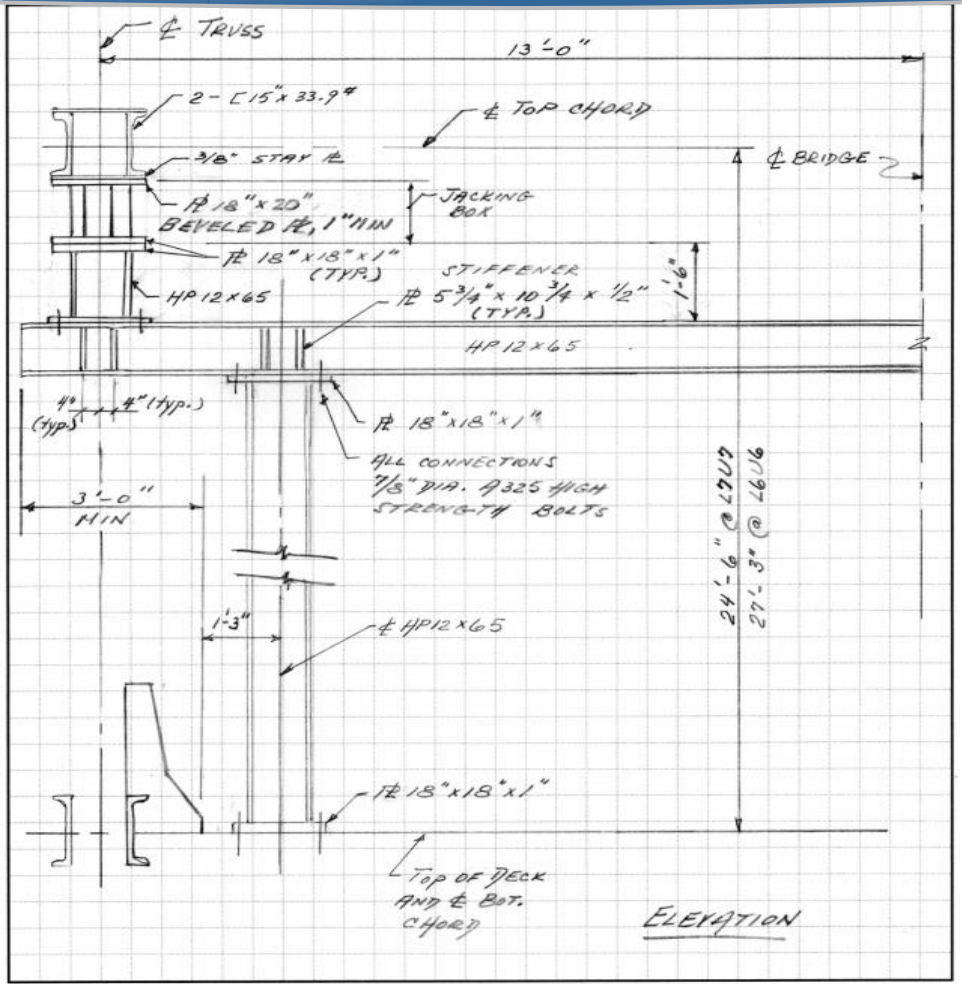
Overhead & Lateral Bracing



Damaged Vertical

Severed Vertical

Sister Beam Connection at Top Joint



Jacking Frame: Preliminary Concept

Challenges:

- Physical Constraints
- Bridge Geometry
- Stability & Load Eccentricity
- Concurrent Construction

Sketch sent to SHA on 12/07/17

Jacking Frame Design

Base Model:

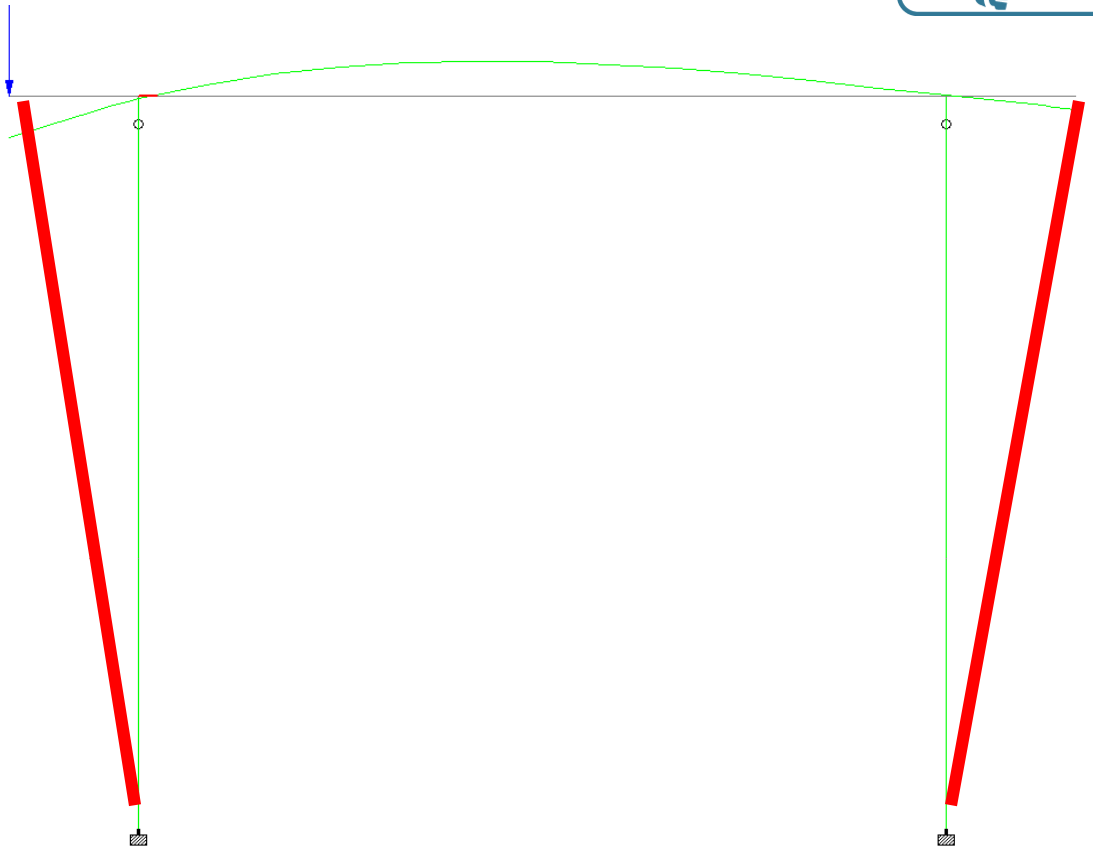
Determine Loads

Initial Results:

Excessive Deformations

Solution:

Add Struts



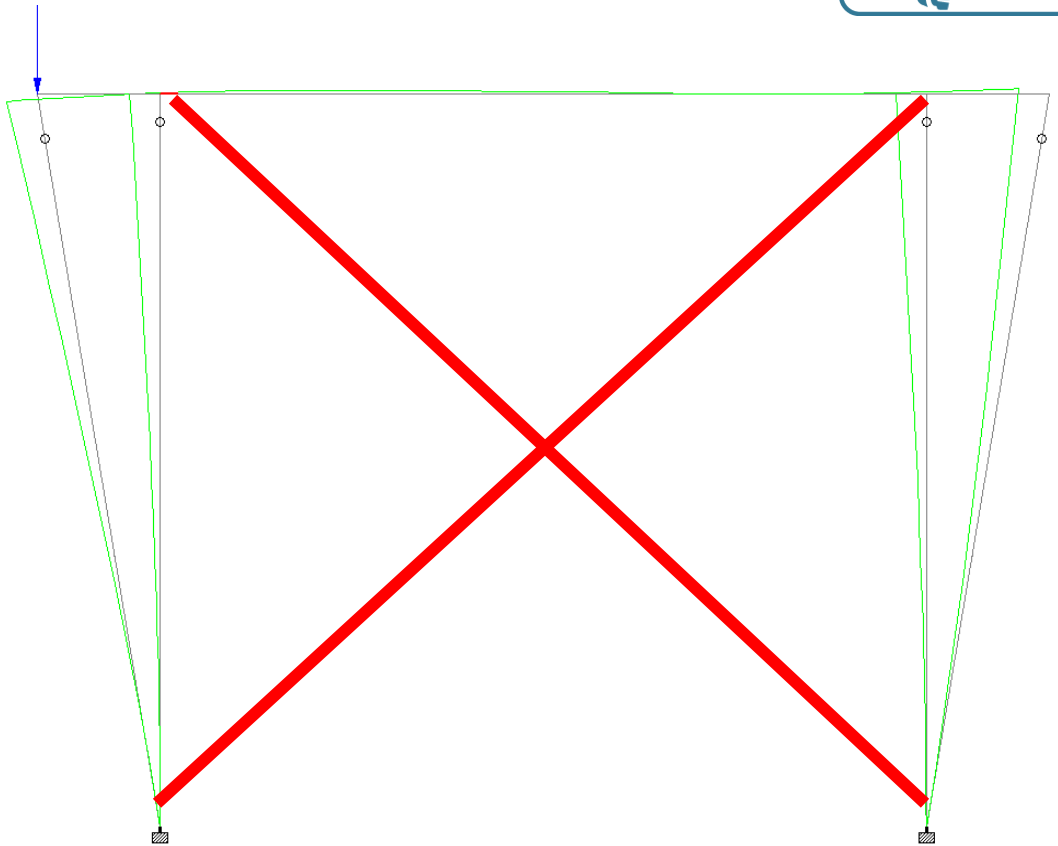
Jacking Frame Design

Revised Model:

- Less Vertical Deflection
- Deformation Still an Issue

Solution:

