AASHTOWare™ BRIDGE DESIGN AND RATING

The US 50-Blue Mesa Bridge Emergency Repair

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2025 Rating and Design User Group Meeting

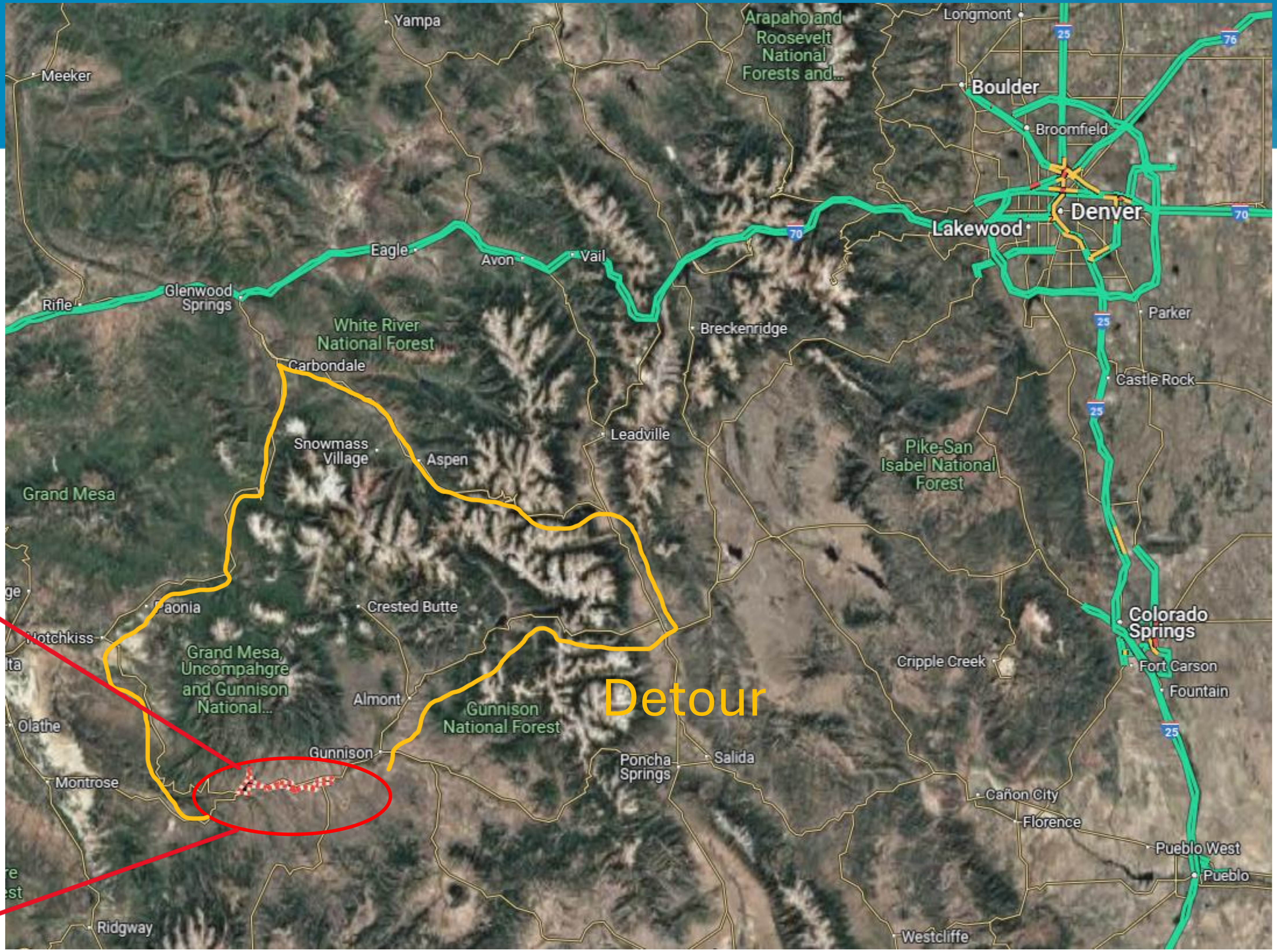
Boise, ID | August 12-13, 2025

Agenda

- Project Overview
- Repair Solution
- Analysis Details
- Lesson Learned

Project Location

- Blue Mesa Reservoir
- 3.5-4 hours from Colorado Springs or Denver
- Located in a very remote part of the mountains



