

Hernando de Soto

EMERGENCY RESPONSE



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Rope Access



Rope in
Action



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Michael Baker

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Rope Access



Rope in
Action

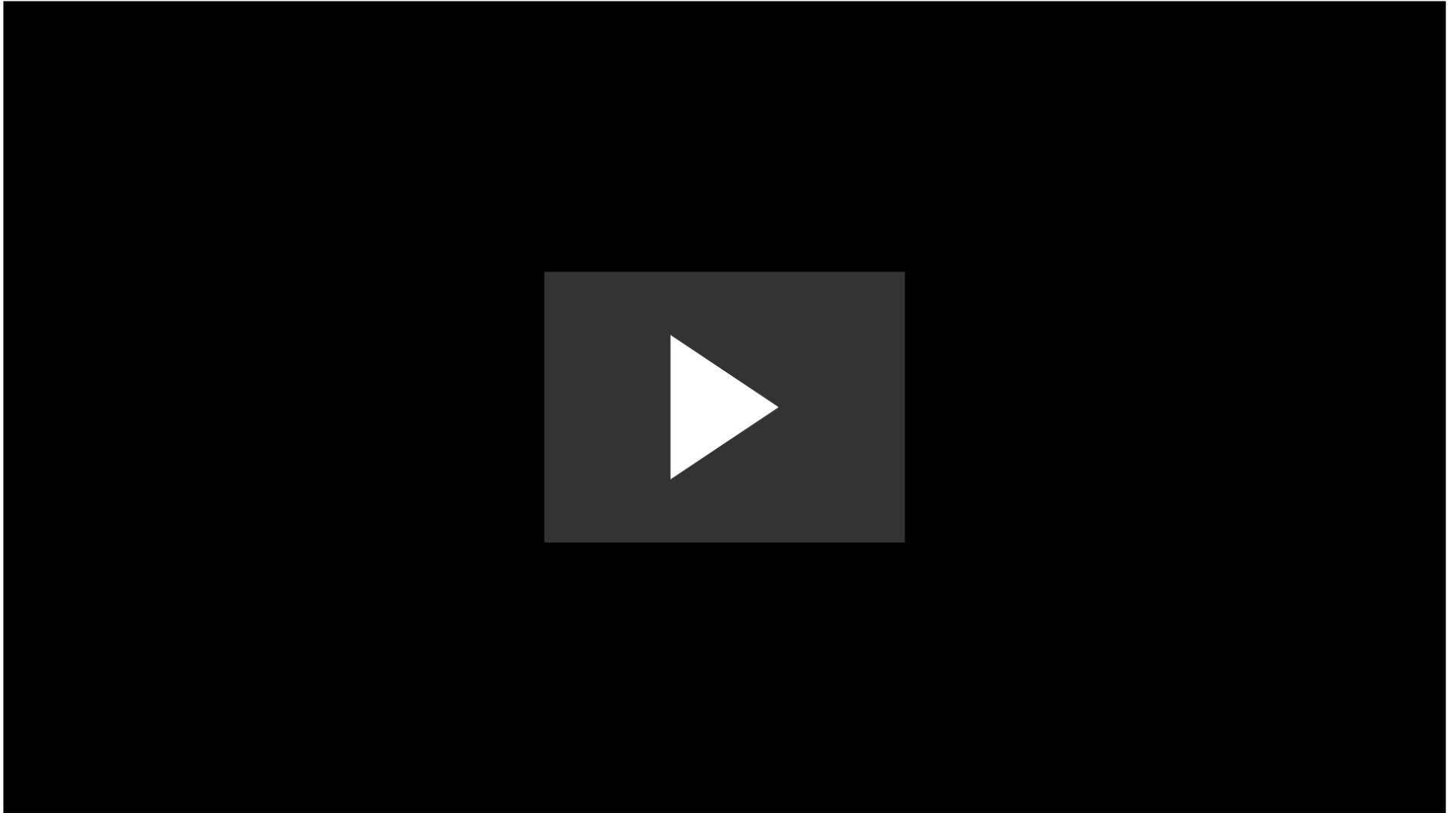


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Rope Access



Rope in
Action



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EMERGENCY RESPONSE



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UAS
Collection
Process

UAS
Team

2019
&
2021

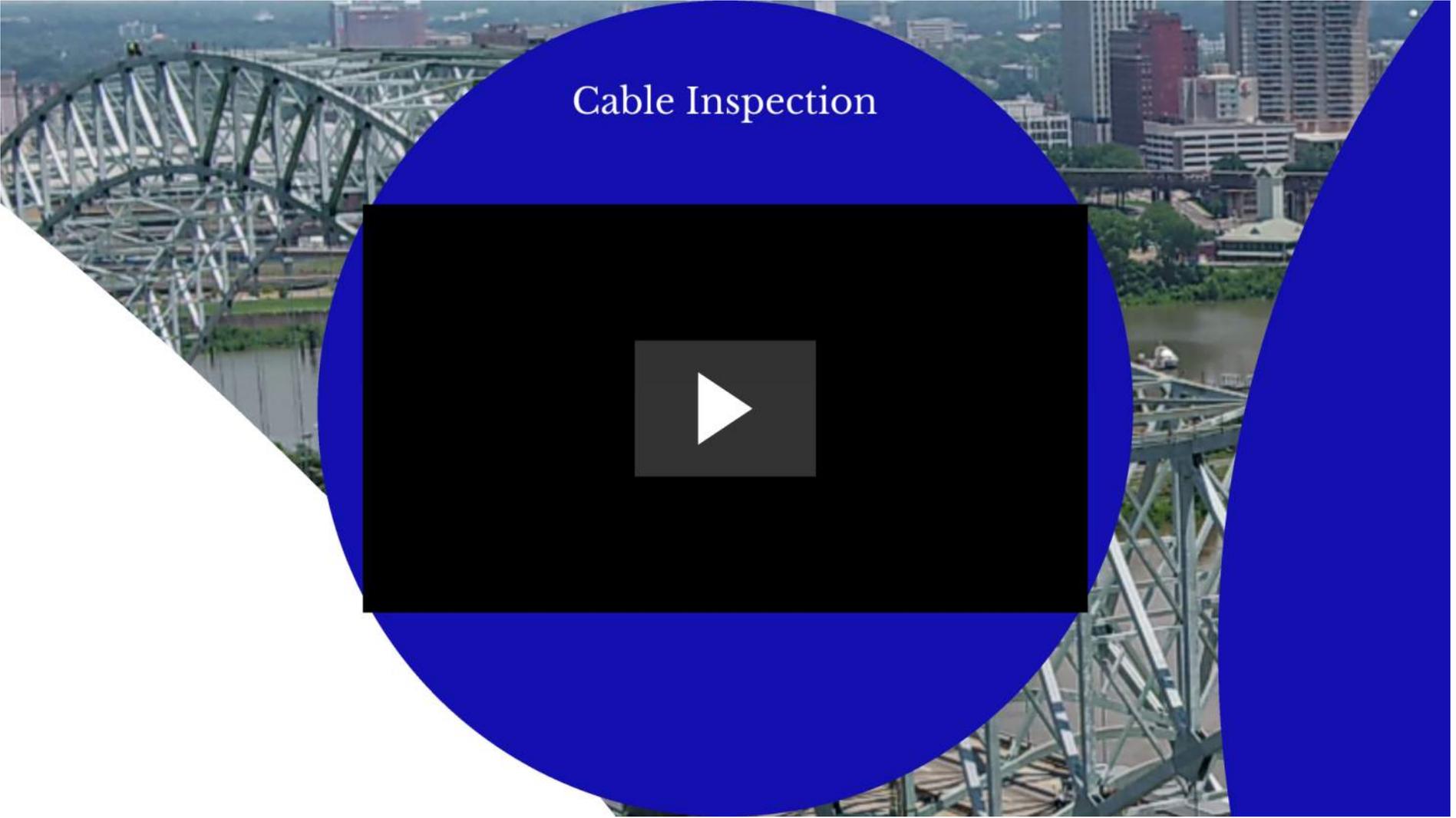
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Typical Techniques