Add Bracing



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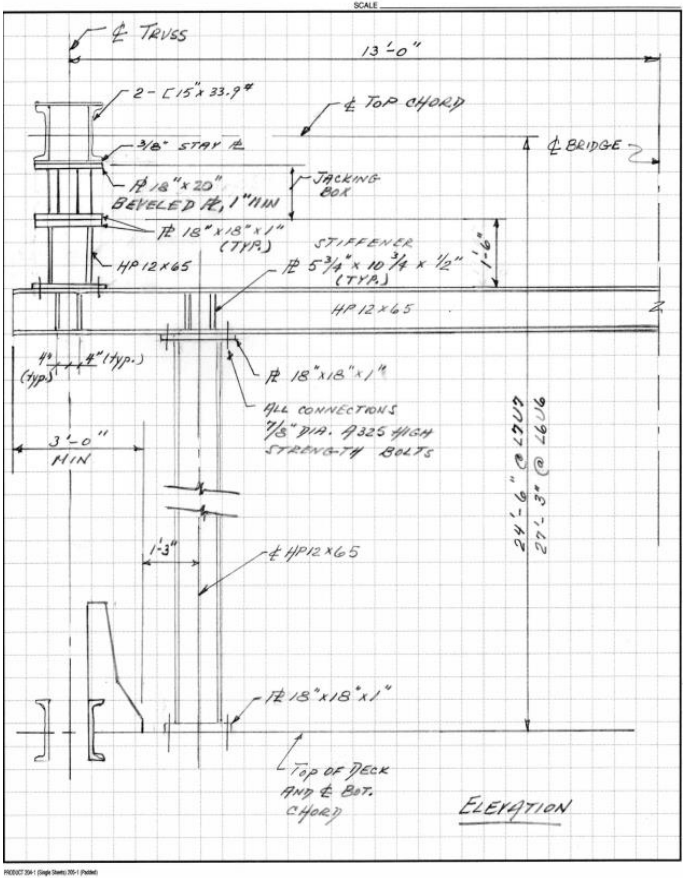
STATE HIGHWAY ADMINISTRATION

GPI

NORTHEAST
BRIDGE PRESERVATION PARTNERSHIP

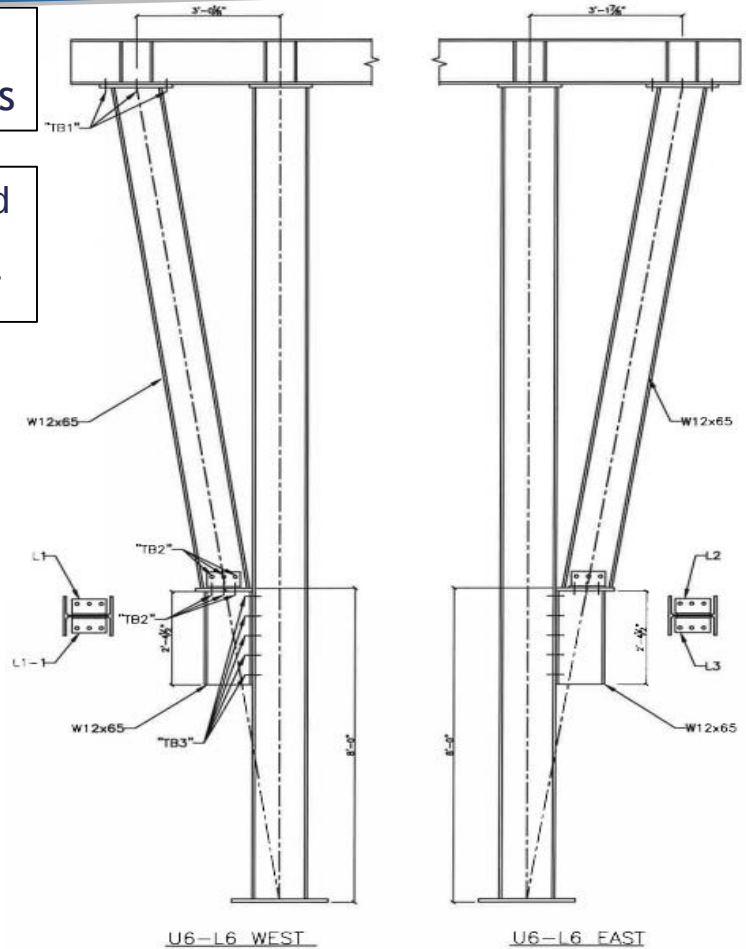
Initial Sketch

JOB M7355 Emergency Repairs
SHEET NO. 1 OF 1
CALCULATED BY HAH DATE 12/7/17
CHECKED BY DATE
SCALE



Shop Drawings

Produced by 12/15/17




MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION
MDOT
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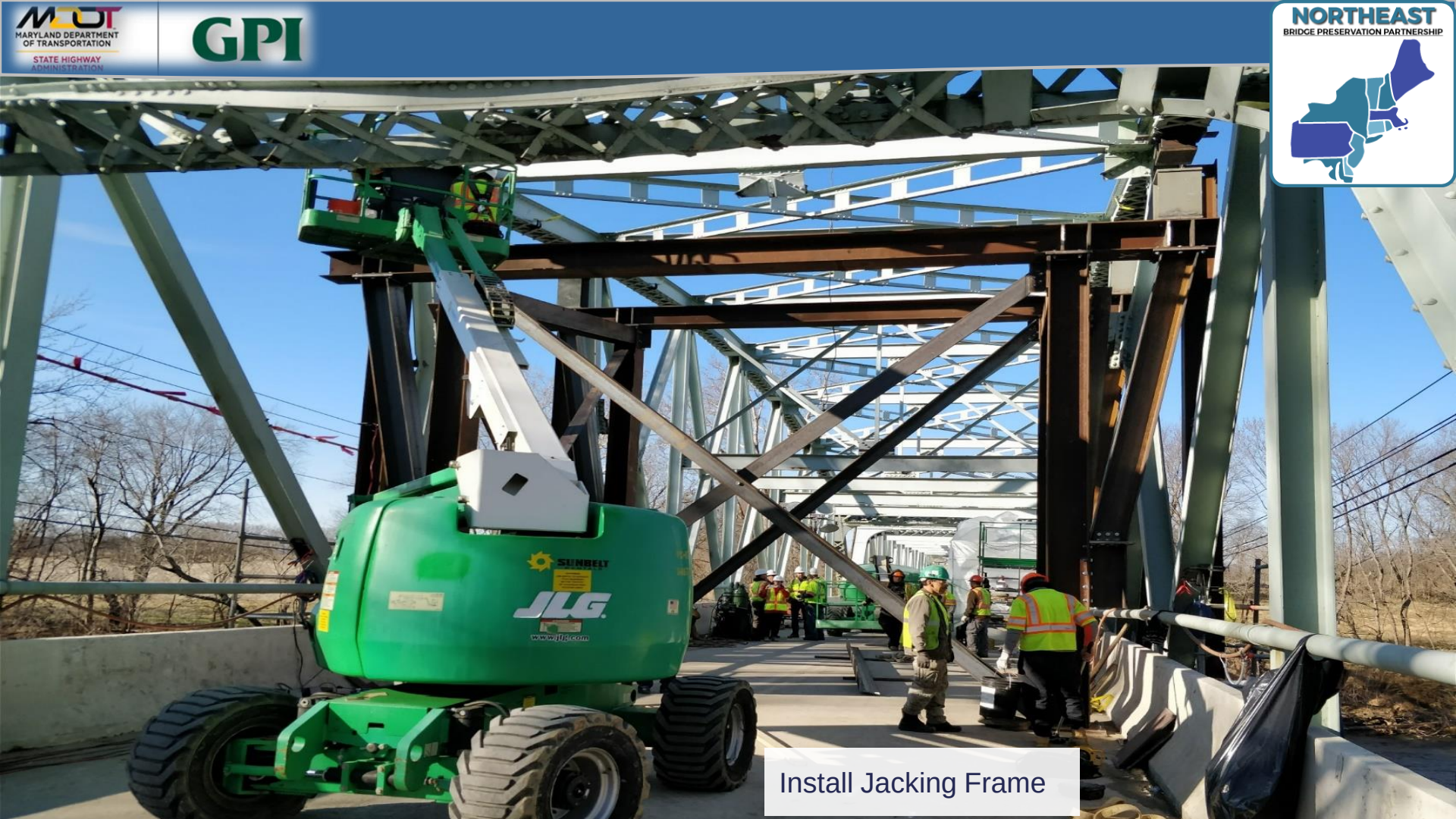
NORTHEAST
BRIDGE PRESERVATION PARTNERSHIP
United Rentals
S-80X
4x4
Sister Beams Installed by 12/12/17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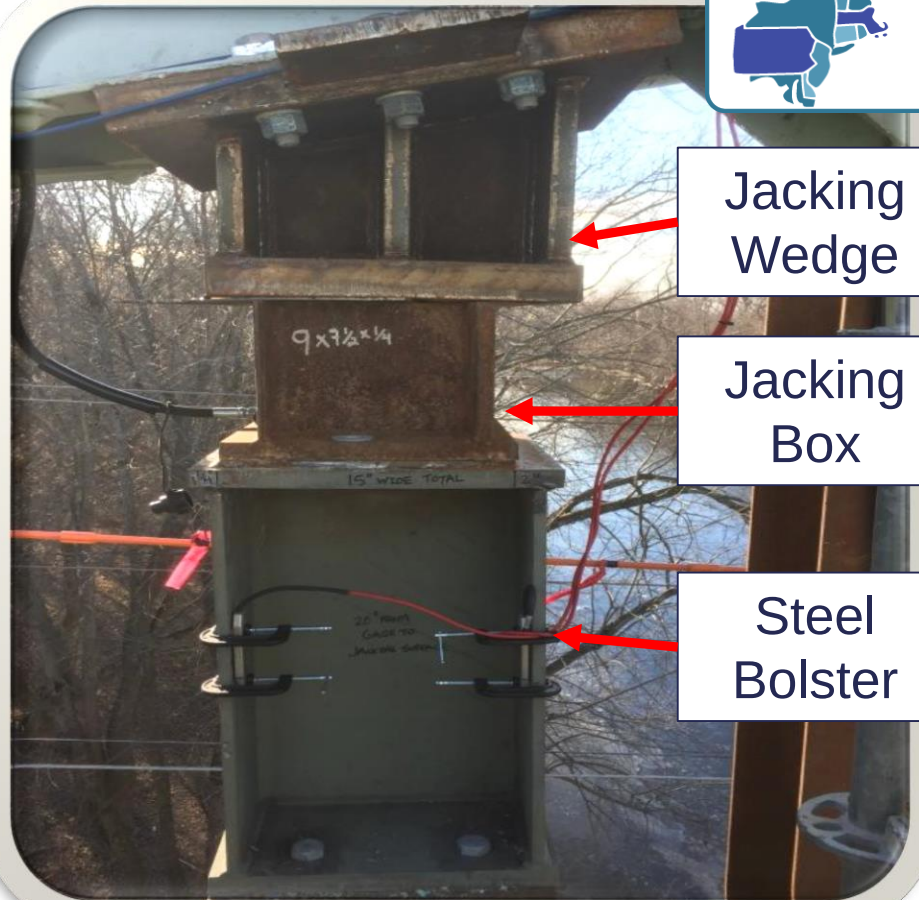
SUNBELT
JLG
www.jlg.com
Install Jacking Frame