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Blue Mesa Bridges - General Information

K-07-A

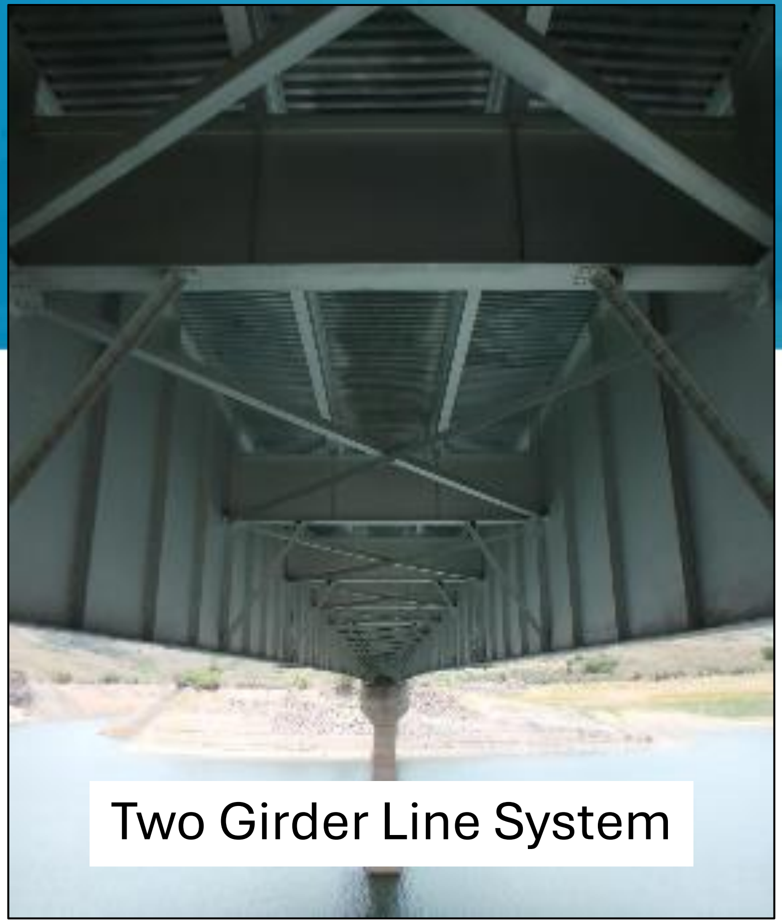
- US 50 over the Lake Fork at mile marker 132.69
- Six Span, Continuous Composite Welded Girder bridge. 993ft, 300ft max span
- Spans three, four, and five are Non-redundant Steel Tension Members (NSTM)
- Two total lanes, one lane each direction
- Built 1963, FAIR Condition