Example
Collection
Video



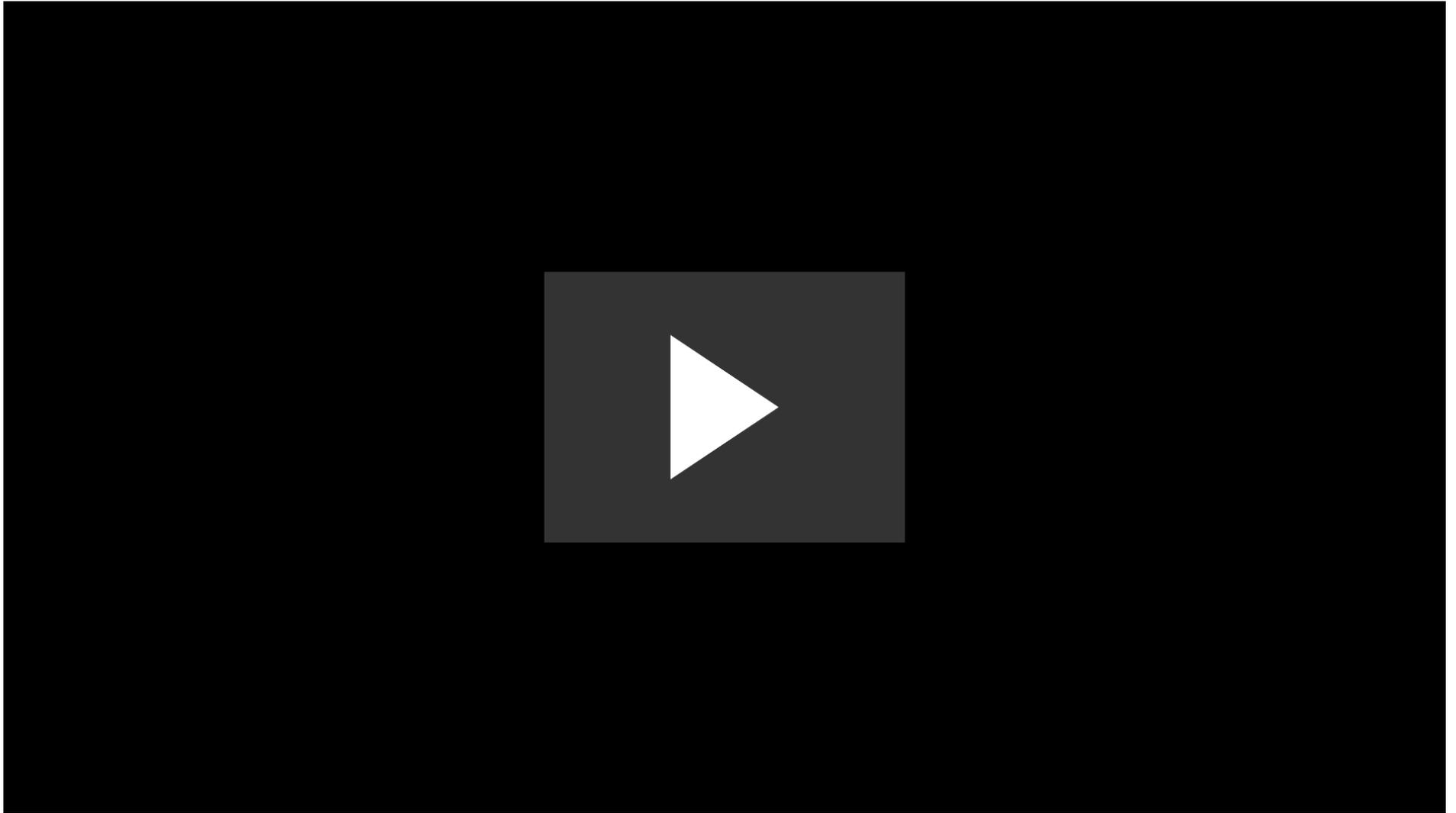
Above-deck



Cable Inspection

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Typical Techniques

Example
Collection
Video



Above-deck

Above-deck Operations



Typical Techniques

Example
Collection
Video



Above-deck



UAS
Collection
Process

UAS
Team

2019
&
2021

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UAS Team Operations





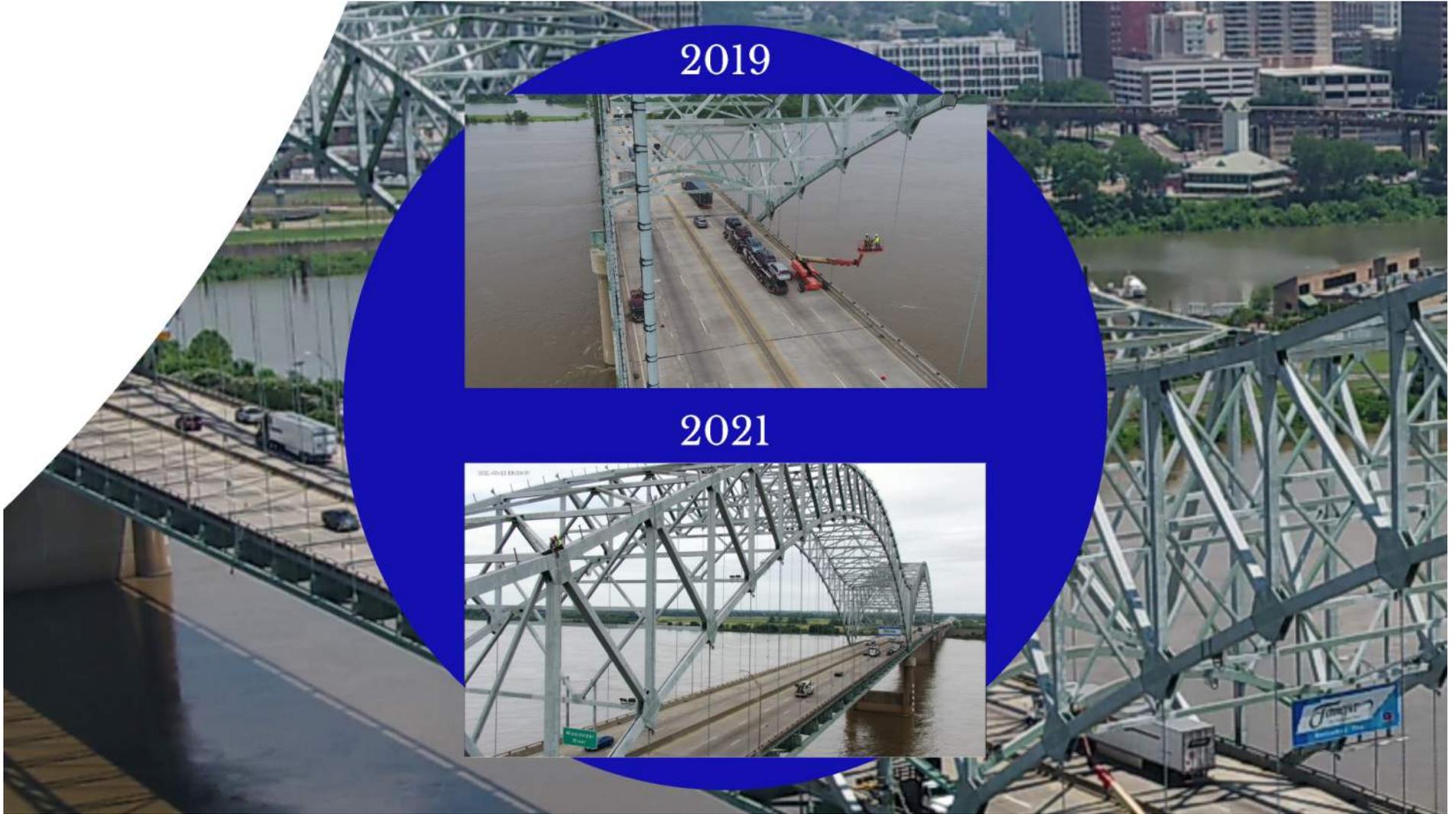
UAS
Collection
Process

UAS
Team

2019
&
2021

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2019

2021

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UAS
Collection
Process

UAS
Team

2019
&
2021

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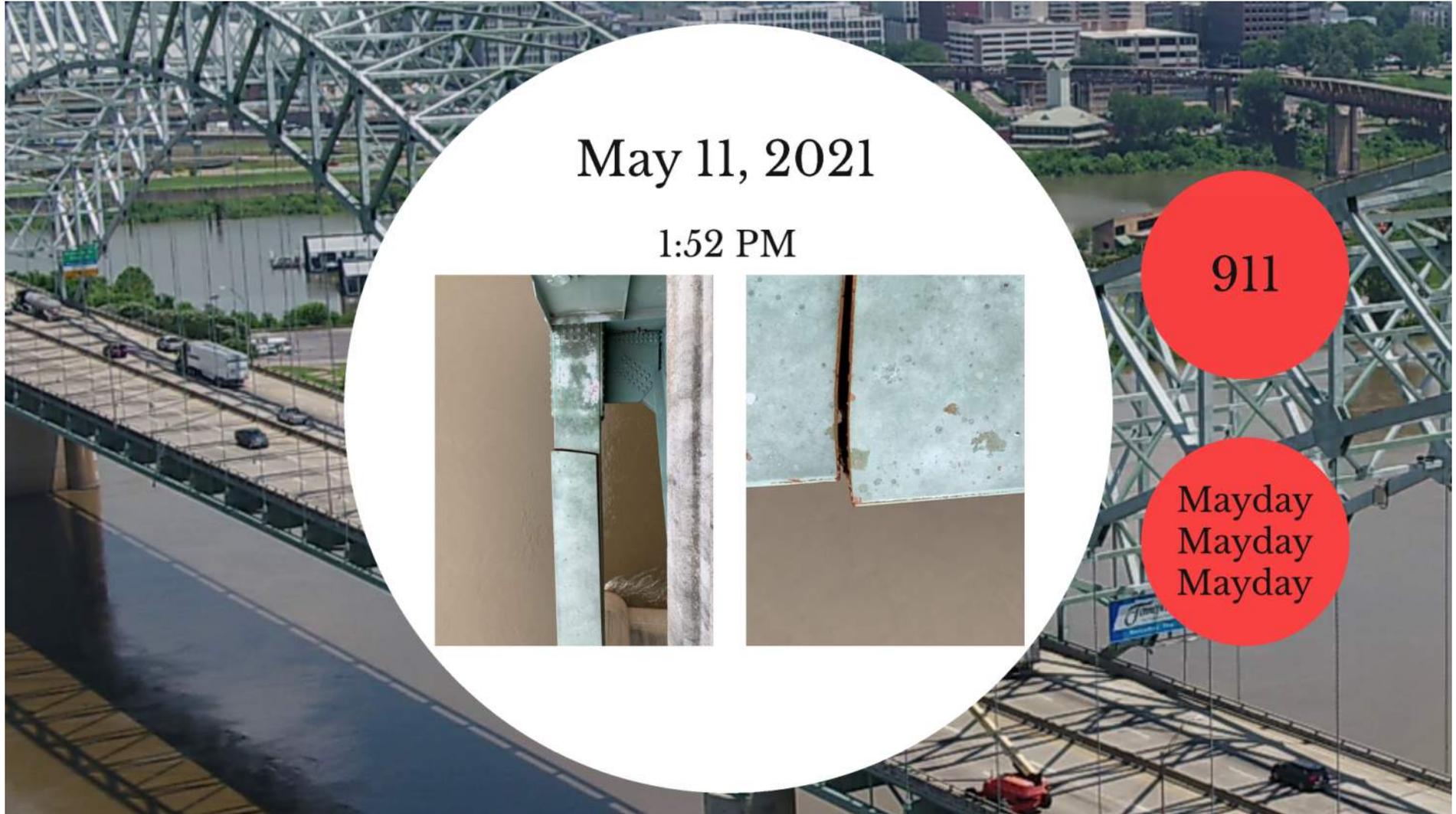
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EMERGENCY RESPONSE



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May 11, 2021

1:52 PM



911

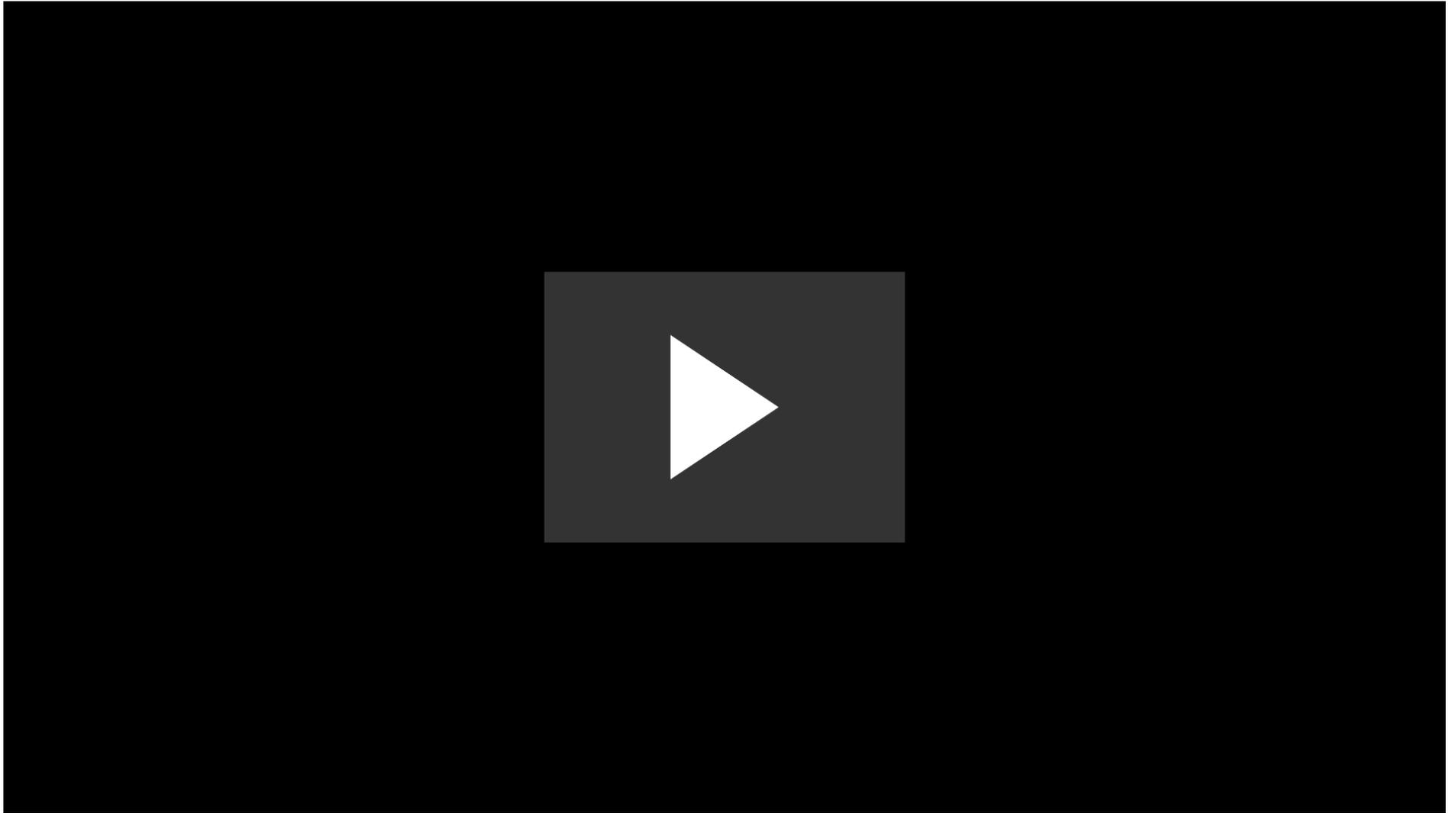
Mayday
Mayday
Mayday

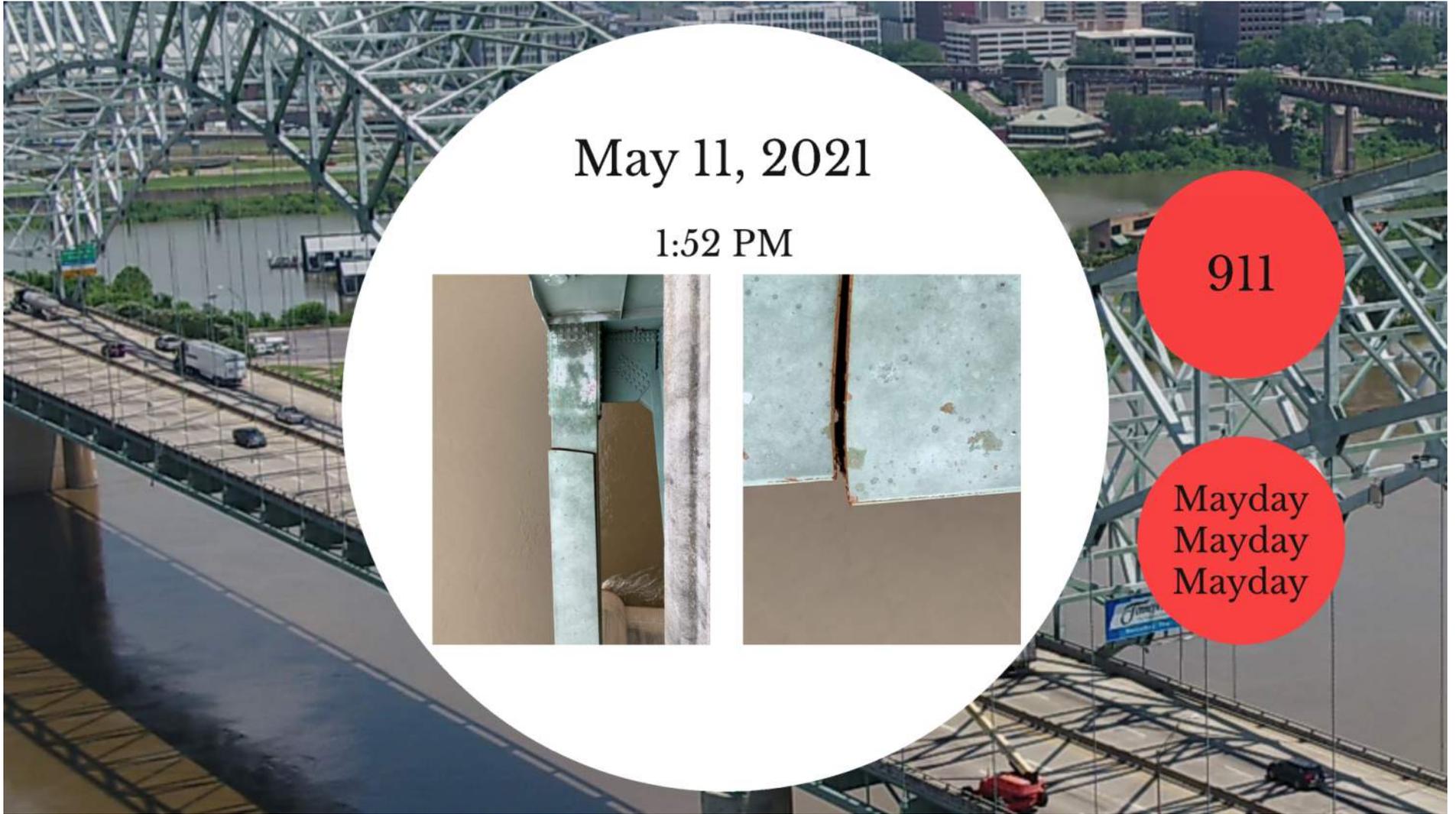
Michael Baker

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Michael Baker
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May 11, 2021

1:52 PM



911

Mayday
Mayday
Mayday

Michael Baker

INTERNATIONAL



Michael Baker
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May 11, 2021

1:52 PM



911

Mayday
Mayday
Mayday

Michael Baker

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1:52pm - 2:16pm



Roadway
Closure

Mobilization
for
Monitoring

River
Closure

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Tennessee



Arkansas

1:52pm - 2:16pm



Roadway
Closure

Mobilization
for
Monitoring

River
Closure

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U.S. barges backup as Mississippi River closed near Memphis

Robert Besser
18th May 2021, 17:27 GMT+10



MEMPHIS, Tennessee: Some 770 barges on the lower Mississippi River have backed up due to a damaged bridge near Memphis, which has closed the waterway.