Jacking Wedge
Jacking Box
Steel Bolster

History

1. Initial Response
2. Stabilize the Bridge
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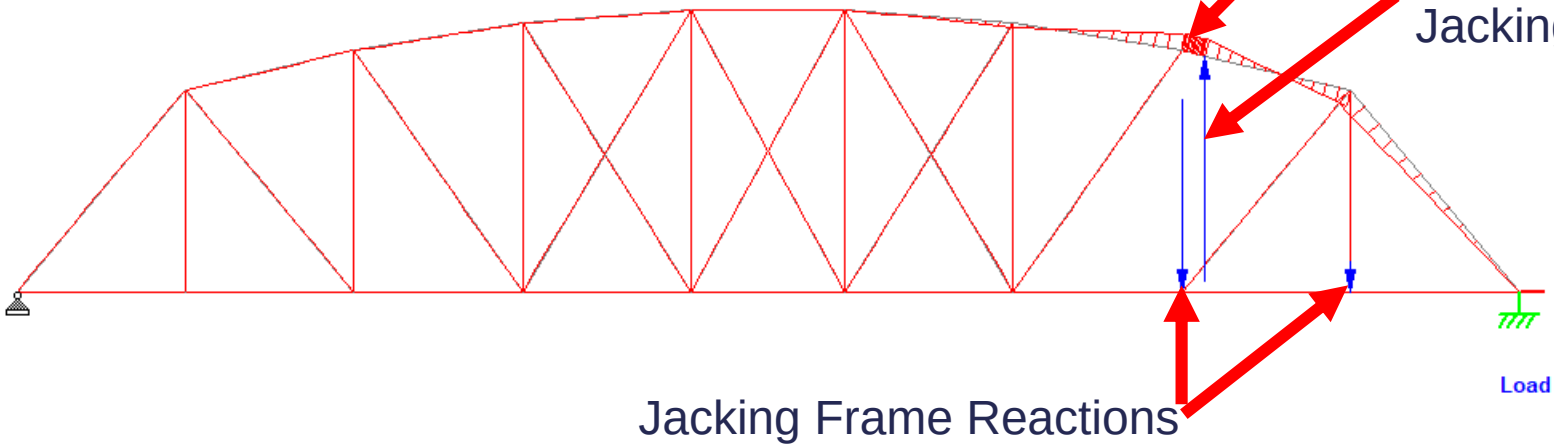
5. Conclusion & Lessons Learned

2D Model Development: Repair Procedure

Objective: **Prevent Further Damage**

Sister Beams Installed

Determine Effects from Jacking



2D vs. 3D Modeling

2D Model:

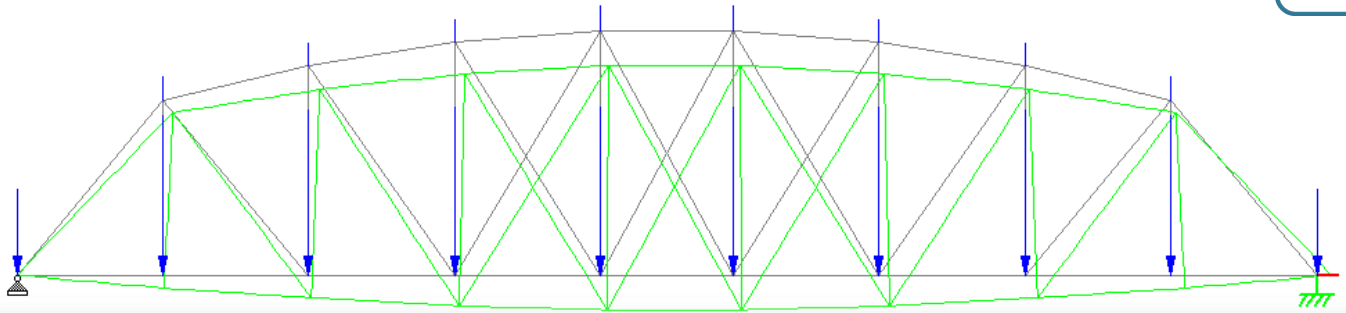
- Quickly determine preliminary design loads
- Determine conservative loads for frame design

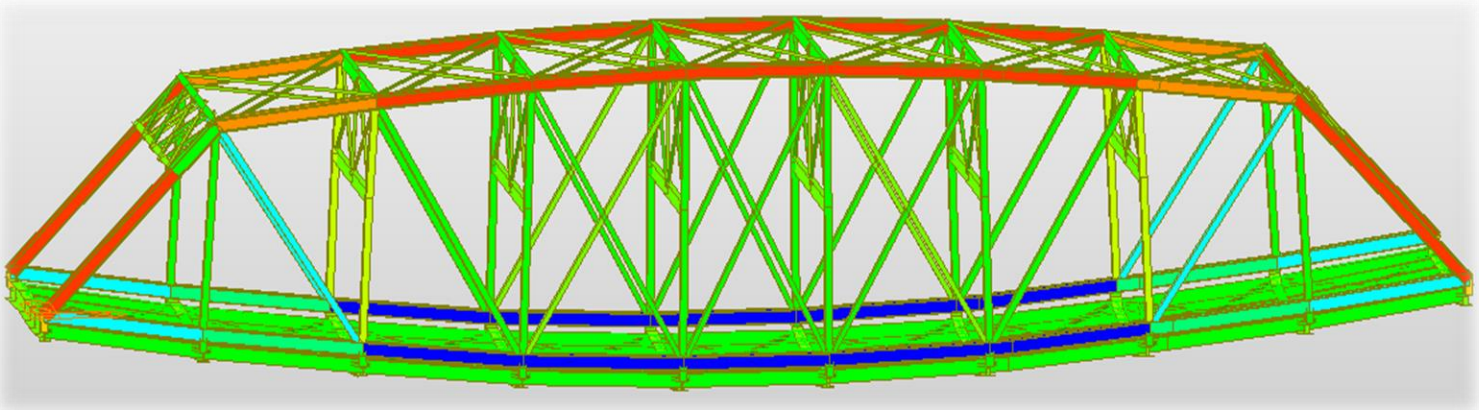
3D Model:

- Asymmetric damage
- Capture effects of transverse load sharing
- Assess overall behavior of structure during replacement operations

3D Model: Compare to 2D Results

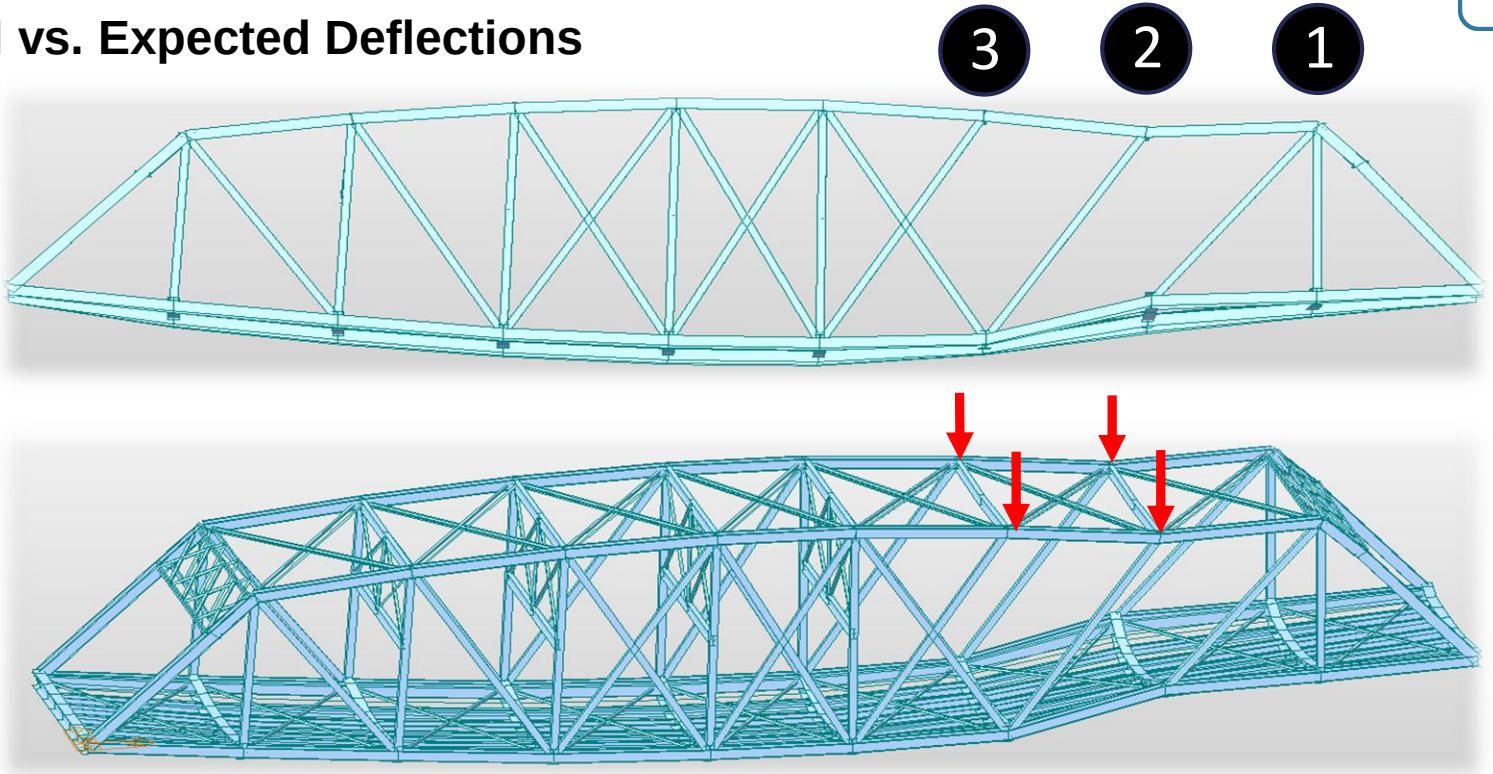
- **Compare:**
- Support Reactions
- Member Forces
- Logic Test