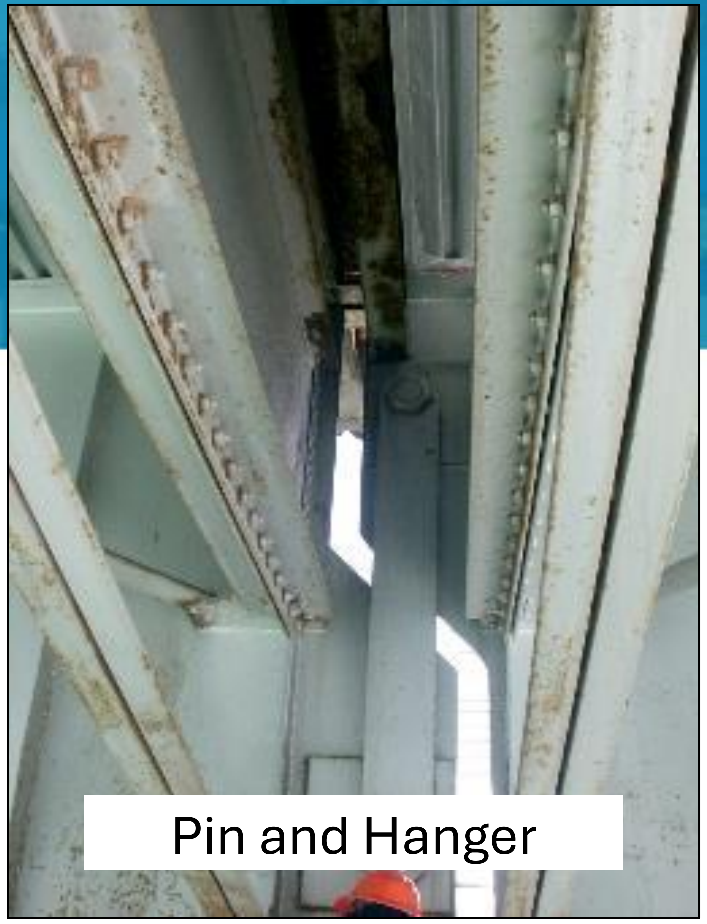
K-07-B

- US 50 over the Blue Mesa Reservoir at mile marker 136.16
- Ten Span, Continuous Composite Welded Girder bridge. 1,532ft, max span 360ft
- Spans five, six, and seven are Non-redundant Steel Tension Members (NSTM)
- Two total lanes, one lane each direction
- Built 1963, FAIR Condition

Blue Mesa Bridges - Existing Structure

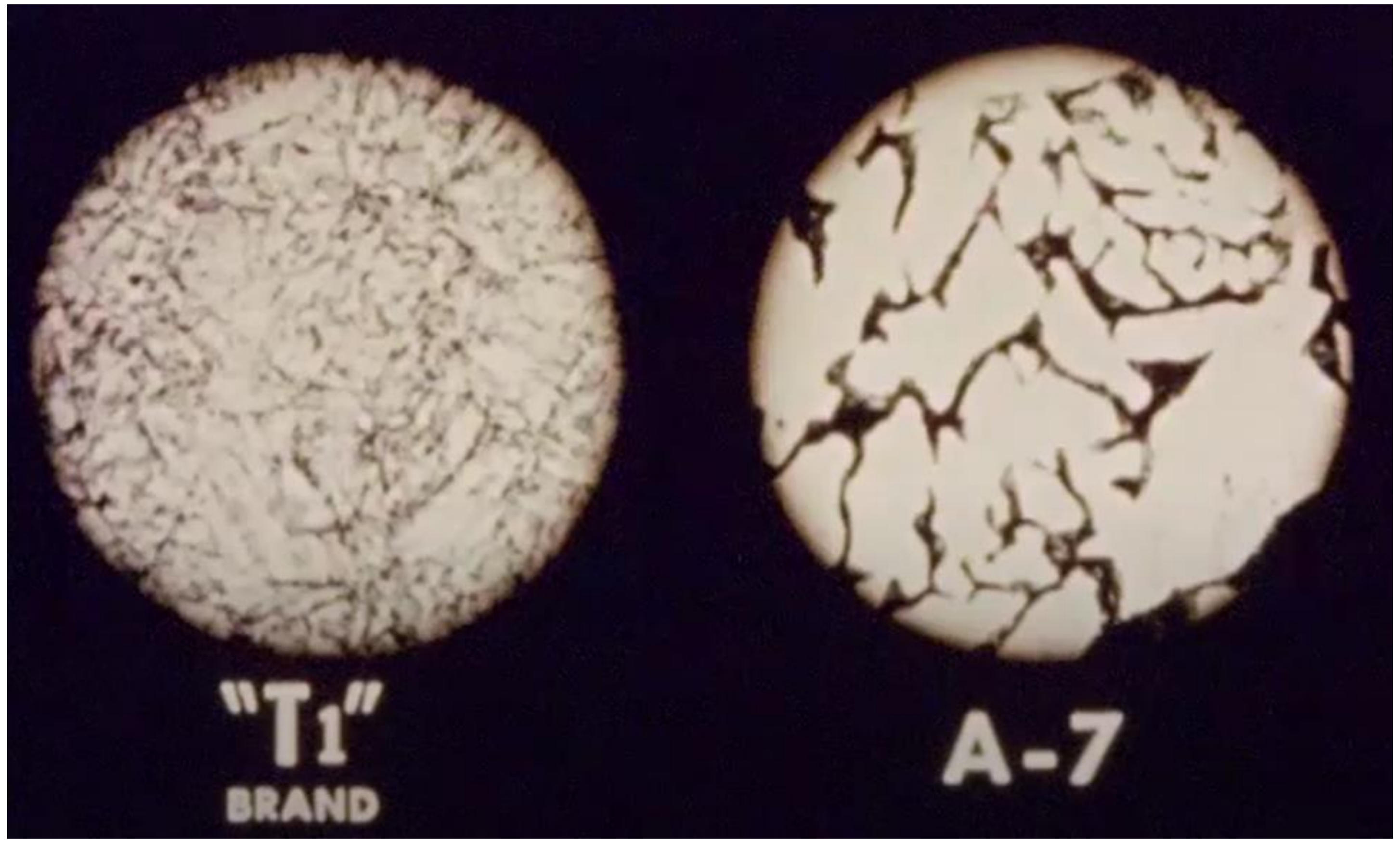
The bridges' main spans are composed of 100 ksi T1 Steel built-Up (welded) members and are Non-redundant Steel Tension Member (NSTM) bridges.