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1:52pm - 2:16pm



Roadway
Closure

Mobilization
for
Monitoring

River
Closure

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1:52pm - 2:16pm



Roadway
Closure

Mobilization
for
Monitoring

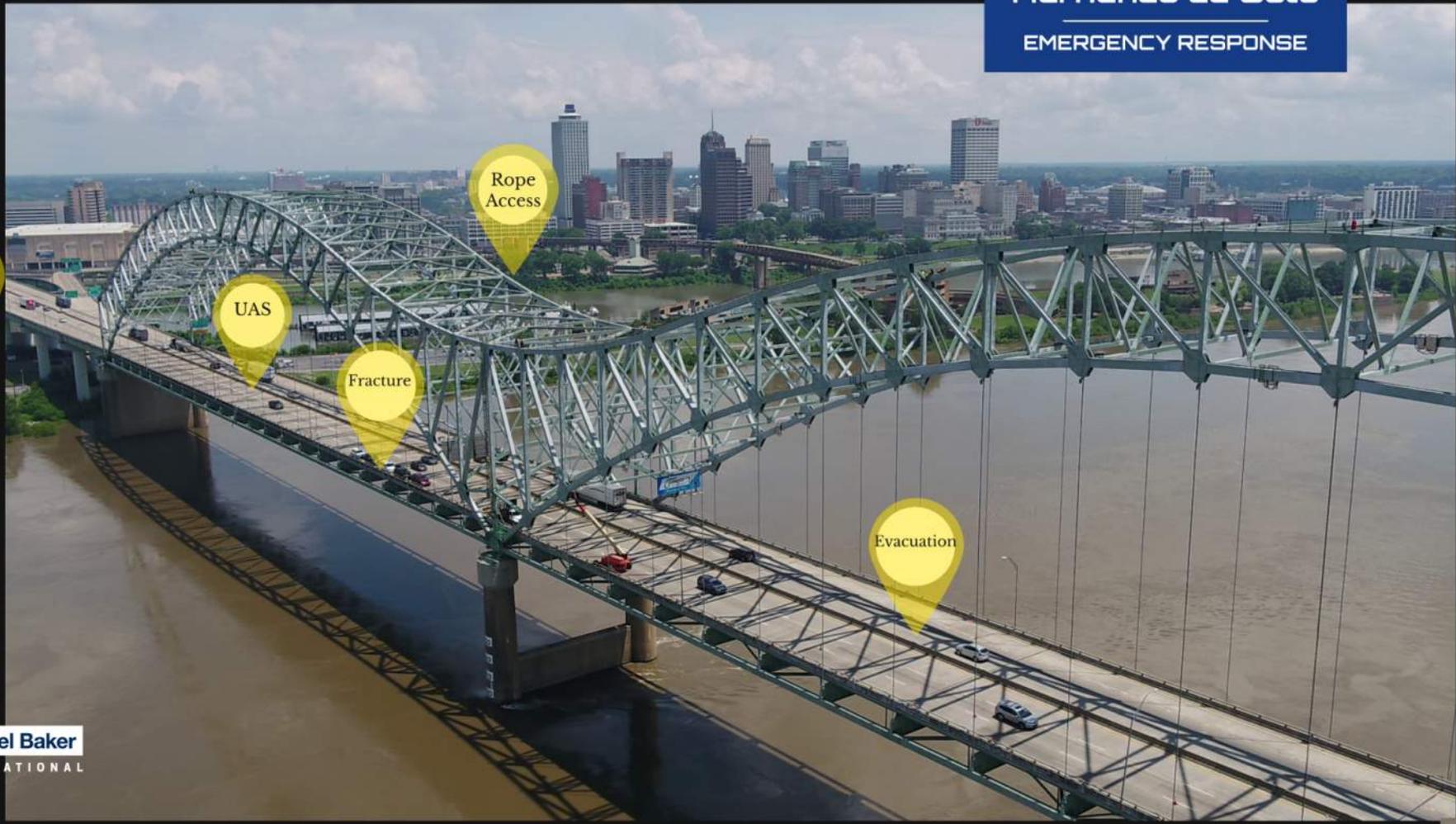
River
Closure

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EMERGENCY RESPONSE



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Monitoring

Post-Event

Live Stream



Mobile Command

Redeploy

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Monitoring

Post-Event

Live Stream



Mobile Command

Redeploy

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Initial
UAS
footage

Regular Monitoring

- Initial UAS monitoring with ARDOT hourly
- Day 2 - Day 5 am/pm checks

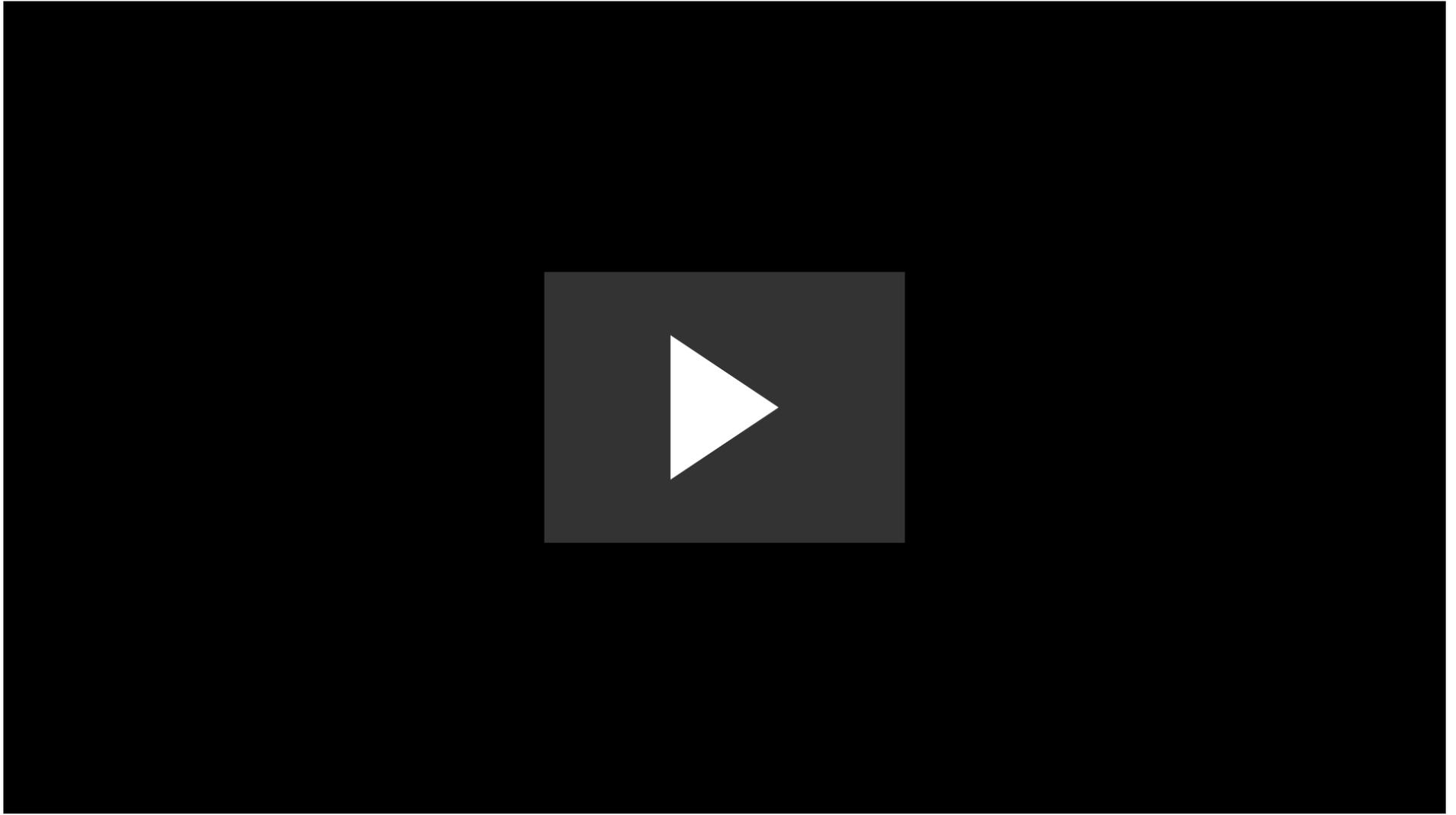


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Initial
UAS
footage

Regular Monitoring

- Initial UAS monitoring with ARDOT hourly
- Day 2 - Day 5 am/pm checks



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Monitoring

Post-Event

Live Stream



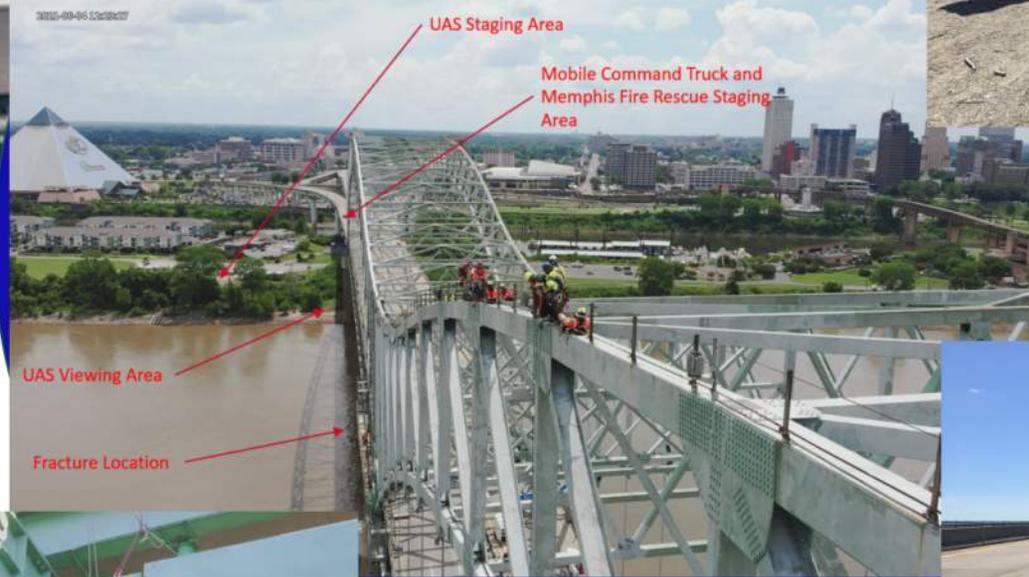
Mobile Command

Redeploy

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Inspection and UAS Live Stream Coordination

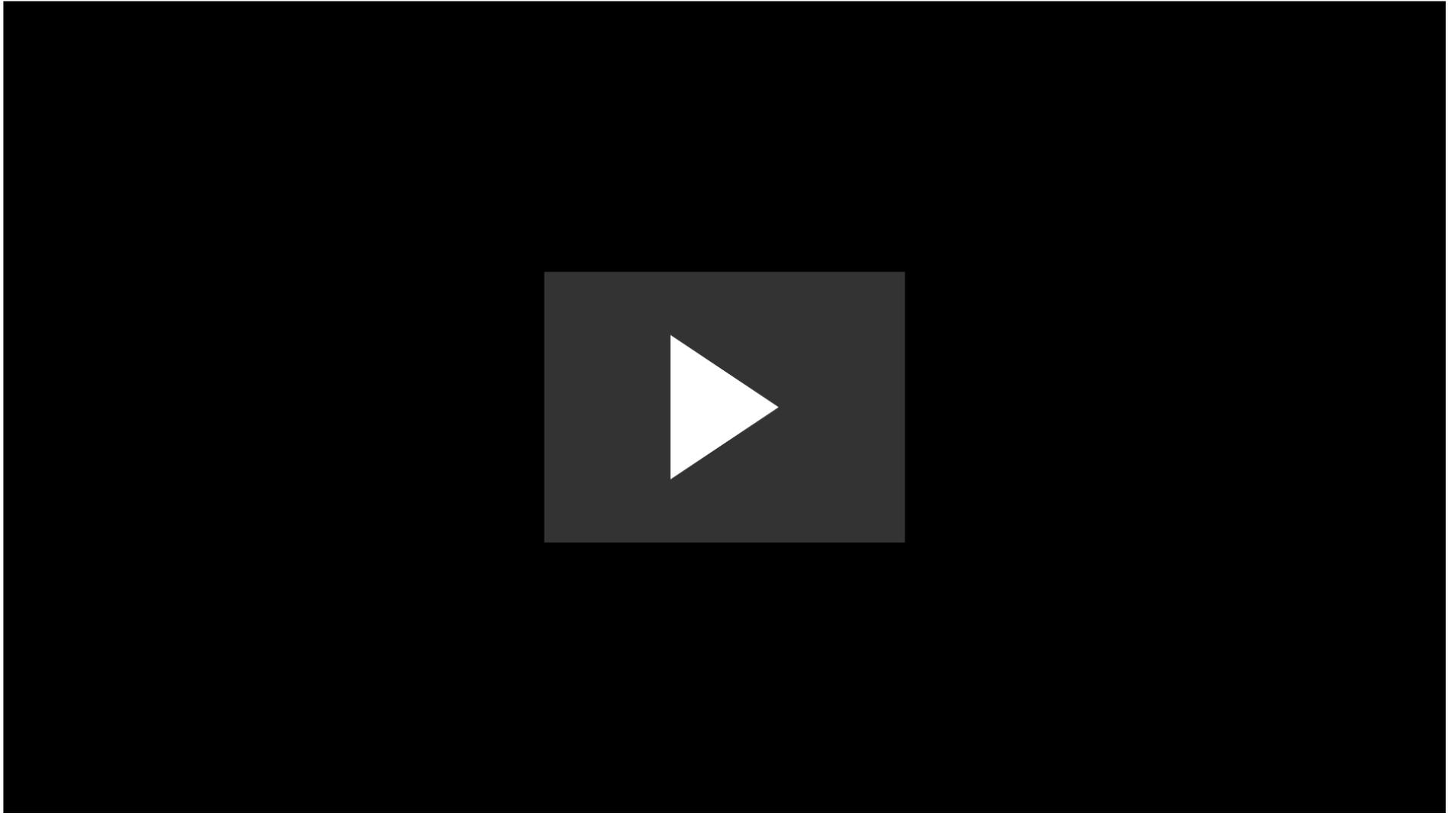


Live Stream Video

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Inspection and UAS Live Stream Coordination



Live Stream Video

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Monitoring

Post-Event

Live Stream



Mobile Command

Redeploy

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Secretary of
Transportation
Visit



Design
Work

Michael Baker
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Michael Baker
INTERNATIONAL

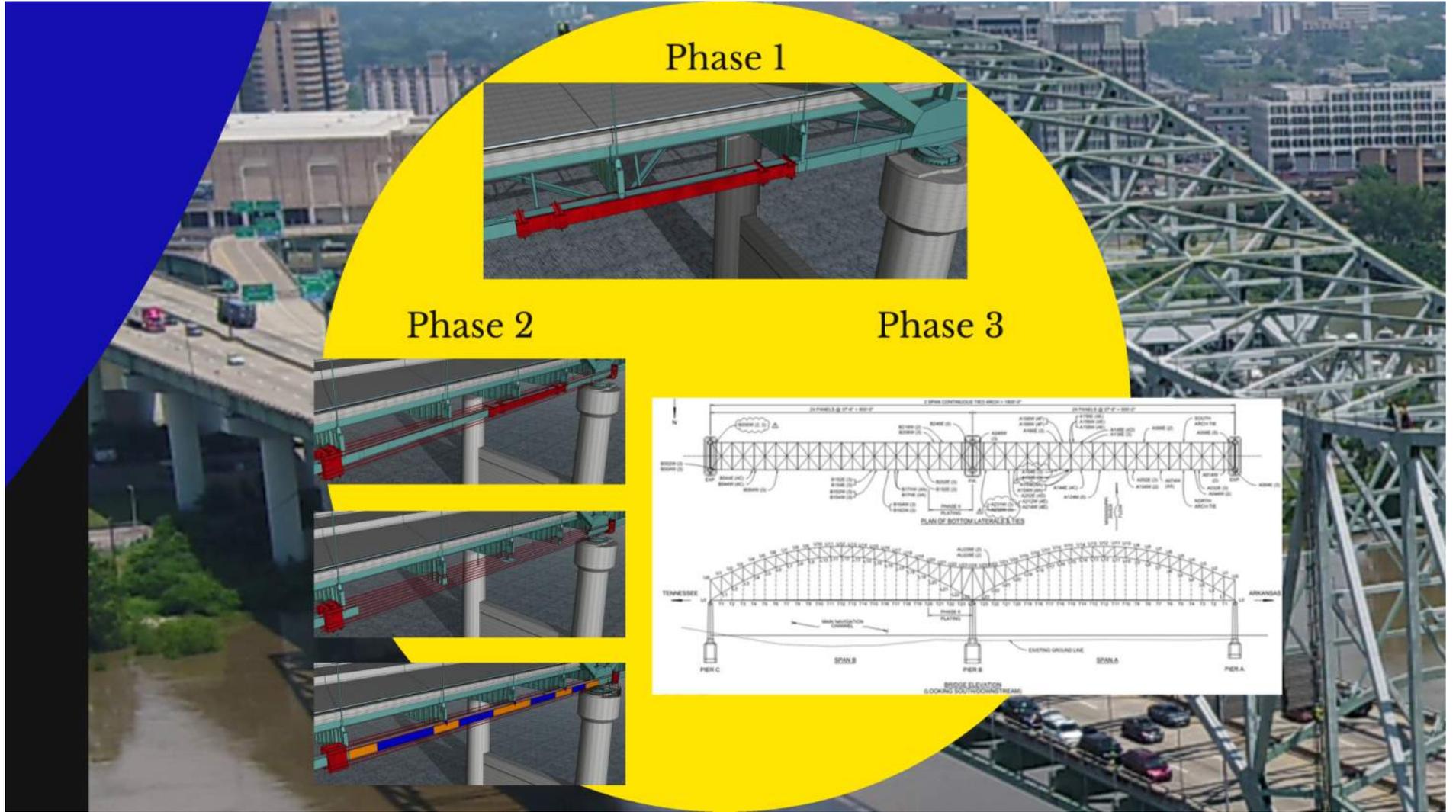


Secretary of
Transportation
Visit



Design
Work

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Visit



Design
Work

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Monitoring

Post-Event

Live Stream



Mobile Command

Redeploy

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EMERGENCY RESPONSE



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I-40 Hernando de Soto Emergency Repair

Critical Actions for a Critical Find

ABCD Central

January 24, 2022

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We Make a Difference



And so the story begins...