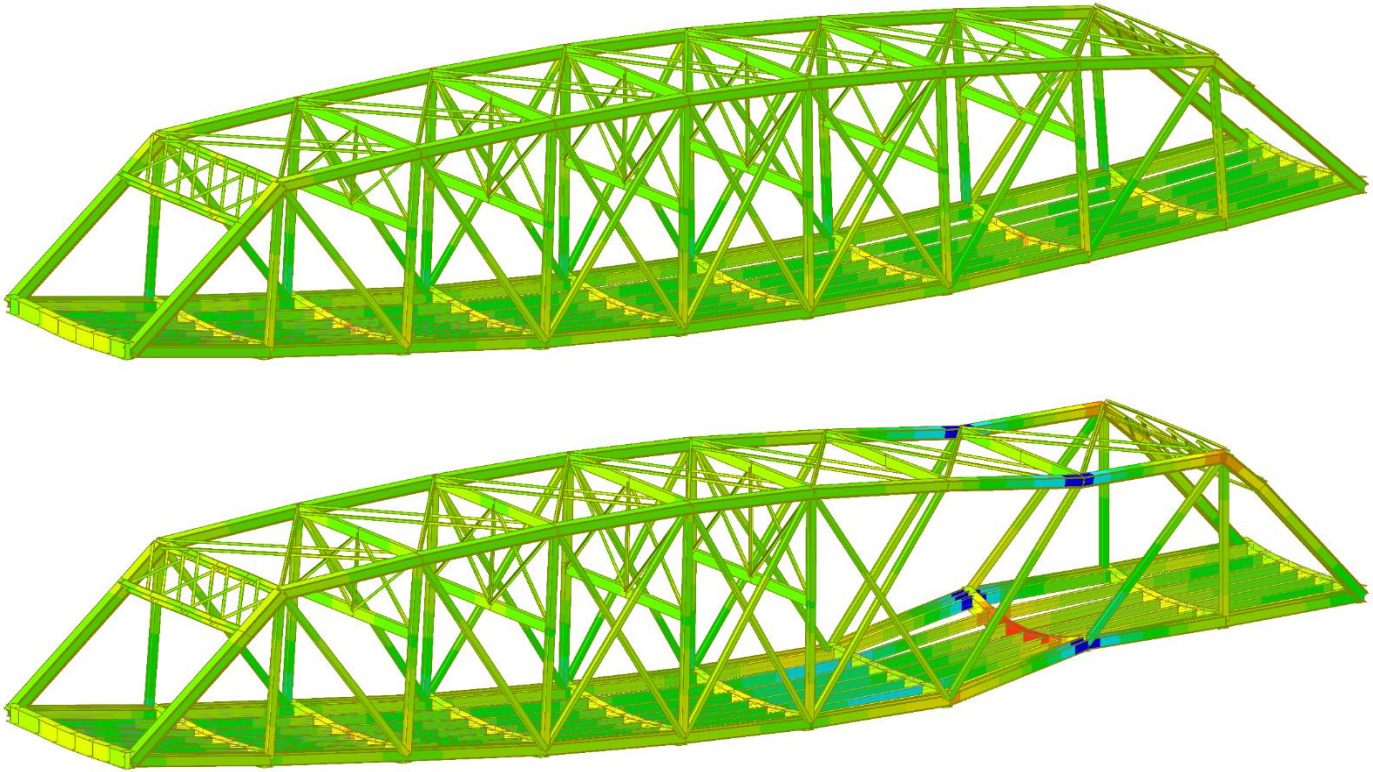


3D Model: Compare to Field Measurements

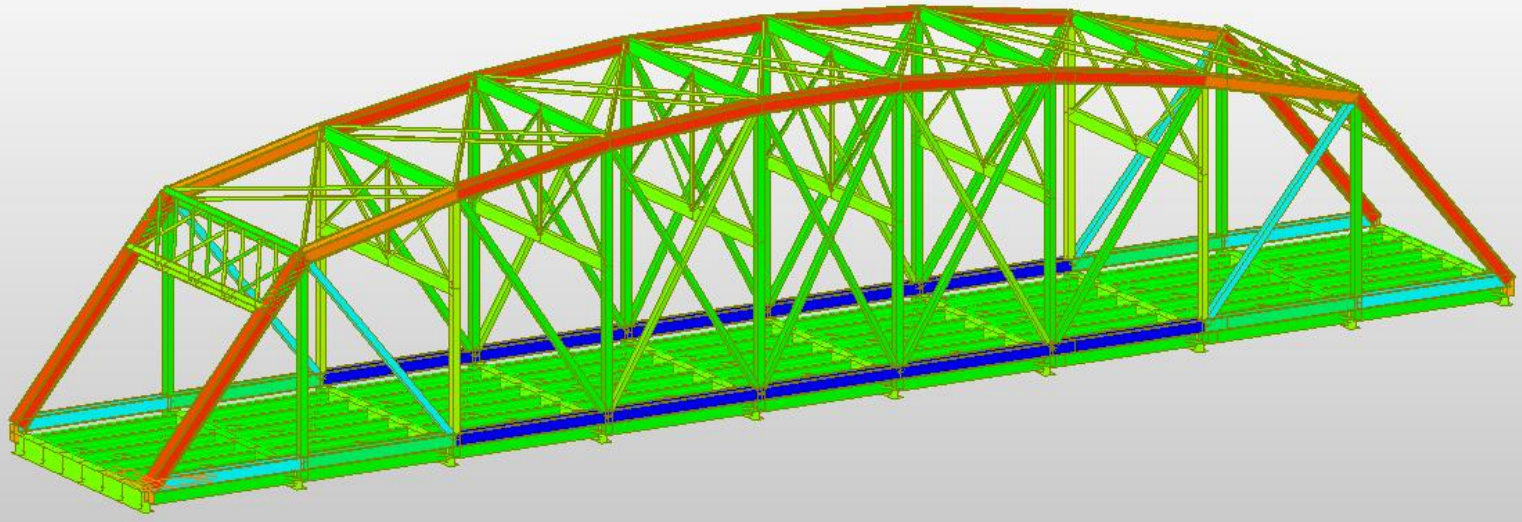
Actual vs. Expected Deflections



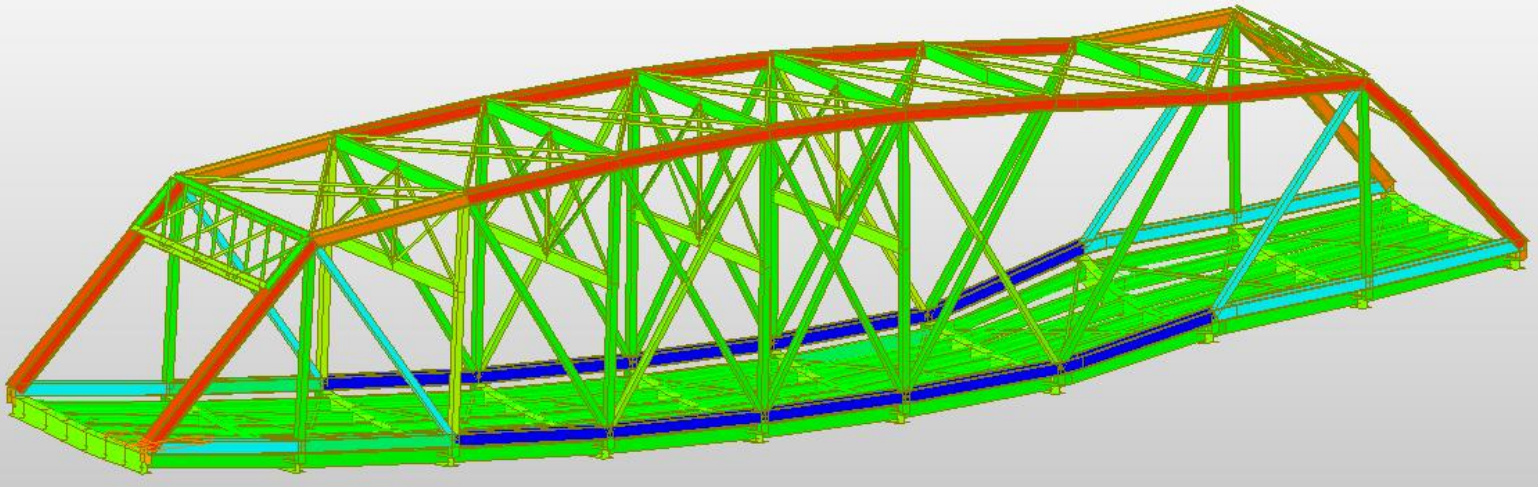
3D Model: As-Built vs. Damaged State



Step 1: As-Built Condition

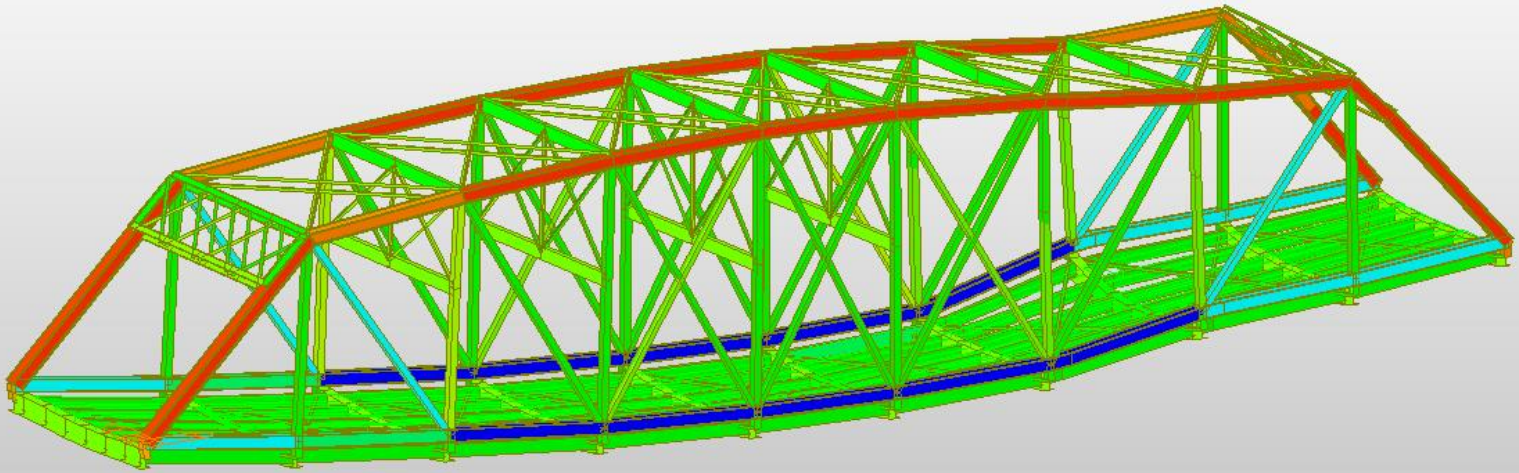


Step 2: Damaged State



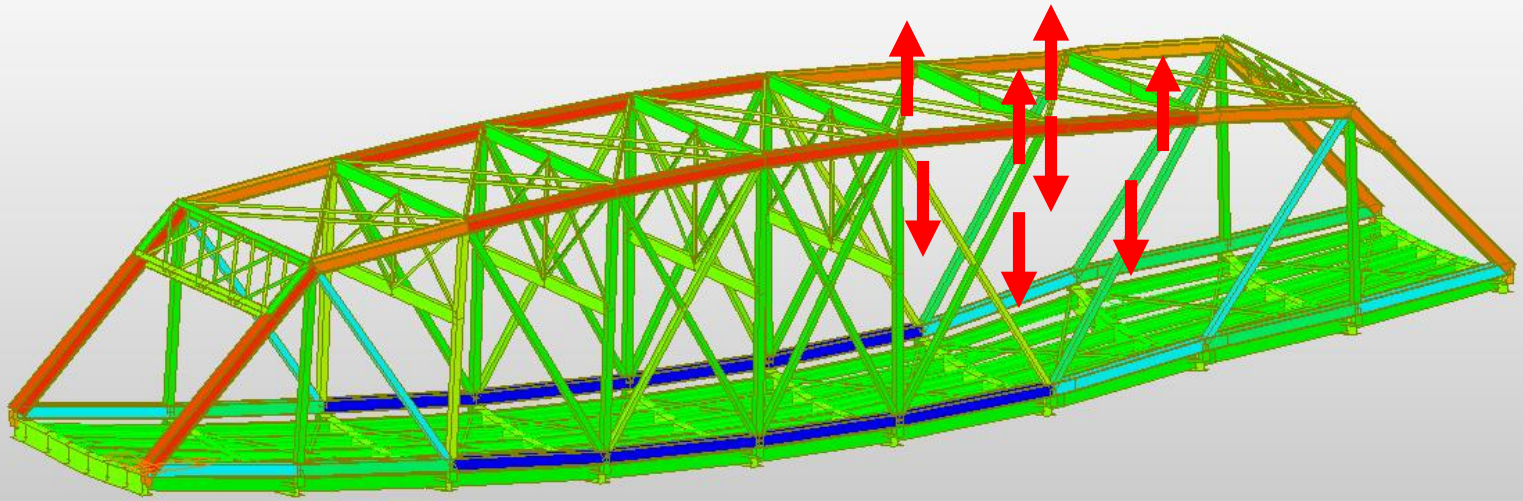
MIDAS/Civil
POST-PROCESSOR
BEAM FORCE
AXIAL
1.50813e+002
1.16805e+002
8.27974e+001
4.87895e+001
0.00000e+000
-1.92262e+001
-5.32341e+001
-8.72419e+001
-1.21250e+002
-1.55258e+002
-1.89266e+002
-2.23273e+002
SCALEFACTOR=
7.9298E+001
STAGE:Damaged (Verticals Re