Two Girder Line System


Pin and Hanger

What Is T1 Steel?

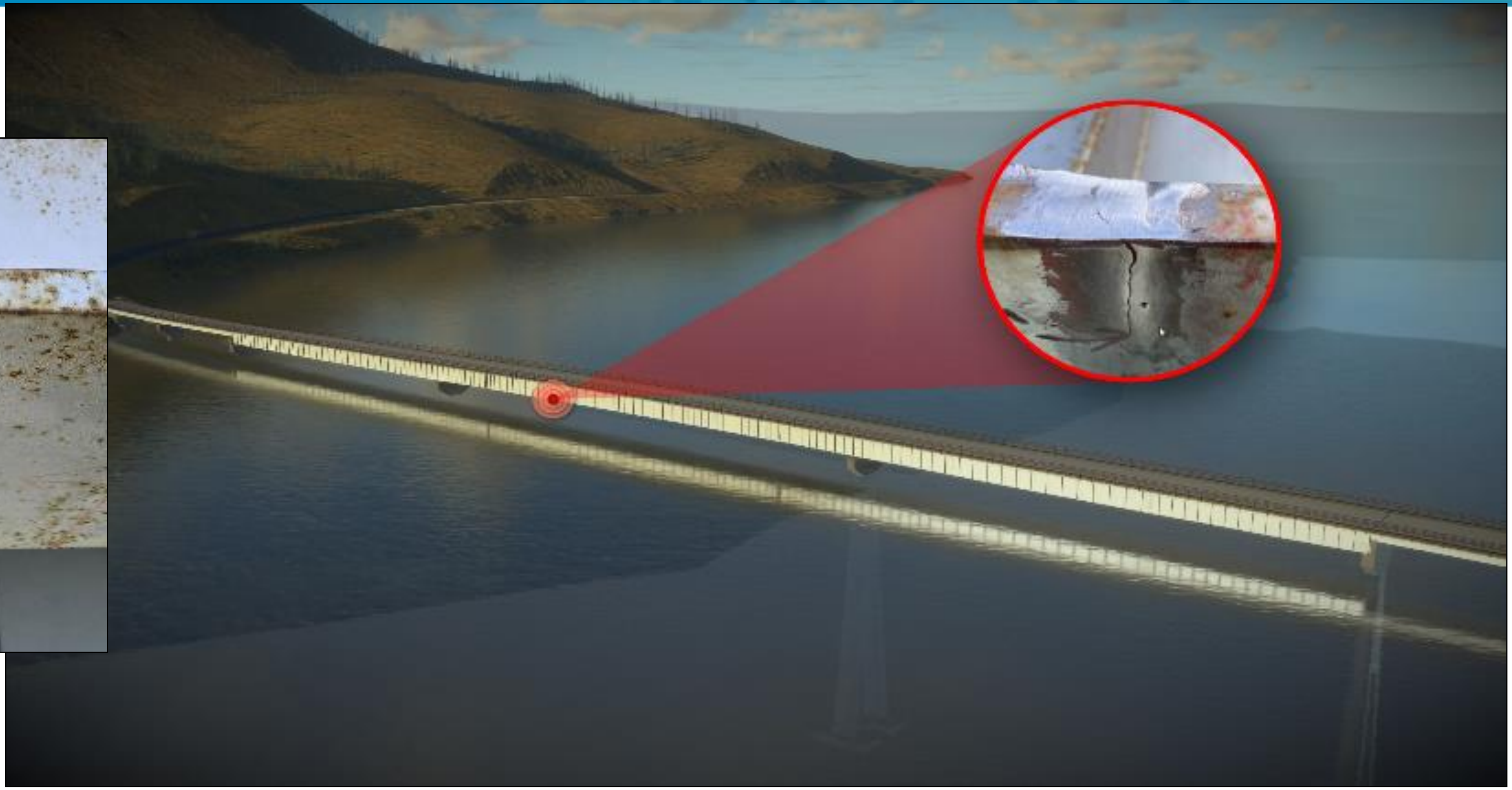
- High strength steel developed in the 1950's and used 1960s - 1980s
- ASTM A514 or A517 designation
- Fy = 100 ksi / Fu = 110 ksi
- T-1 is US Steel Marketing name
- Weldability issues ended its use in bridges