Tuesday May 11th, 2021



Agenda

- Immediate Response
- Modeling and Analysis
- Three Phase Approach
 - Phase I – Stability of Structure
 - Phase II – Long Term Repair of Fracture
 - Phase III – Re-Opening to Traffic
- Lessons Learned



Bridge History

- Hernando de Soto
- Constructed 1967-1973
 - Opened August 2, 1973
- Two Span Continuous Tied Arch Bridge
 - 2 – 900ft spans
 - 109ft above the water
 - Designed by Hazlett and Erdall

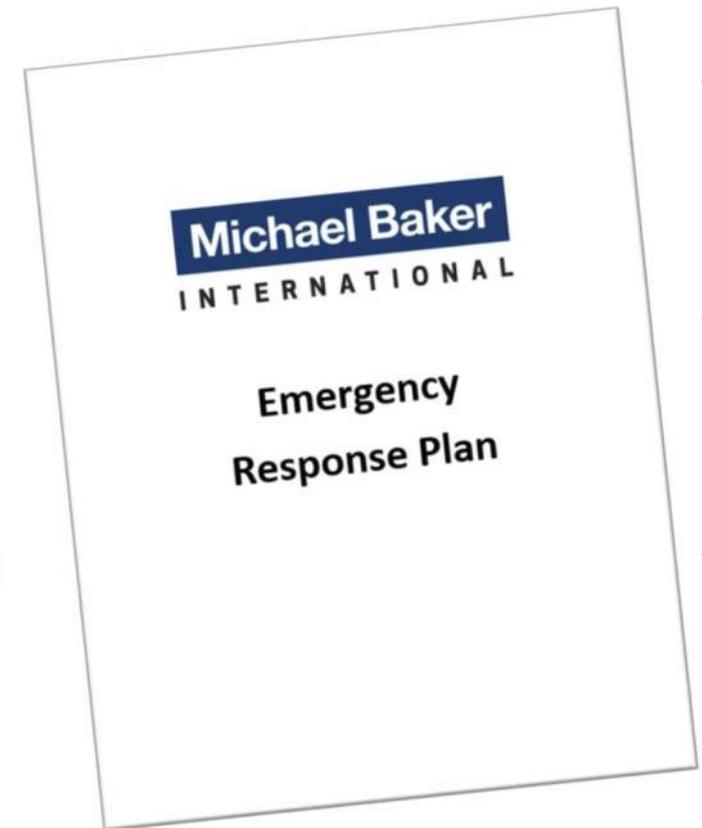


Regional Importance

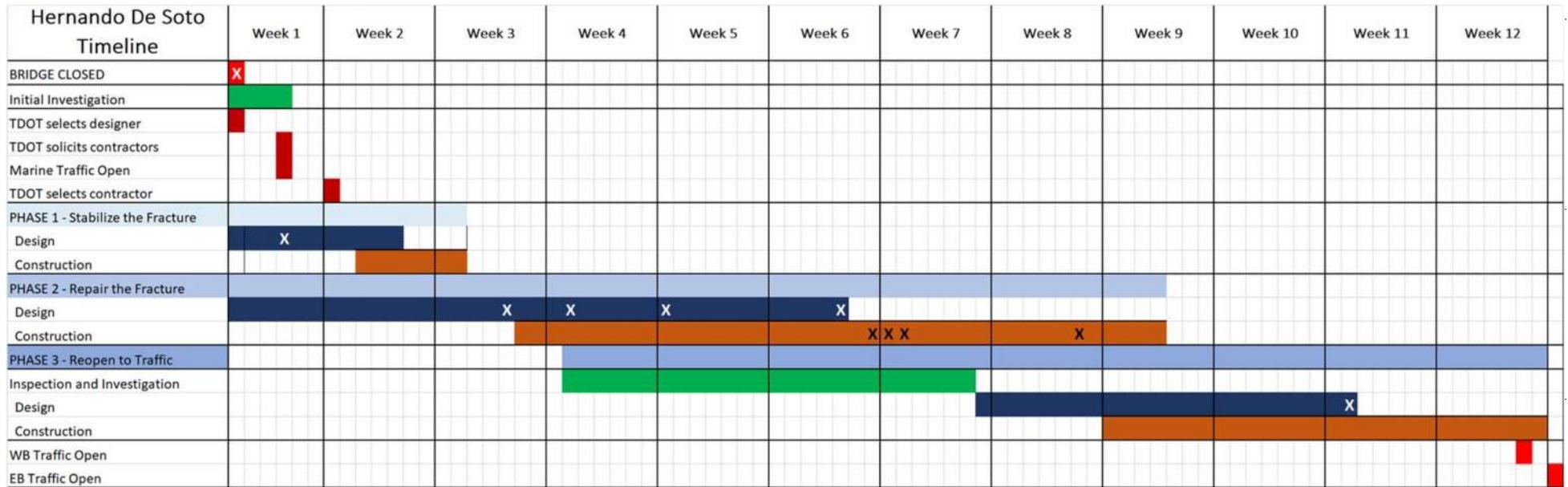


Critical Startup Activities

- **Gathering Data**
 - Bridge Plans, Shop Drawings, Inspection Reports, Models, Test Data...
- **Mobilize Engineering Staff and Teams**
 - Analysis team
 - Phase 1 Repairs
 - Phase 2 Repairs
- **Other activities**
 - Project Management
 - Communication / Meetings
 - BIM Modeling



Project Timeline



Closer Look at Fracture

- Condition
- Measurements



How Bad is it?

- T1 steel = 100 ksi (+)
 - P/A design = 38ksi
- Fracture 113 in² -> 51.5in² (**45%!**)
 - P/A after Fracture = 83ksi
- Eccentric Loading
 - Refined Analysis
- Unknowns
 - Actual force in the tie

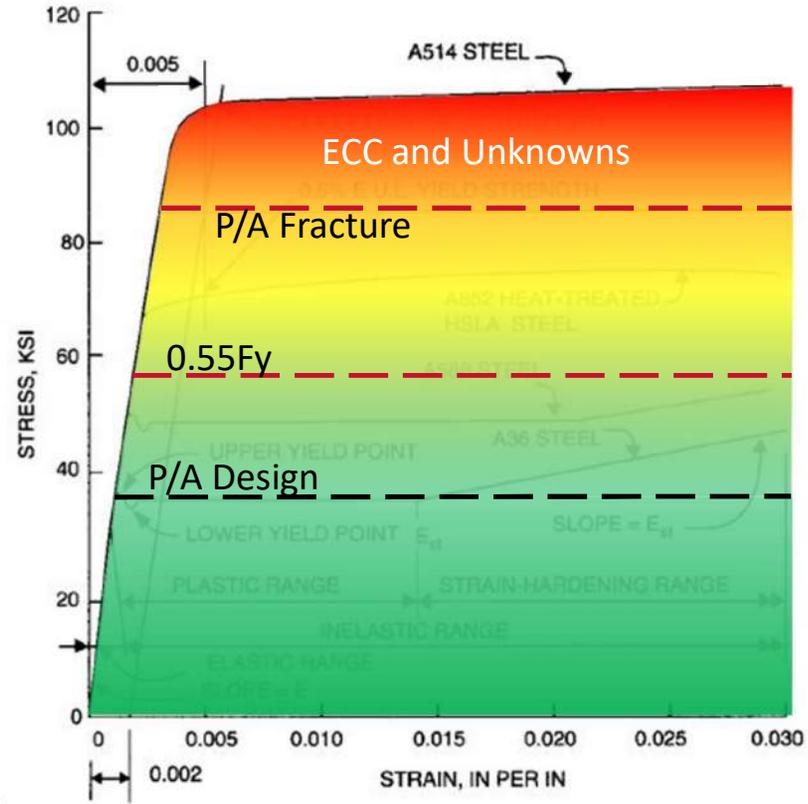
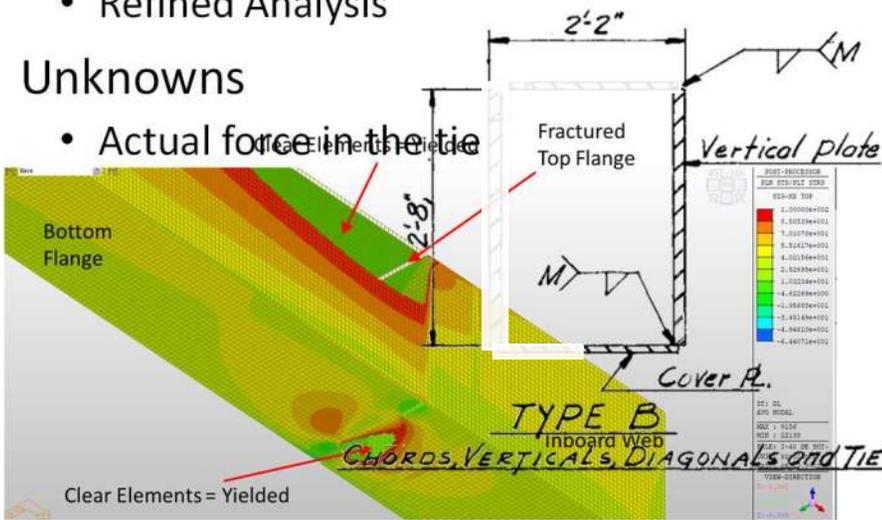


FIGURE 1.4 Partial stress-strain curves for structural steels strained through the plastic region into the strain-hardening range. (From R. L. Brockenbrough and B. G. Johnston, *USS Steel Design Manual*, R. L. Brockenbrough & Associates, Inc., Pittsburgh, Pa., with permission.)



Model Development

2D FE Model

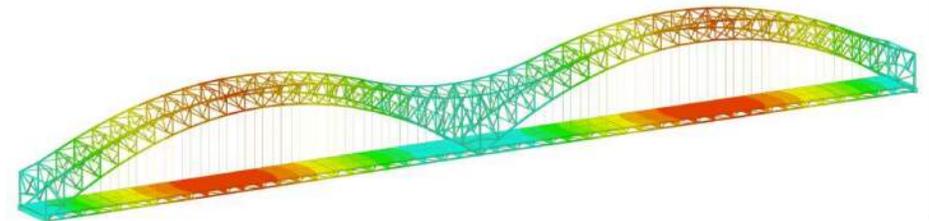
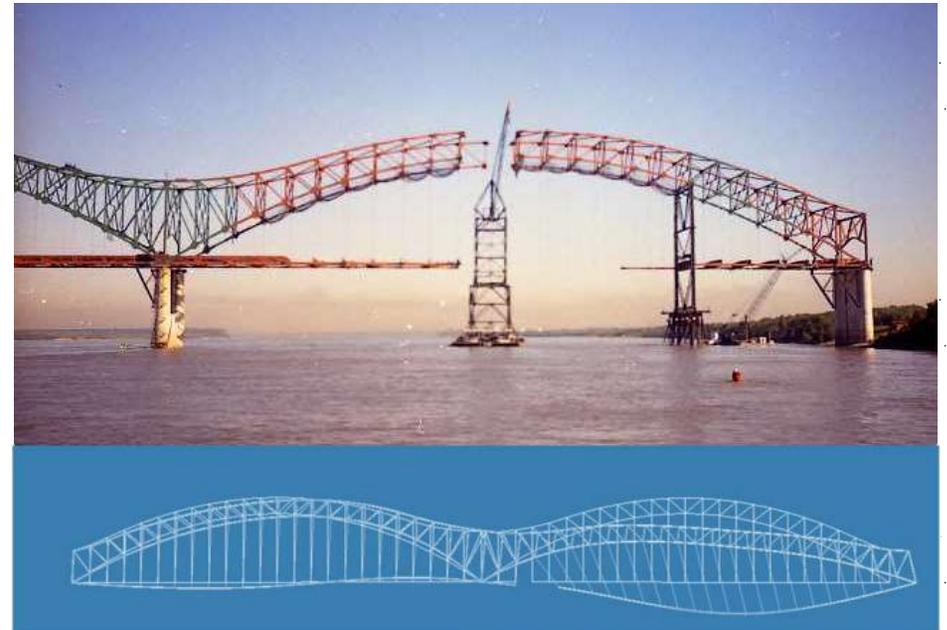
- Simple model – existing plan geometry

3D FE Model

- Adjusted for any design/shop drawing discrepancy
- Steel DL Calibration

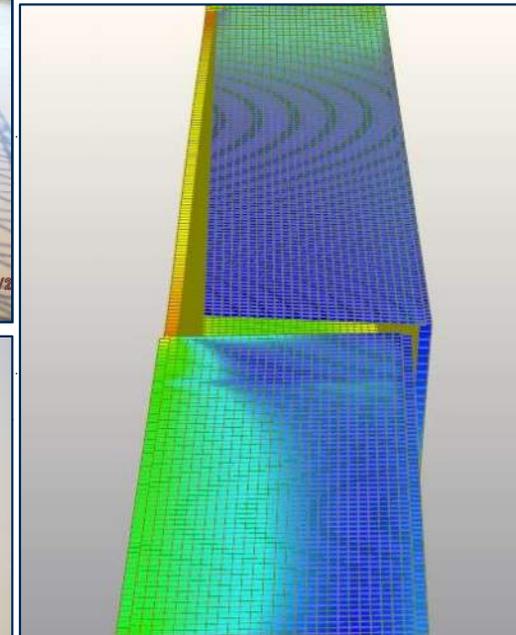
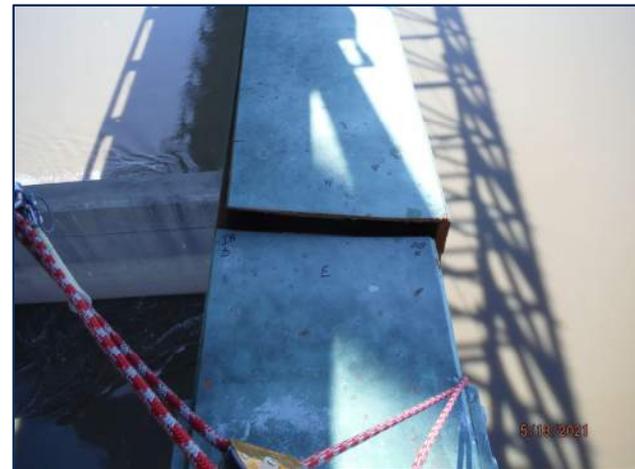
Where did the Load go?