CS: SUMMATION
LAST STEP
MAX : 194
MIN : 376
UNIT: kips
VIEW-DIRECTION
X:-0.483
Z: 0.259

Step 3: Stabilize with Sister Beams



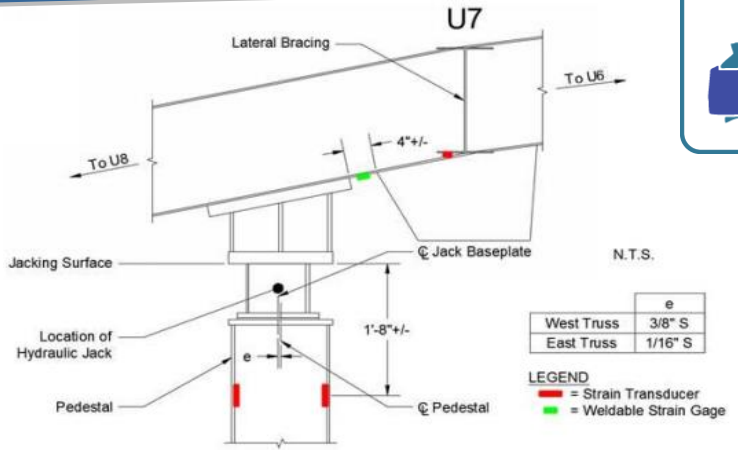
Step 4: Perform Repairs (Jacking Operation)

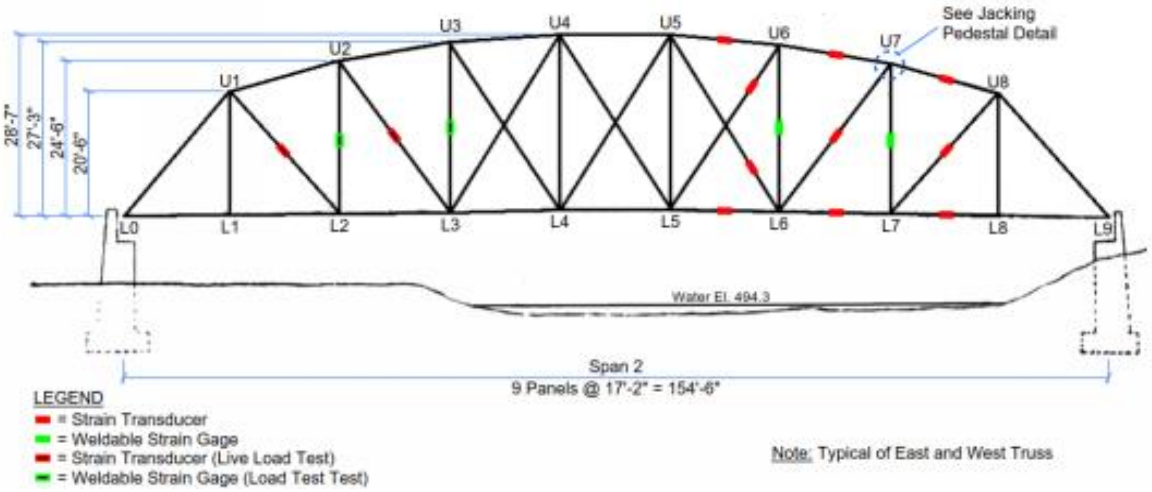
- Determine Jacking Forces & Effects on Adjacent Members
- Prevent Overstressing Connections (set limits)



Monitoring Plan:

- 32 Sensors Installed
- Monitor Structure During Repairs
- Observe Real-Time Strain Response





Monitoring Plan:

Repair Procedure:

- Lift Top Chord
- Monitor Impacts to Adjacent Members
- Assess Response
- Evaluate & Proceed