- Investigate Alternate Load Paths
- Boundary Conditions
- Stiffness of the structure



Stability and Localized Yielding

- Yielding extent on remaining section
 - Over 50% of the section was lost
 - Is there any capacity left from the remaining area of the section?
- Retrofit operations
 - Overstress the tie
 - Effect of unbalanced PT forces
 - Effect of removals
- Non-linear Analysis
 - Geometric
 - Material
 - Incremental



Phase 1: Stabilize the Structure

How do you fix it?

- Tie w/ 4,300 kips +/-
- Displaced laterally and rotated
- Limited reserve capacity

And...

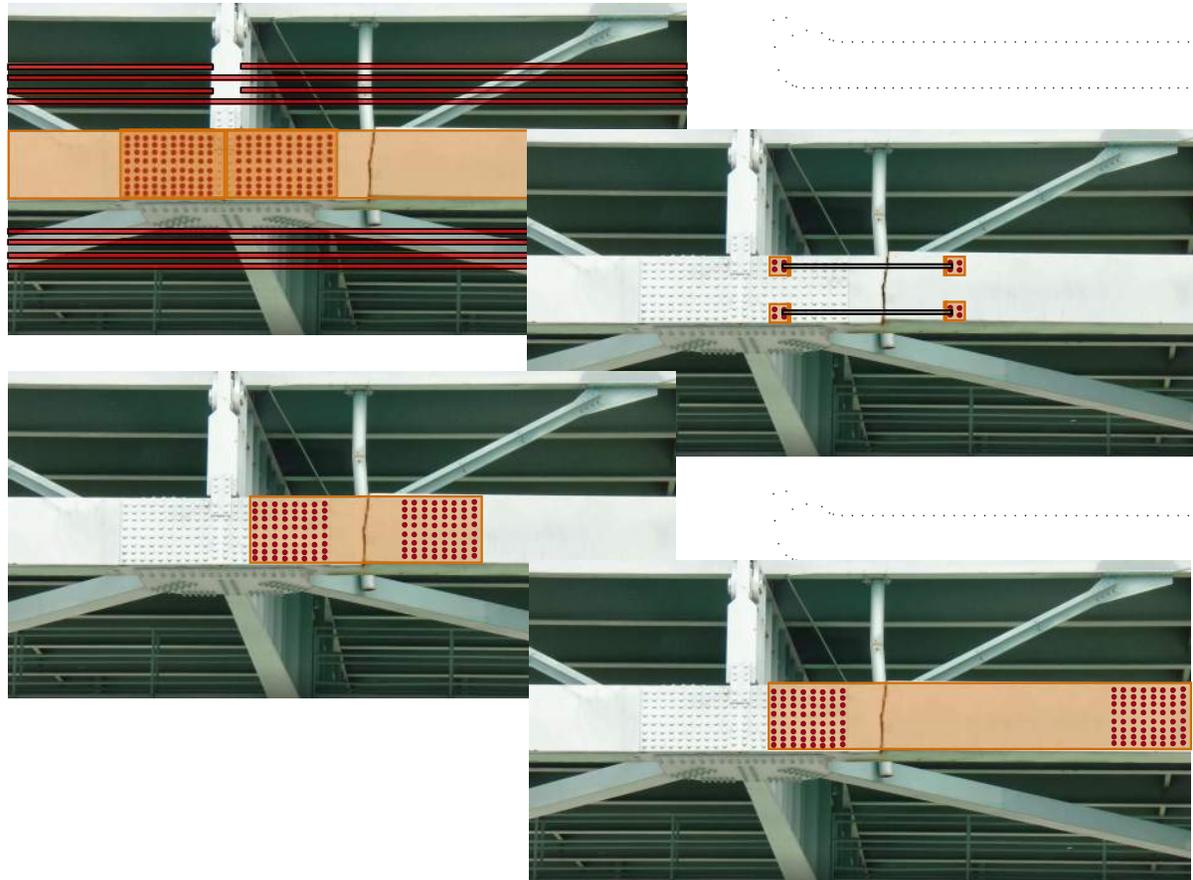
- **Time is of the Essence**



Phase 1: Stabilize the Structure

How do you fix it?

- Permanent Fix
 - *Duration too long*
- Shoring Towers
 - *Navigation / Duration*
- Temporary PT
 - *High Loads*
 - *Long lead time / fabrication*
- Adjacent Splice
 - *Distortion of the box*
- Lengthen Splice
 - *Showed promise*



Phase 1: Stabilize the Structure

Availability

- Initial contact with several fabricators looking for plate availability
- HPS 70W in stock and able to be used for the repairs
- 2+” Thickness? Length?
- You can't install what you can't get!

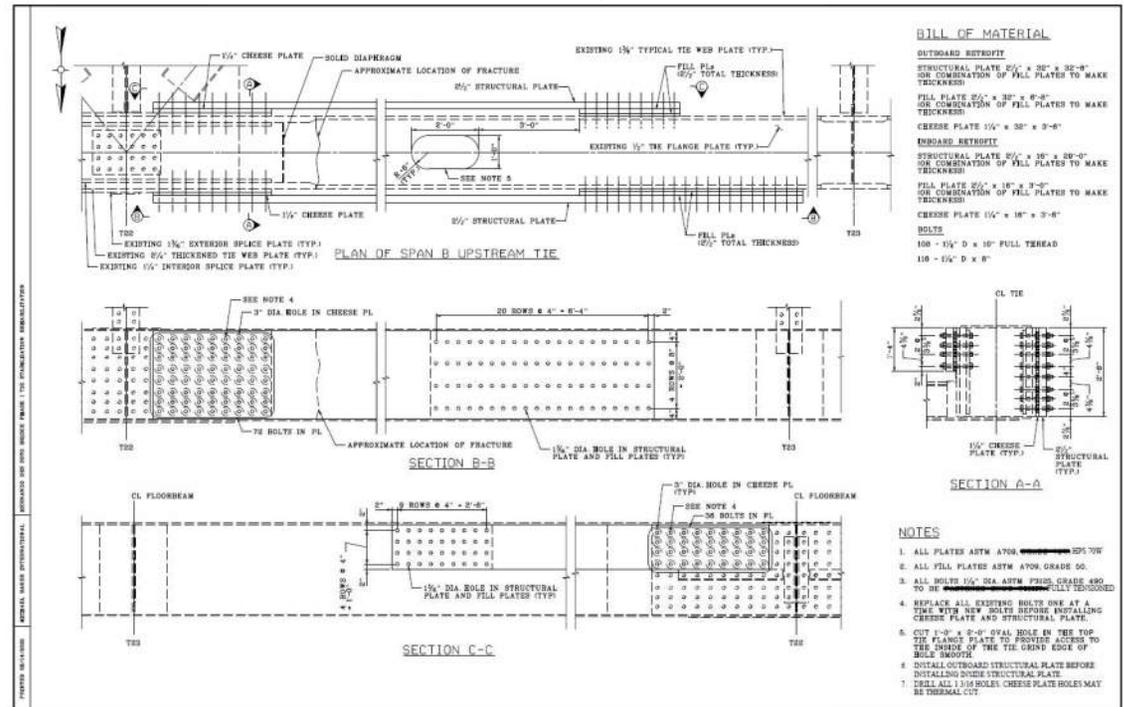


Stupp Bridge in Bowling Green, KY



Week 1 Timeline

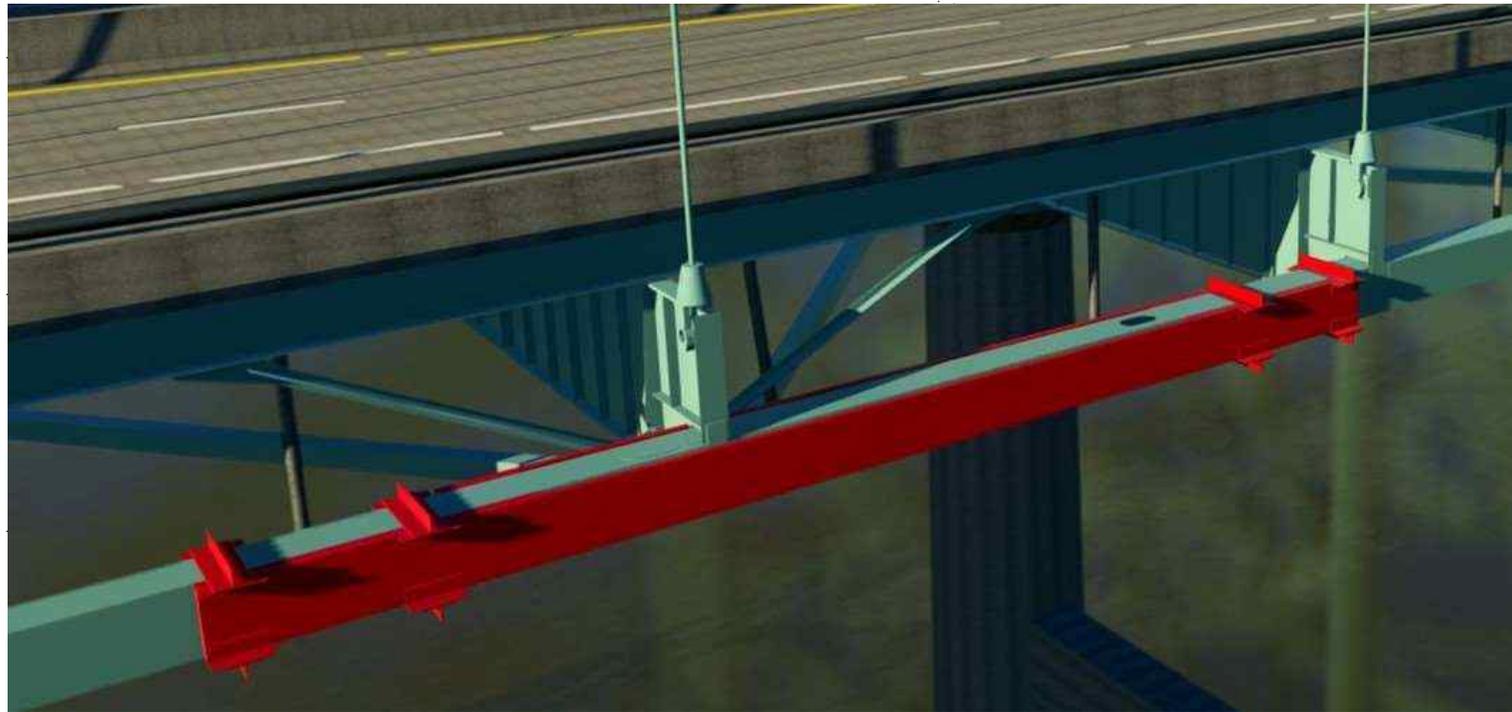
- 5/11 – Closure of Bridge
- 5/12 – Data Gathering, Model development
- 5/13 – Preliminary Analysis, Historical information, Navigation resumes
- **5/14 – Draft Plans Available, TDOT Advertises for CM/GC**
- 5/17 – Kiewit Selected as CM/GC



Phase 1: Stabilize the Structure

CM/GC

- Selected 5/17
- Contractor (Kiewit):
- **Reduce Risk...**
 - Add capacity
 - low impact operations (drilling not bolt removal)
 - No attempt to straighten the tie



Phase 1: Stabilize the Structure

Fabrication

- Design Completed 5/18
- Shop drawings created and approved 5/20
- Fabrication began 5/21
10 days after discovering the fracture
- TDOT maintenance picked up the steel 5/22



Phase 1: Stabilize the Structure

Construction

- Trucks came from west end of the bridge
- Used chain fall to move plates on Span 2 and into place
- No work barges or river access was used during the duration of the project
- Installation completed 5/25



Phase 1: Stabilize the Structure

Construction

- Outboard PL placed w/ 3" of fill plates
- Cut floorbeam web for inboard plate
- Anchored beyond the girder twist
- Stiffening T's added to account for Eccentric connection moment
 - Eccentric connections highly loaded would try to crush box
 - Thin cover plates attached with poor welds



Offset Plate to clear Fracture and Ex Splice.

Stiffening Brackets



Phase 2 Repair Design

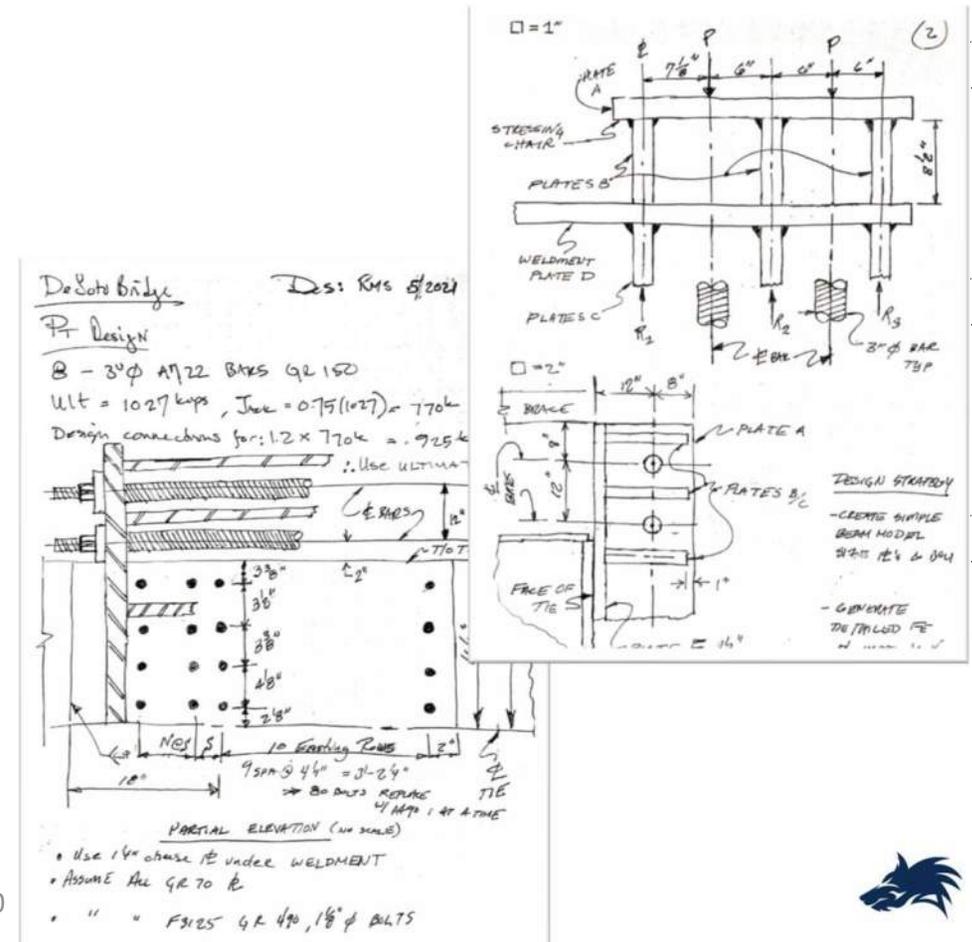
Initial Calc 8:44 PM on 5/11

Design Philosophy

- Preserve capacity of original tie
- How much post-tensioning ?
- How much of the gap do we need to close?
- Effects on Secondary Members?
- How effective will the Post-Tensioning actually be?

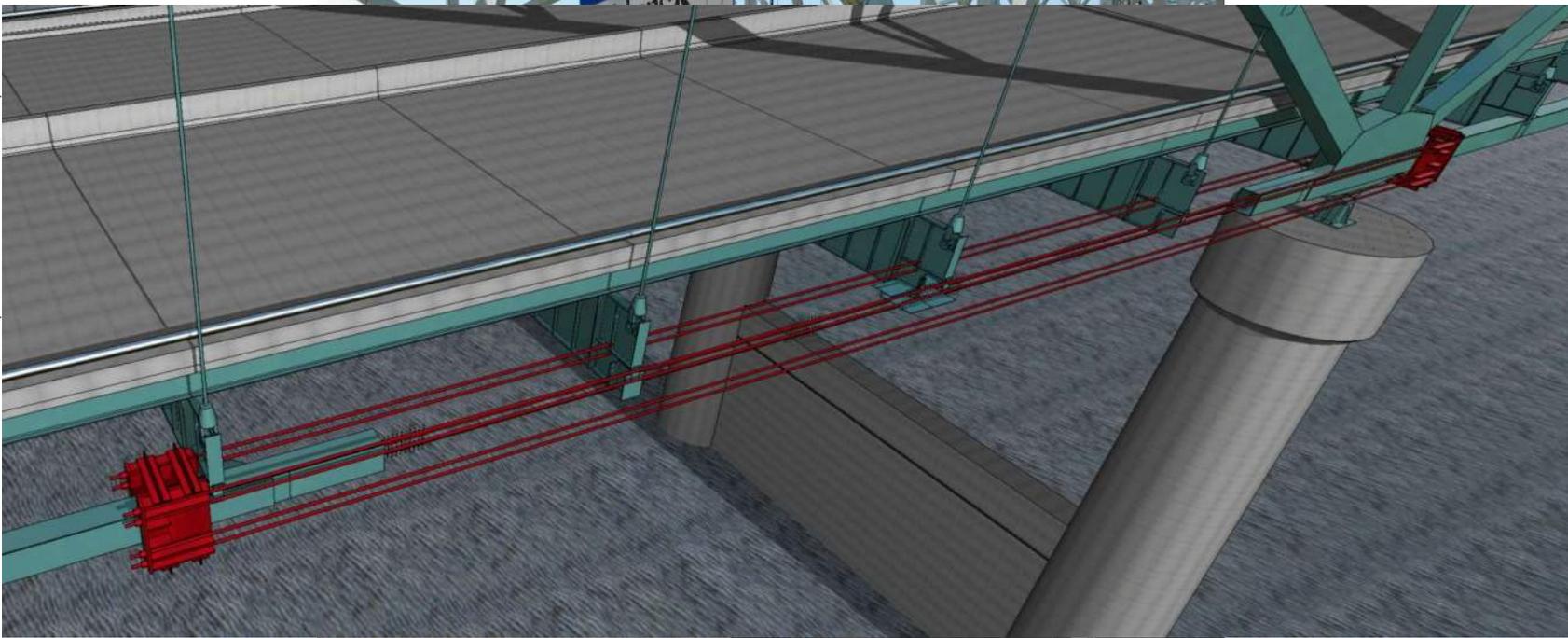
Multiple concepts considered

- Ultimately, load path to the tie girder dictated design



Tie Girder Complete Replacement

- Initial direction: completely remove the old/fractured tie
- End Result: Cut out Fracture and Plate back to connections



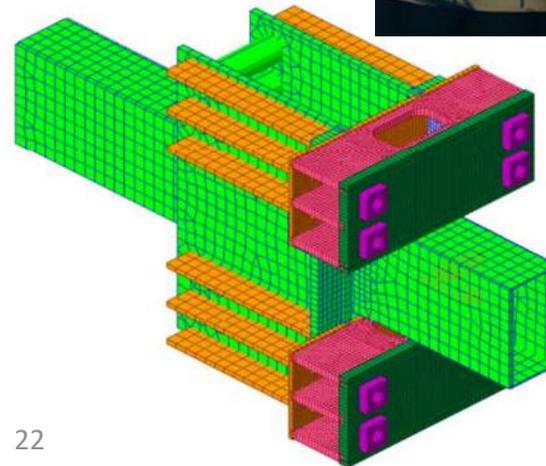
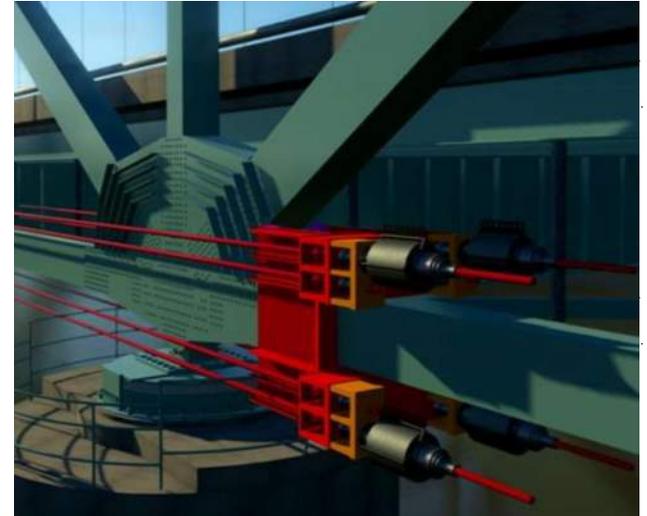
Post-Tensioning System Design

P/T System

- 8 - Cold-rolled 150 ksi 3" diameter PT bars
- Allowance for fitment/eccentric loads
- Staged PT
- Monitoring Plan including direct force measurement

Elastic / Self Reacting Anchorage

- Design by hand computations
- Checked/Verified with FE analysis

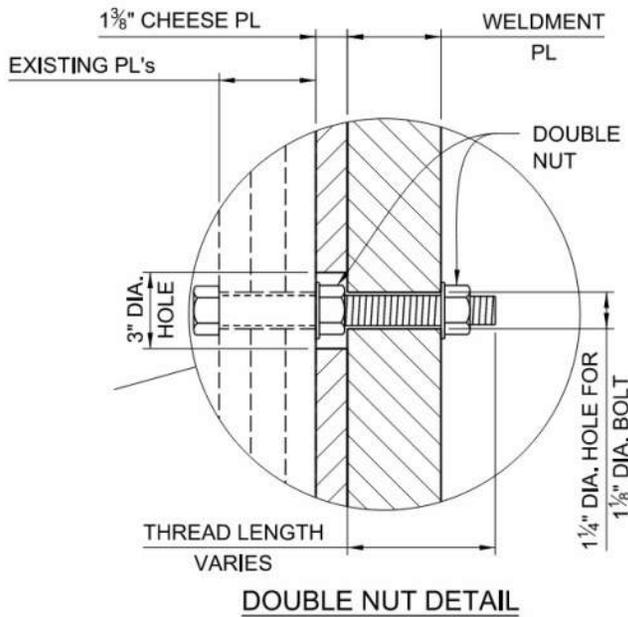


3D Model

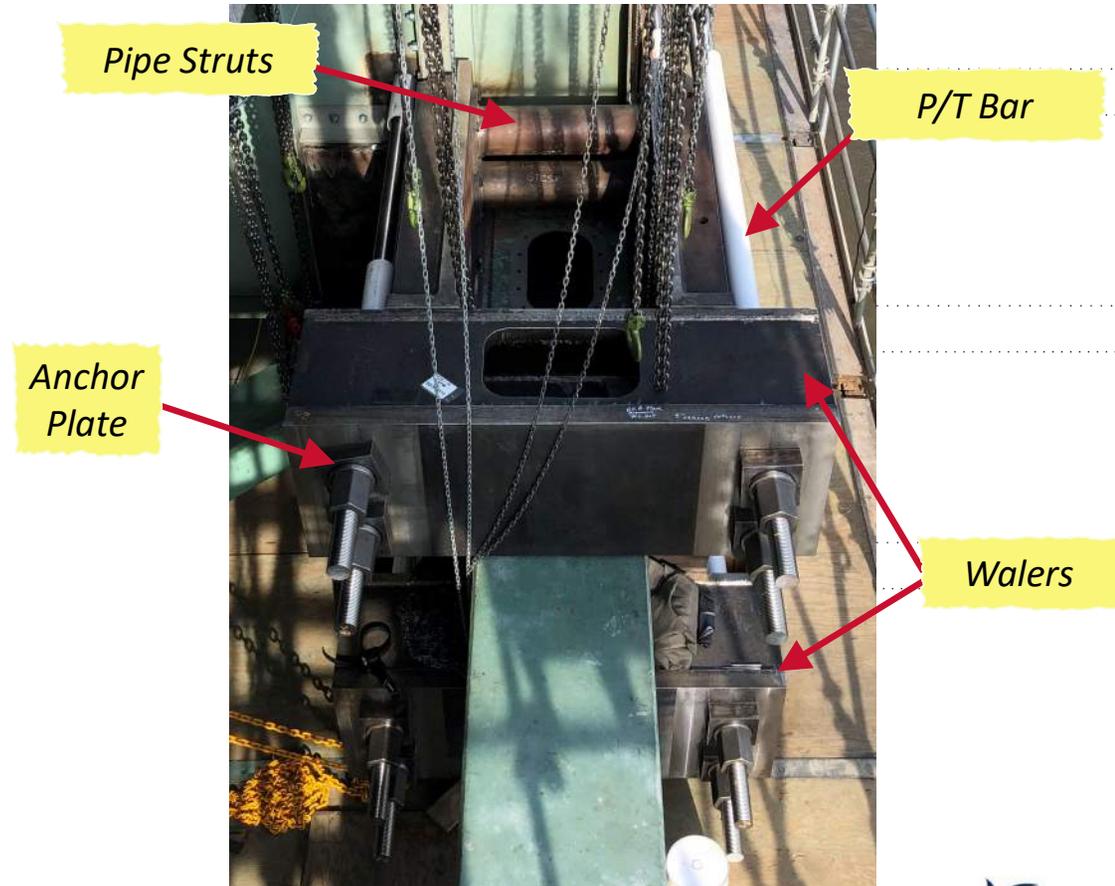
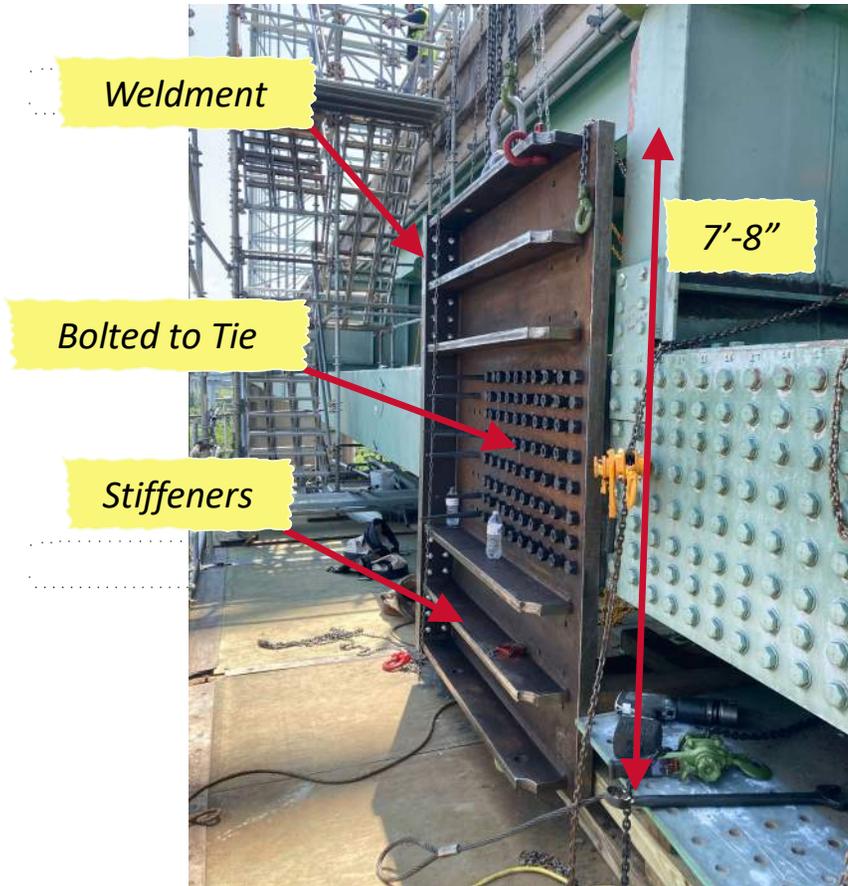
- Detailed Model used to find conflicts