History

1. Initial Response

2. Stabilize the Bridge

3. Modeling and Instrumentation

4. Repair Procedure

5. Summary & Lessons Learned

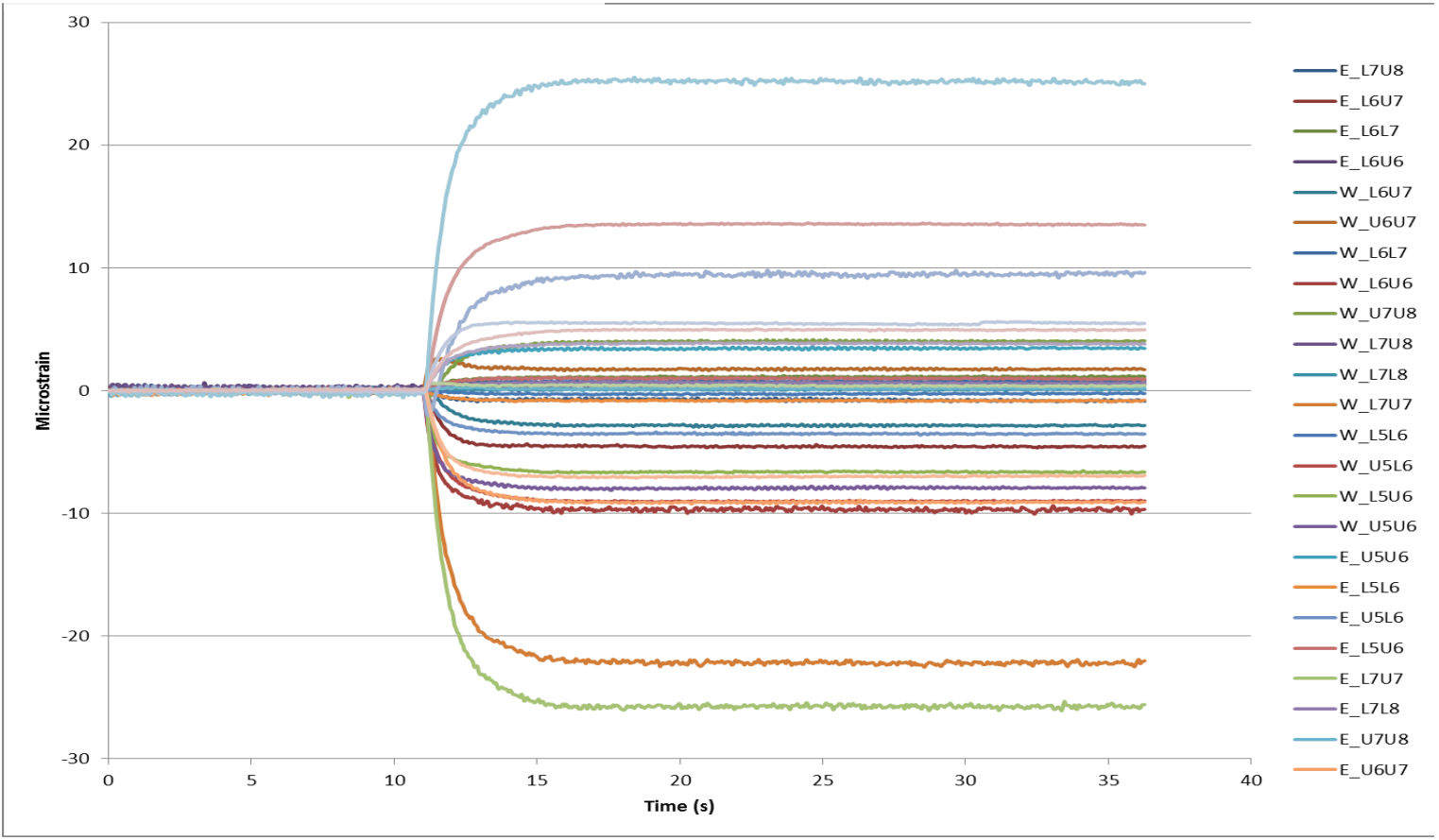
Perform Test Run

- Test the Procedure
- Determine Accuracy of Model + Assumptions

Test Run Date: 12/19/17

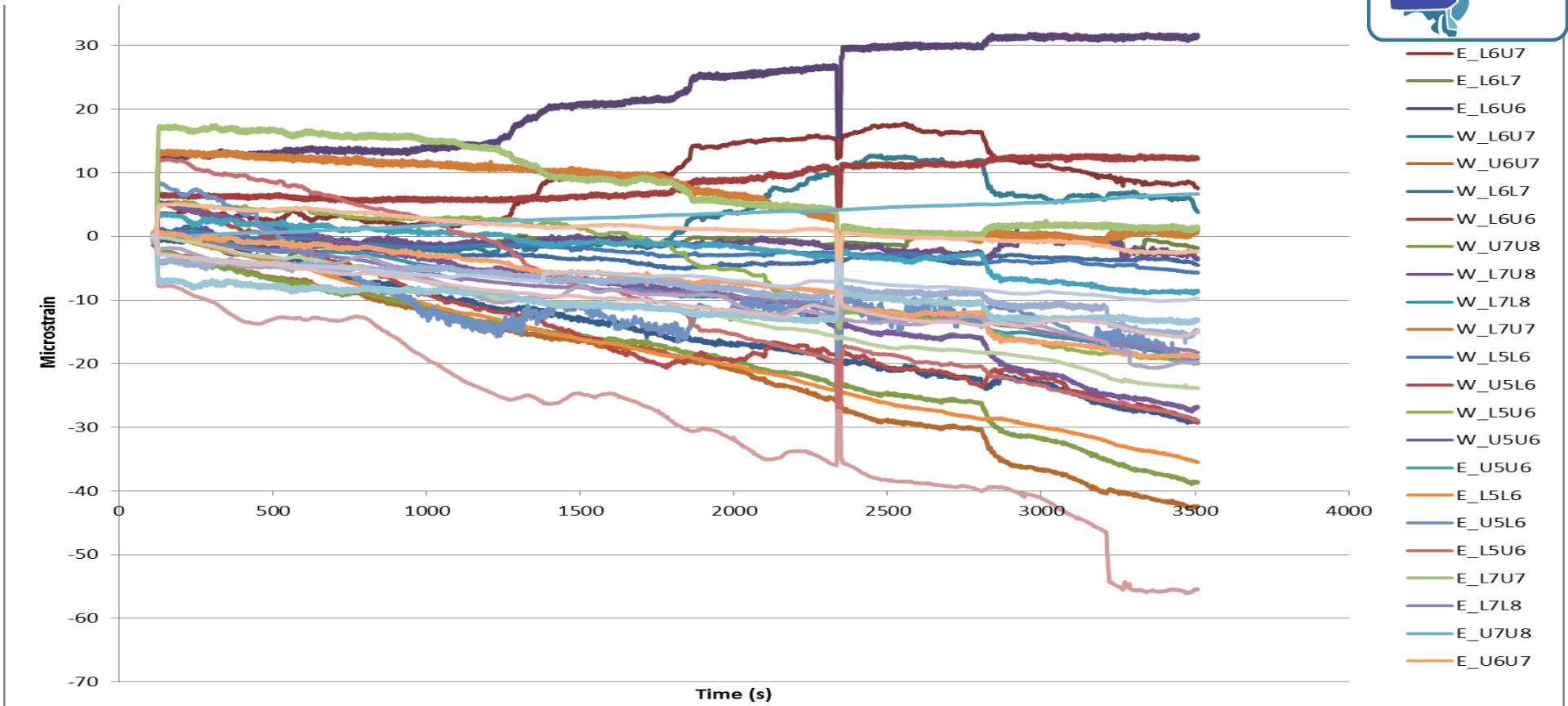

G17
EAST

Perform Test Run



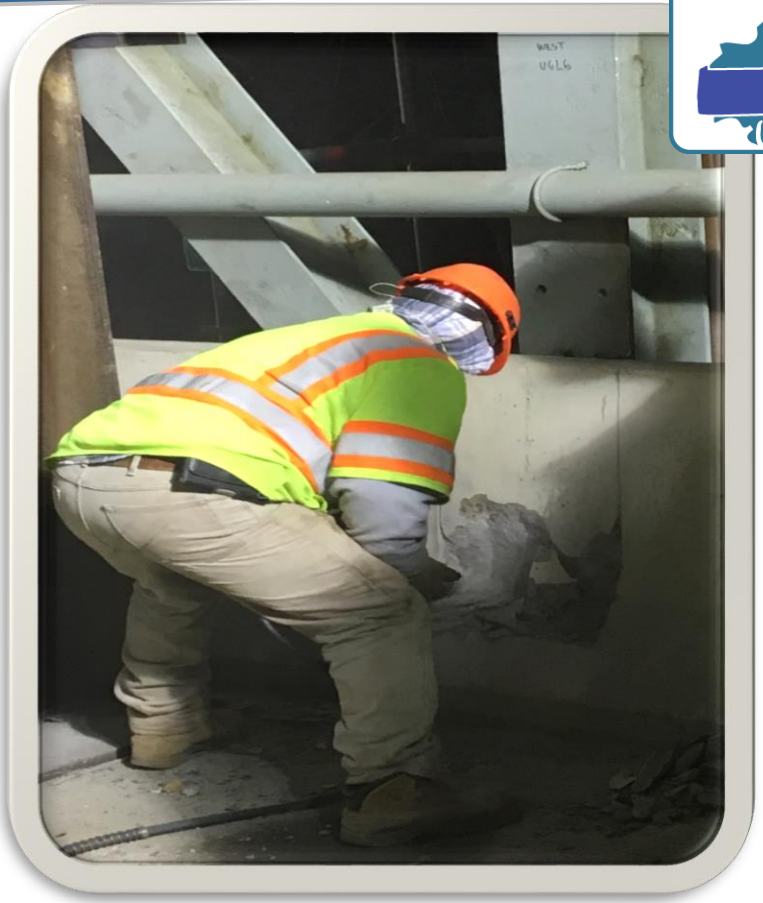
1. Apply Force
2. Does Response Make Sense?