Cheese Plate & Double Nut



Post Tensioning Anchorage



Stressing

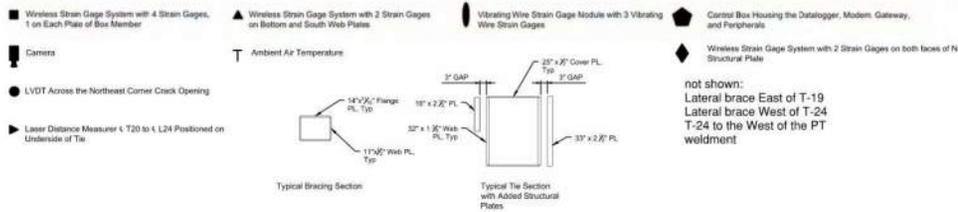


DSI Jacks



PT Monitoring

Strains Gages



Dyna Force Sensors



Removing the Fracture

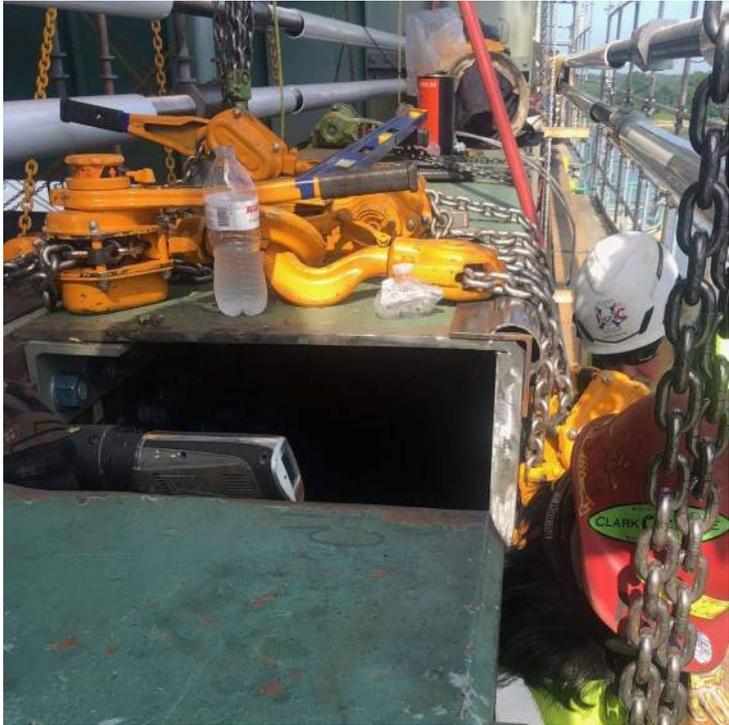
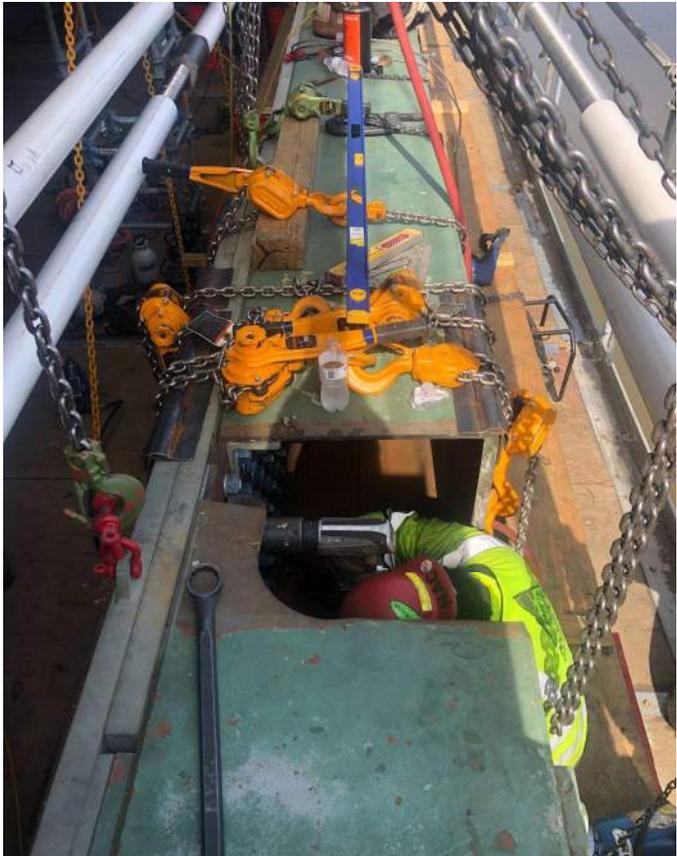


Phase 2 Plating

- Plating fabrication by W&W /AFCO in Little Rock, Arkansas
- 70 ksi material with A325 bolts
- Partial submittals / approvals for speed of fabrication
- Last Plate installed and torqued on Saturday, July 2nd



Squaring of the Box



Phase 2 Completion



Phase 3 – Inspection

- Full Penetration Butt Weld detail typical throughout structure
 - Potential for similar defects
 - Mitigate any potential concerns
- Arch Tie Members and Hanger Pins (Approx. 500 welds)
 - HNTB with CAN-USA (NDT)
- Arch Truss Members
 - MBI with Fickett (NDT)



NDT Inspection of Arch Tie Member

(HNTB Final Inspection and NDT Results Report)



Fracture Analysis

Figures obtained from WJE Fracture Investigation Report

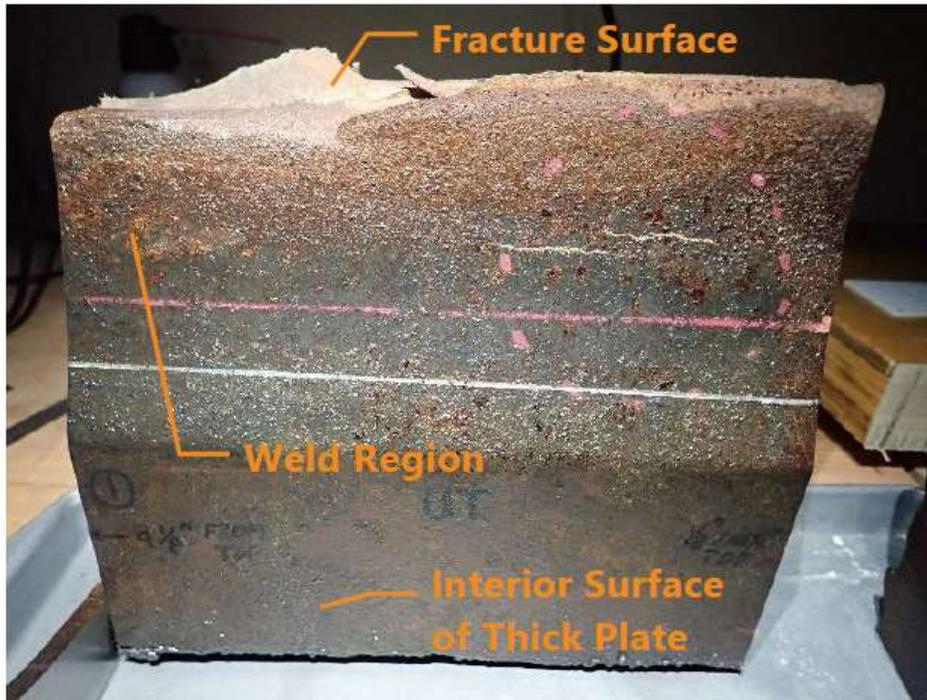


Figure 1. Sample under white light showing MT filings at crack locations.

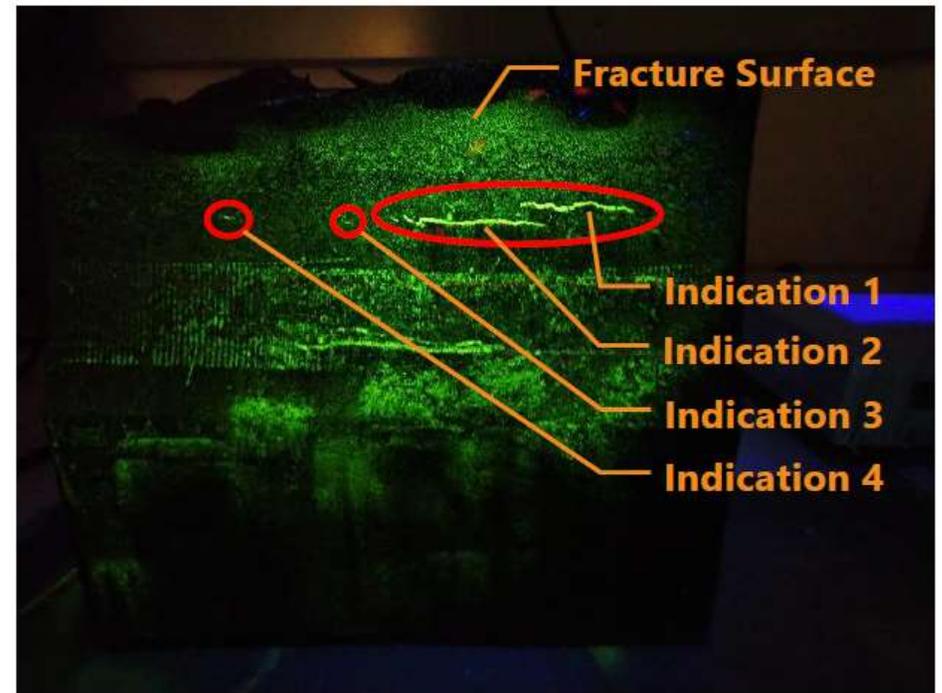
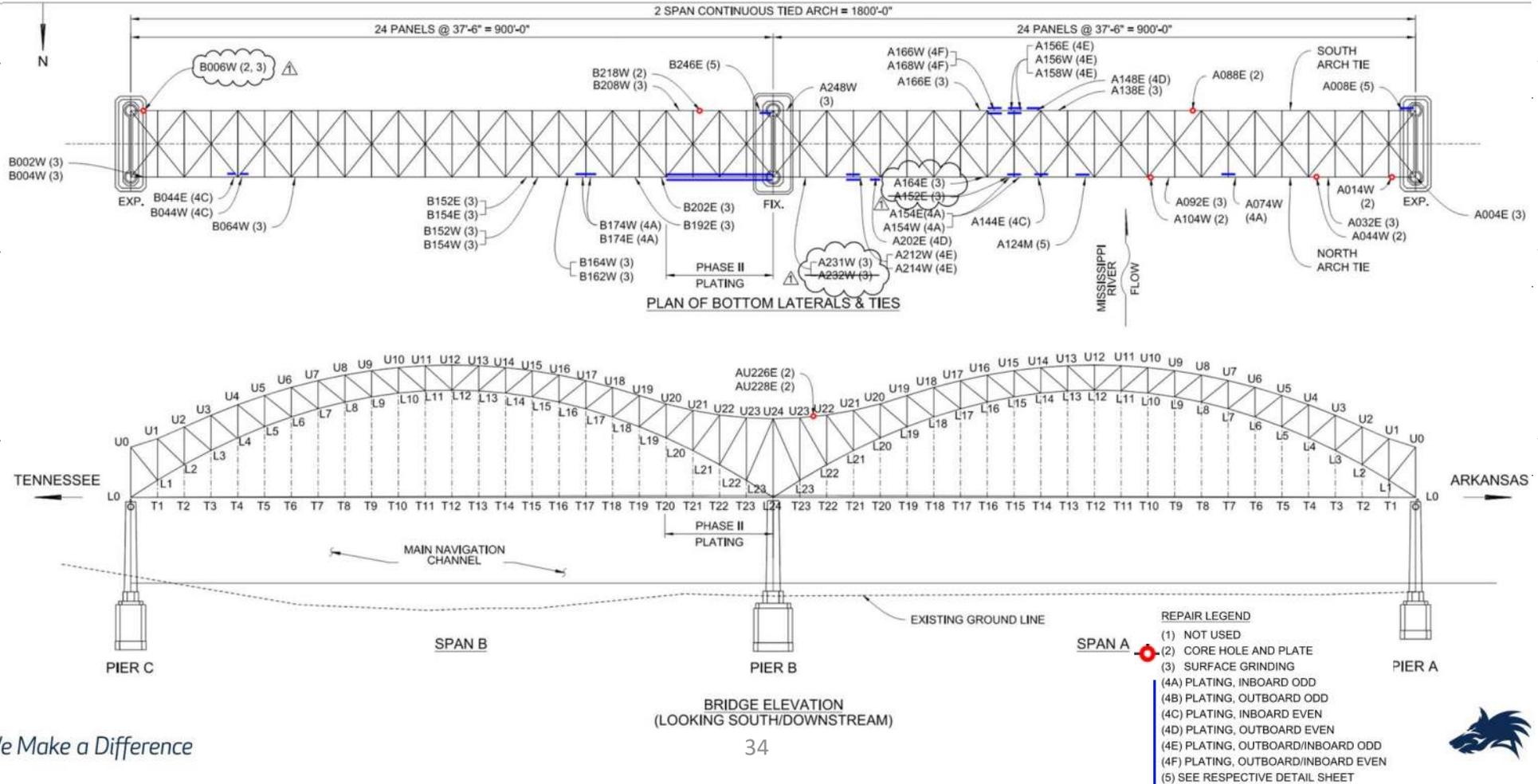


Figure 2. Sample under black light during wet fluorescent MT inspection with four MT indications (red circles)



Phase 3 – Repair Summary



Phase 3 – Fabrication



Phase 3 – Installation



Even Joint Plating



Phase 3 – Bridge Reopening



Fracture Analysis

Figures obtained from
WJE Fracture
Investigation Report

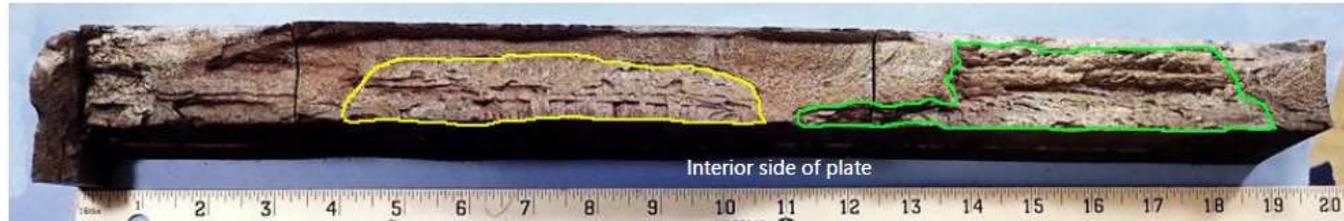


Figure 20. Lower portion of fracture showing Primary Preexisting Crack Region (yellow) and the Secondary Preexisting Crack Region (green).

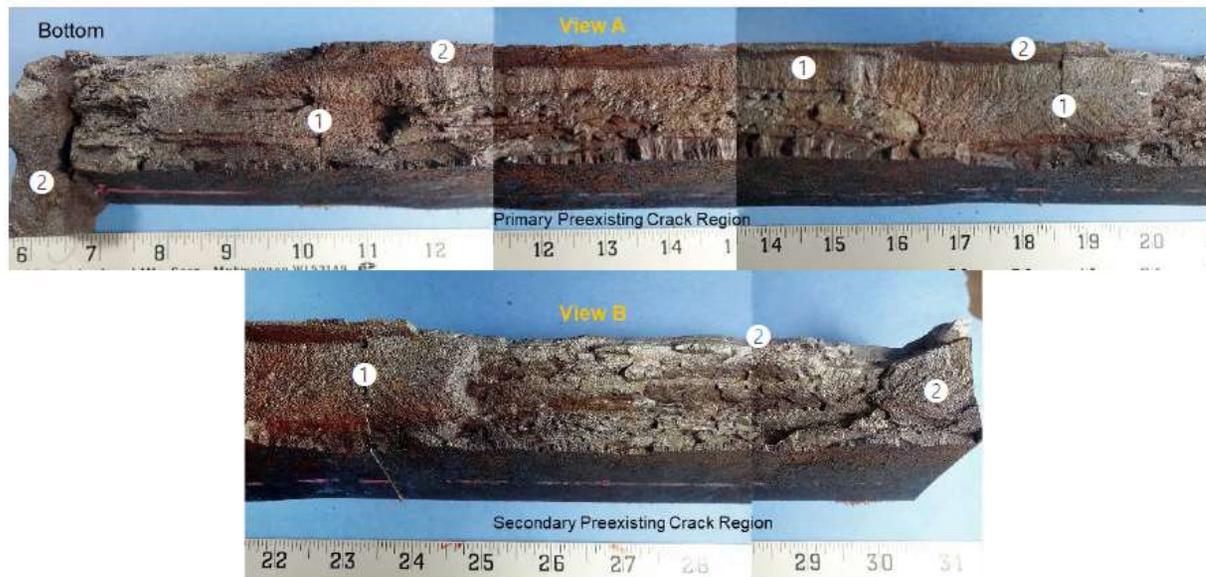


Figure 21. Higher magnification of the two preexisting crack regions after cleaning (1 first fracture and 2 second fracture).



Fracture Analysis

Figures obtained from WJE Fracture Investigation Report

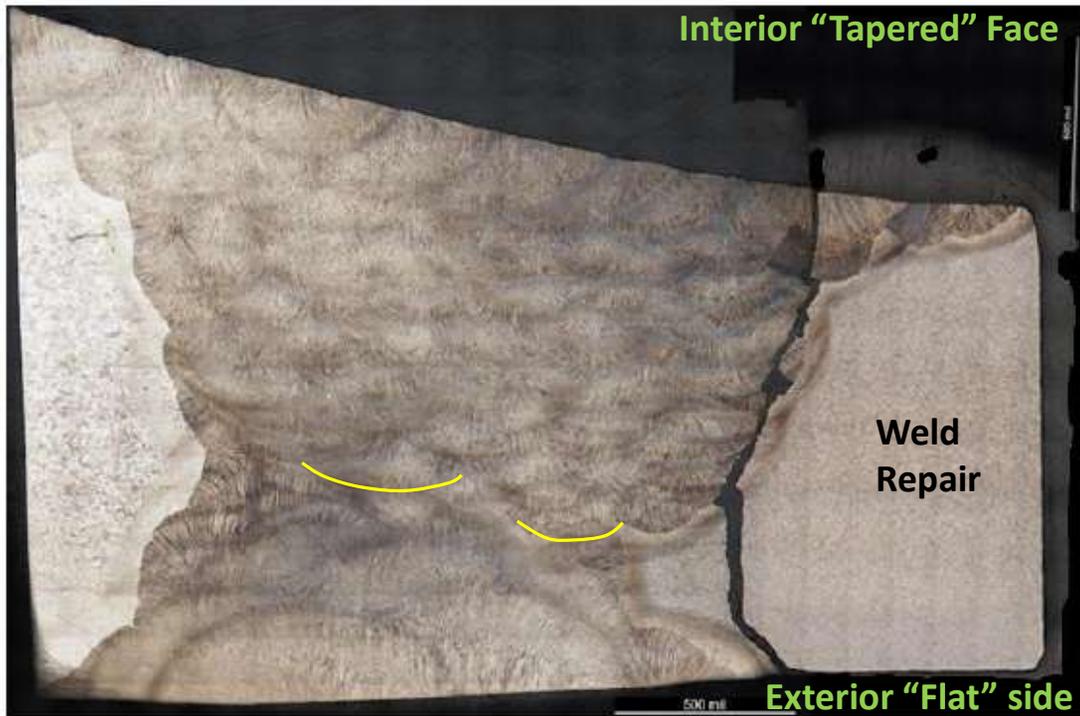


Figure 39. Primary preexisting crack weld profile.

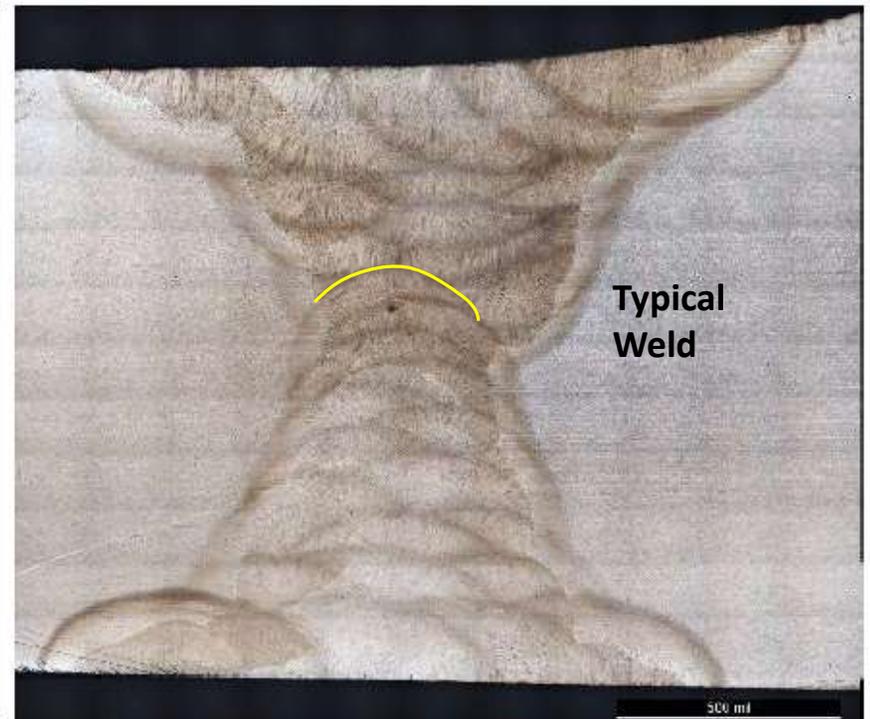


Figure 40. Core Sample SA008E weld profile.



Fracture Analysis

Figures obtained from WJE Fracture Investigation Report

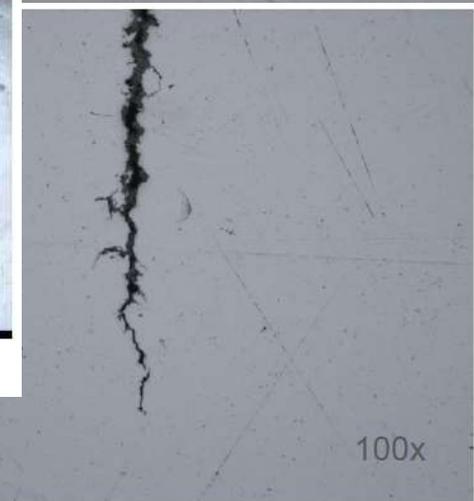
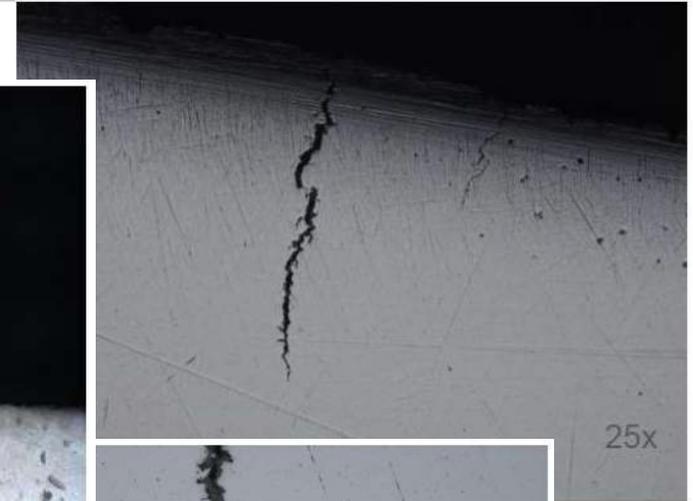


Figure 54. Cracks in the top weld passes at location SA168W



Fracture Analysis

Figures obtained from WJE Fracture Investigation Report

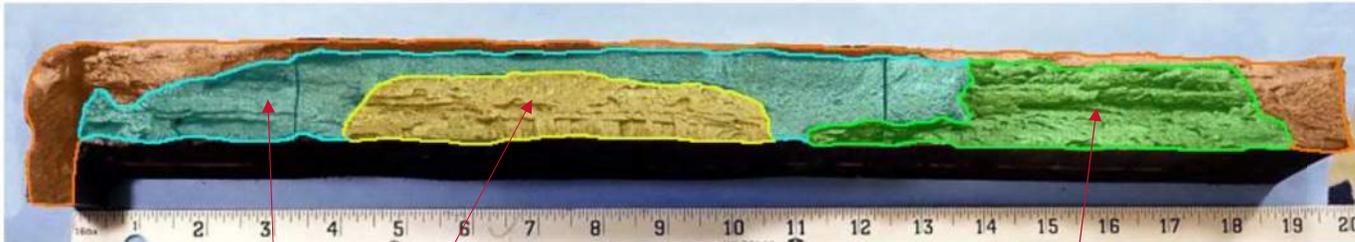


Figure 61. Lower portion of fracture, color-coded to indicate failure sequence.

Fracture Event #1

Secondary Pre-existing Crack

Primary Pre-existing Crack

Fracture Event #2

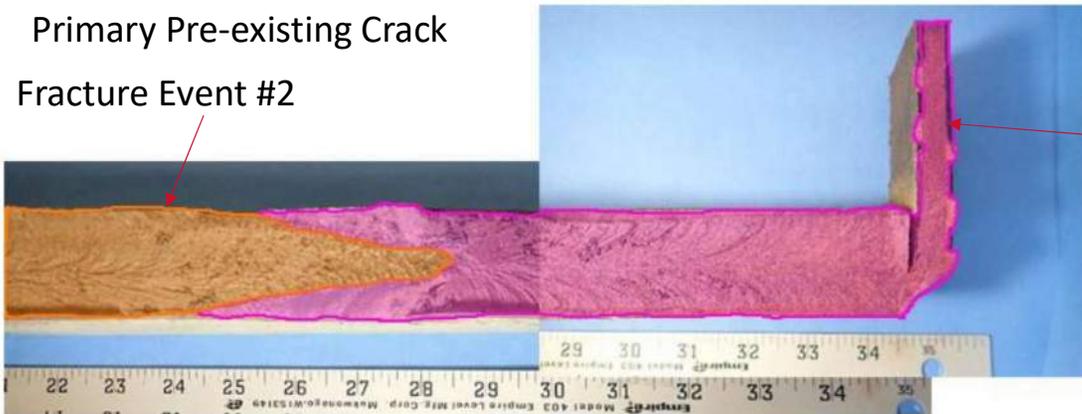
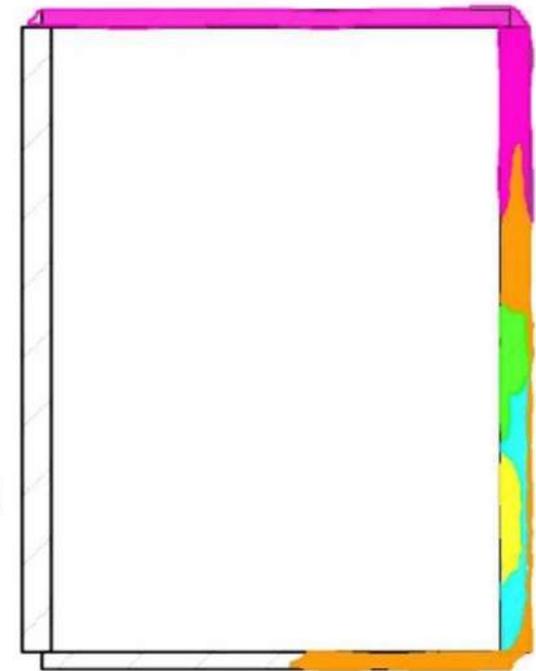


Figure 62. Upper portion of fracture, color-coded to indicate failure sequence.

Fracture Event #3



4

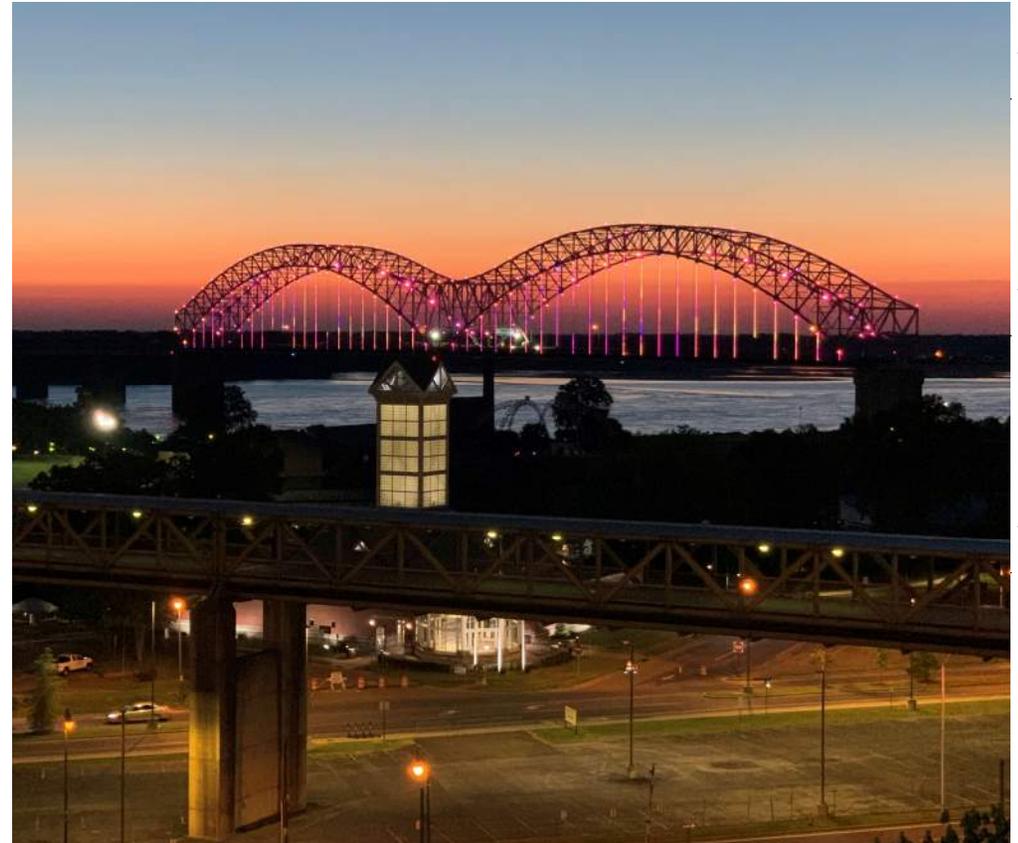
MAY 2021

SCALE: NTS (LOOKING WEST)



Lessons Learned

- Collaboration
 - Everyone with a Common Goal
- Communication
 - Internal and Externally
 - Many moving pieces and parts
- CM/GC Benefits
 - Risk Reduction
 - Improved Constructability
 - Material Procurement / Schedule
- Be Prepared for Challenges and Setbacks



By the Numbers

PHASE 1

30,000 LBS

of structural steel redundancy plating to stabilize the Tie Girder

448

Temporary bolts required to install the plates

Total Repair Cost = \$9.7M

PHASE 2

108,000 LBS

of structural steel redundancy plating added to the Tie Girder

Over 4,400

Permanent Bolts used to connect the plates

1,424 Feet

of 3" diameter High-strength Post tensioning rods utilized in the repair procedure

1.2Million +

Pounds of tension removed from the fractured section and put on the composite section

PHASE 3

17 Welds

were plated for a total of 78,000 LBS of structural steel

Over 4,000

Permanent Bolts used to connect the plates

1,202 ft

of welds inspected and tested in the 472 but welds of Tie Girders

29

Additional weld defects ground or cored out





We Make a Difference

Questions?