Perform Test Run

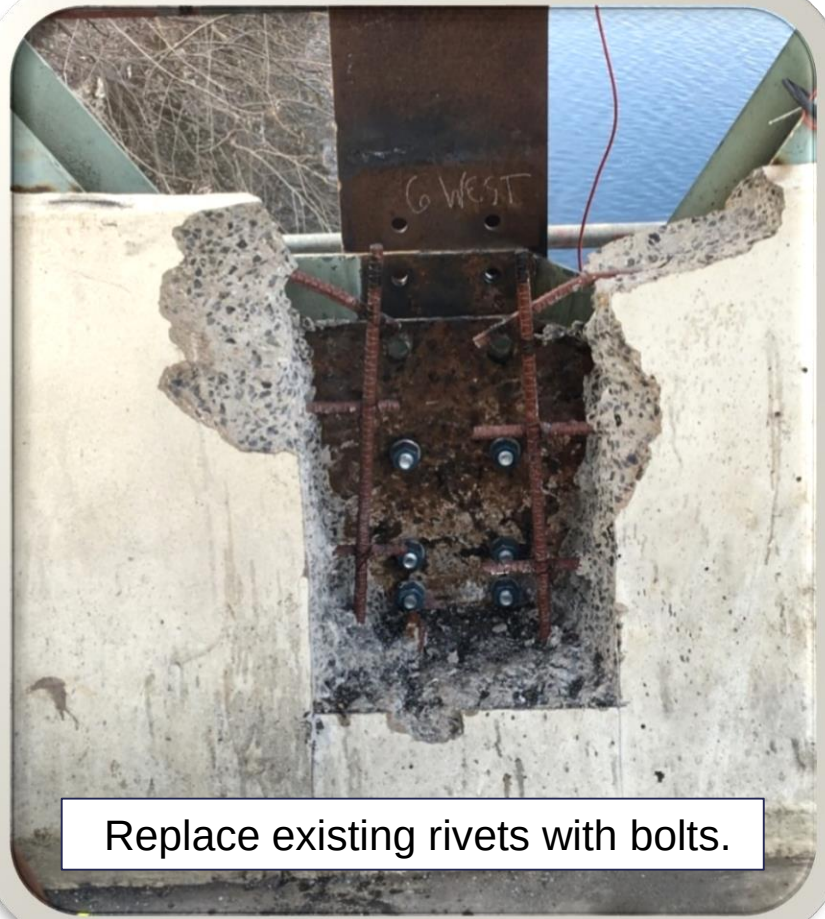


Test Run: Lessons Learned

- Understand the Equipment
  - How to Apply Intended Forces
  - Equipment Shortcomings
- Use Properly Sized Equipment
- Test to Verify Function
- Refine Procedure in Less Critical Regions
- Coordination Essential for Controlled Runs



Carefully perform work to prevent damaging the Gusset Plates.



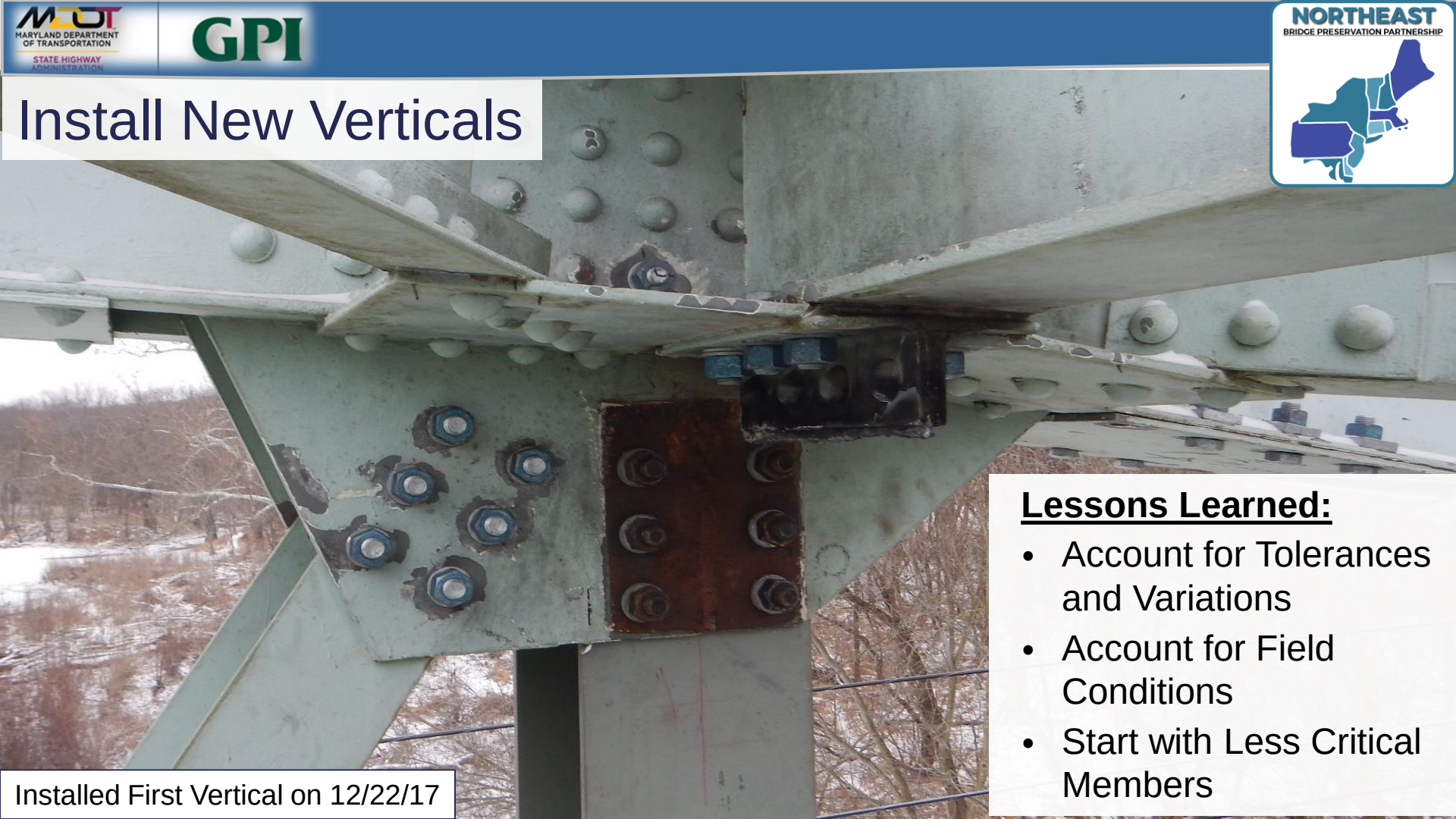
Replace existing rivets with bolts.

Grind surfaces for splice connections.

Install New Verticals

Start Installation by 12/22/17

Install New Verticals



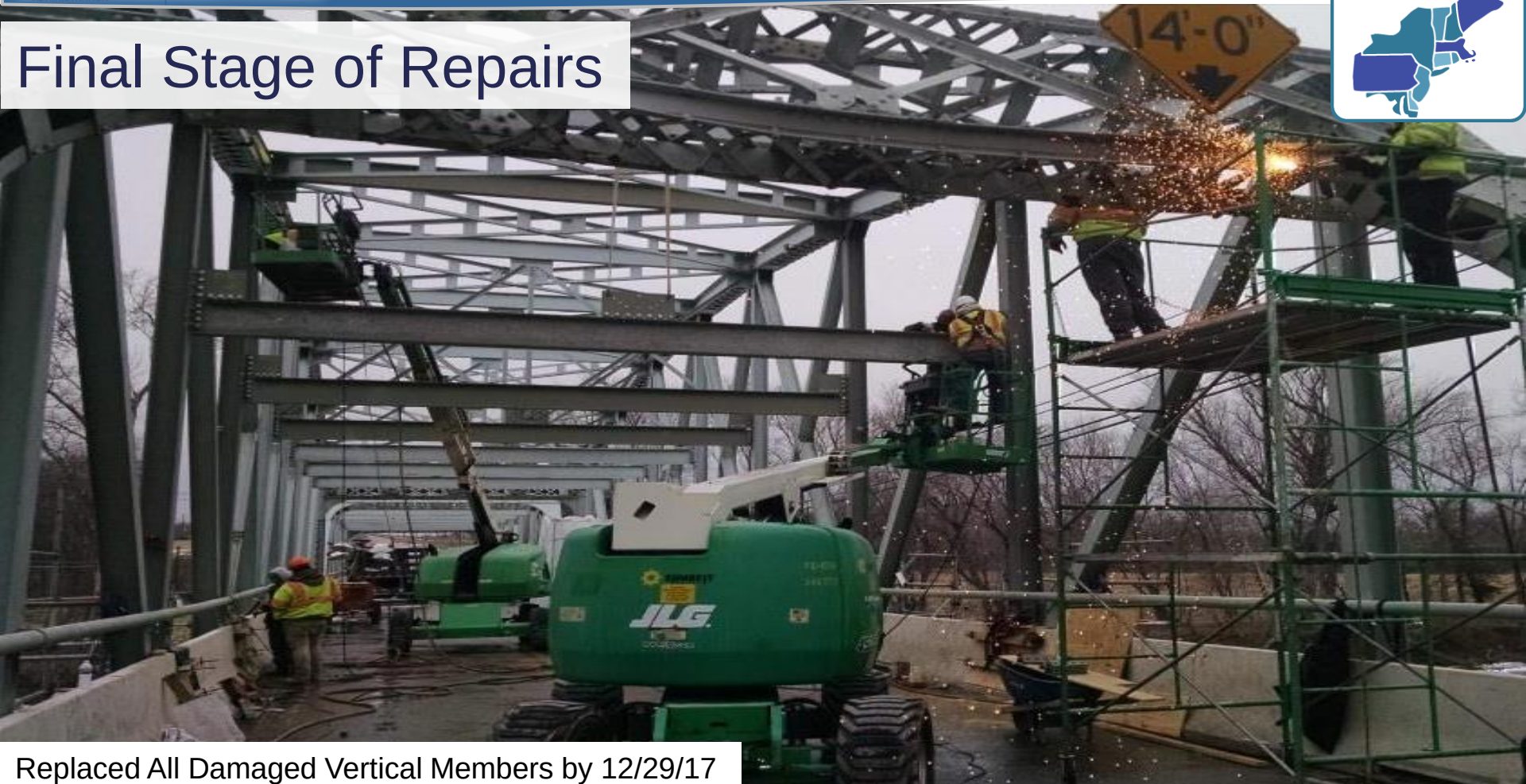
Installed First Vertical on 12/22/17

Lessons Learned:

- Account for Tolerances and Variations
- Account for Field Conditions
- Start with Less Critical Members


TOP
inside

Final Stage of Repairs

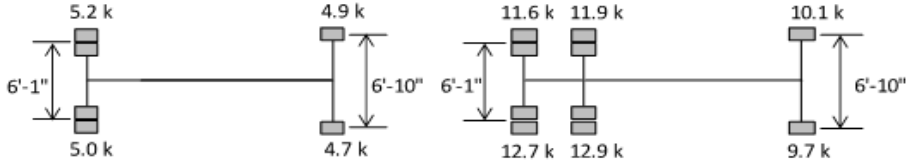


Replaced All Damaged Vertical Members by 12/29/17

Repairs Complete

All Repairs Completed by 01/10/18

Perform Live Load Test

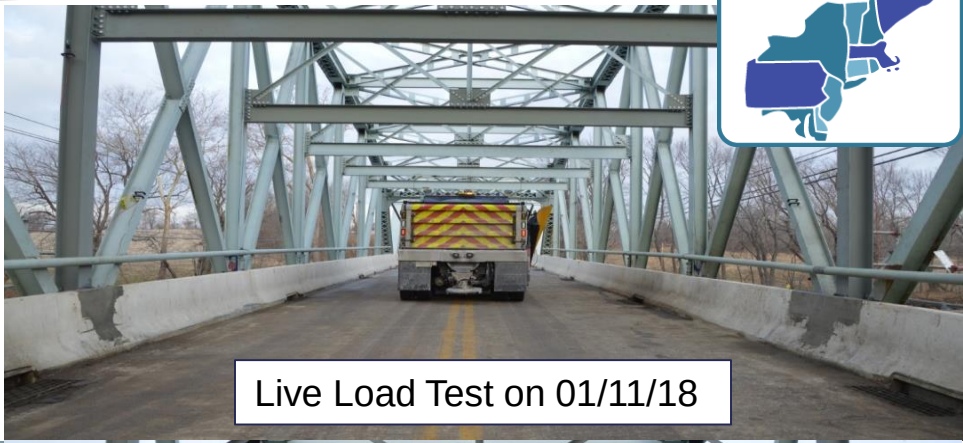


Trailer Truck

Gross Vehicle Weight = 19.8 ± kips

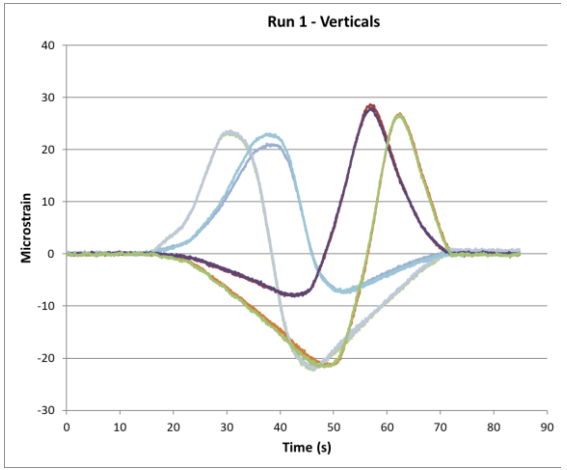
Plow Truck

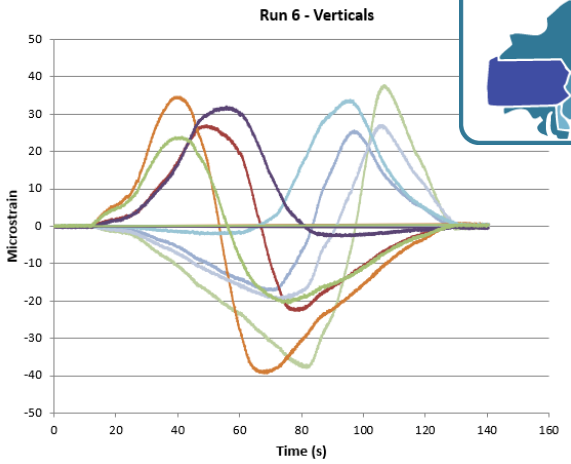
Gross Vehicle Weight = 68.9 ± kips

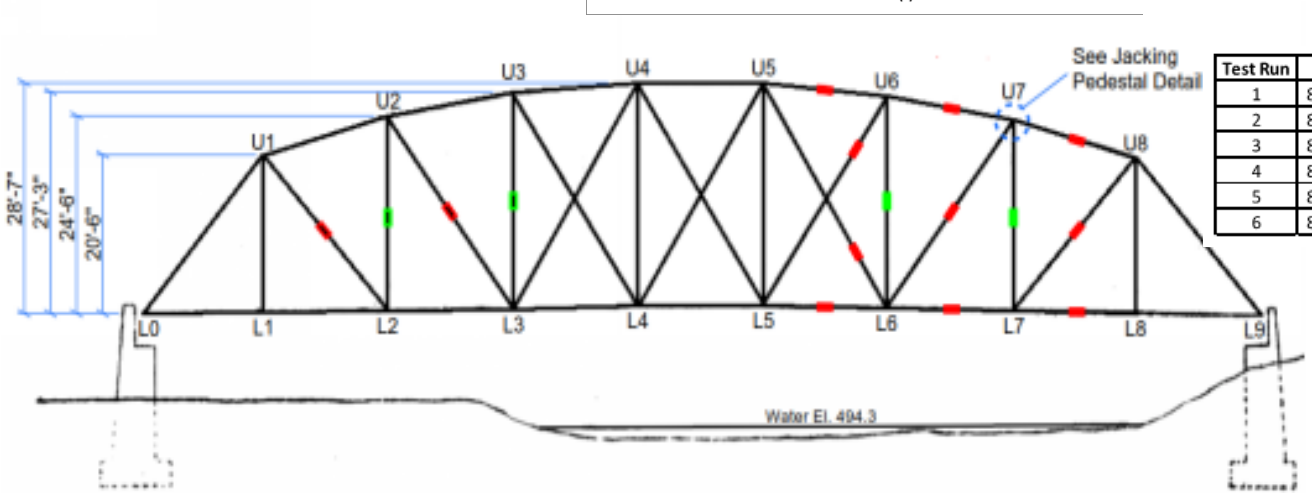


Live Load Test on 01/11/18

Perform Live Load Test







Test Run	Time	Direction	Speed	Plow Truck Position	Trailer Truck Position
1	8:25 AM	SB	Crawl	Centered on bridge	-
2	8:29 AM	SB	Crawl	-	Centered on bridge
3	8:31 AM	NB	Crawl	Centered on bridge	-
4	8:33 AM	NB	Crawl	-	Centered on bridge
5	8:48 AM	SB	Crawl	NB Lane	SB Lane
6	8:54 AM	NB	Crawl	SB Lane	NB Lane

Bridge Re-Opened on January 11th, 2018

History

1. Initial Response

2. Stabilize the Bridge

3. Modeling and Instrumentation

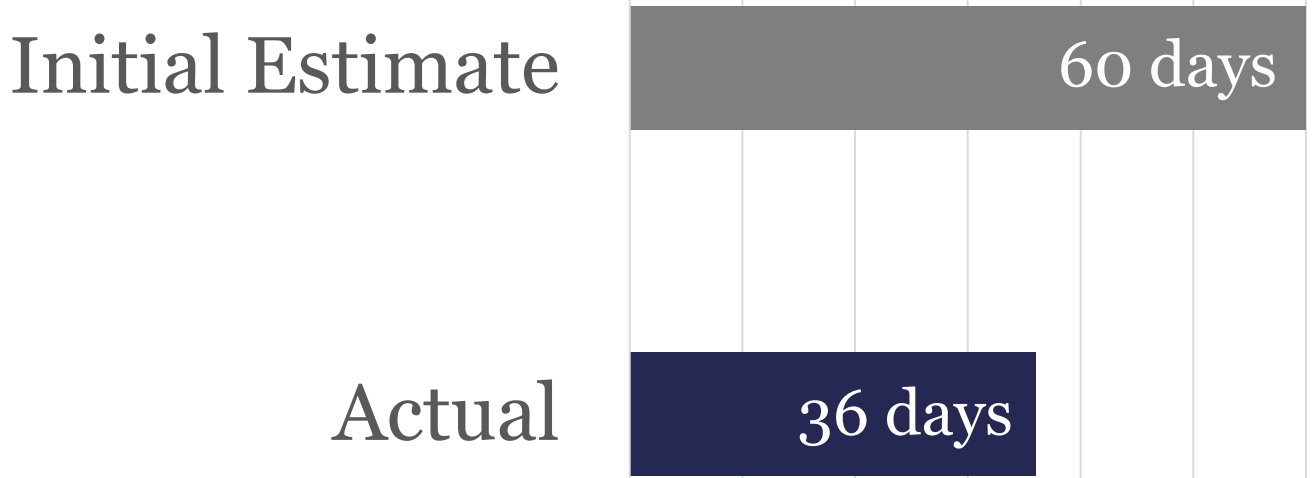
4. Repair Procedure

5. Conclusion & Lessons Learned

Emergency Response Timeline:

Bridge Impacted:	12/06/17
Bridge Stabilized:	12/12/17
Test Run:	12/19/17
Verticals Replaced:	12/29/17
Sway Bracing Replaced:	01/10/18
Live Load Test & Re-Opened:	01/11/18

Expedited Repairs: Re-Opened in 36 Days



Bridge Closed: 12/06/17
Bridge Opened: 01/11/18

Lessons Learned:

- Communication is Critical for Success
- Design for Constructability
- Understand Capabilities and Limitations of Your Tools
- Verification Process is Key
- “Practice Makes Perfect”
- Public Outreach Leads to Favorable Response

MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

GPI

NORTHEAST
BRIDGE PRESERVATION PARTNERSHIP

Questions?