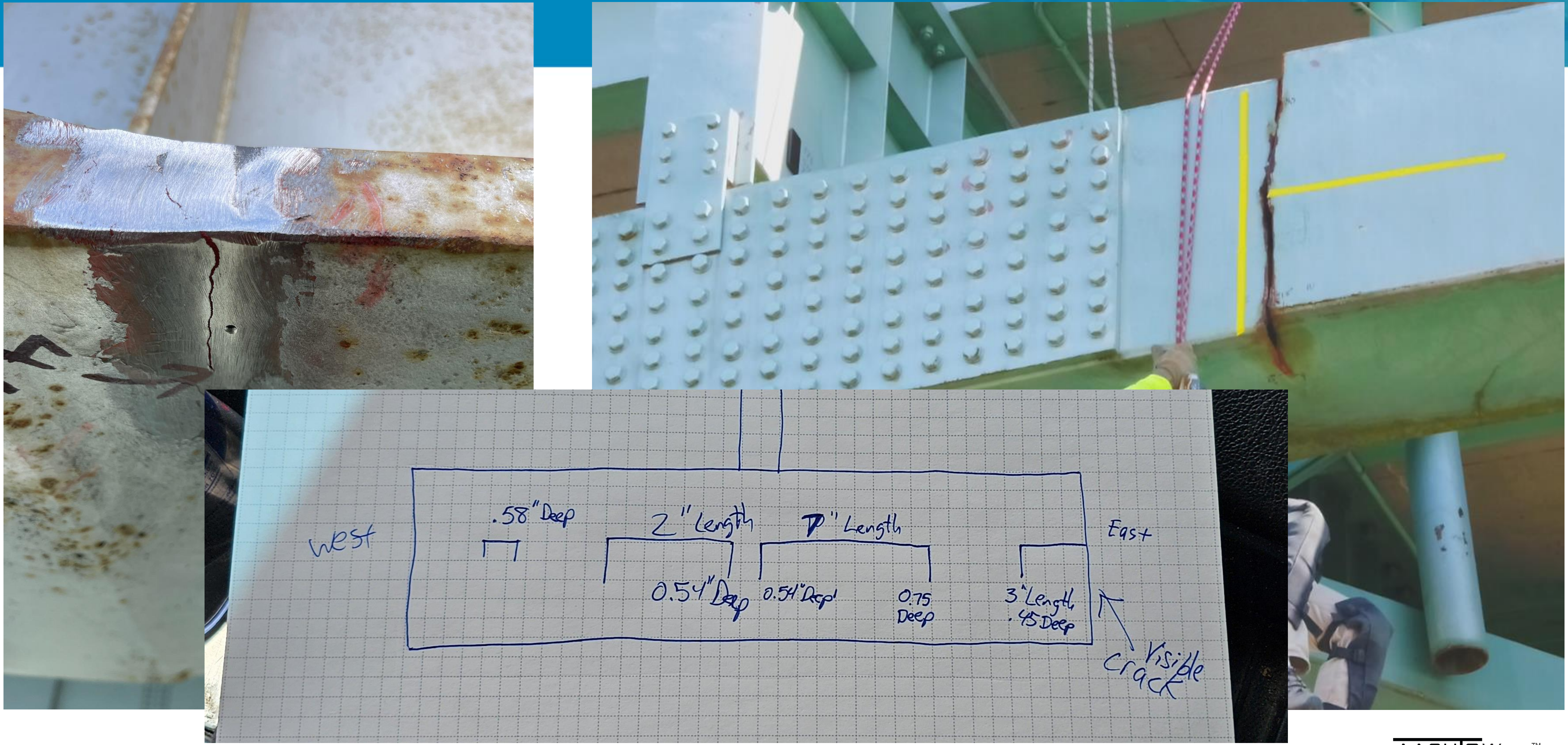
Low Carbon Tempered Martensite

[Proven Engineering Material: T1 Steel (youtube.com)]

Bridge B 1st Determined Crack Span 6, GB, BF 11

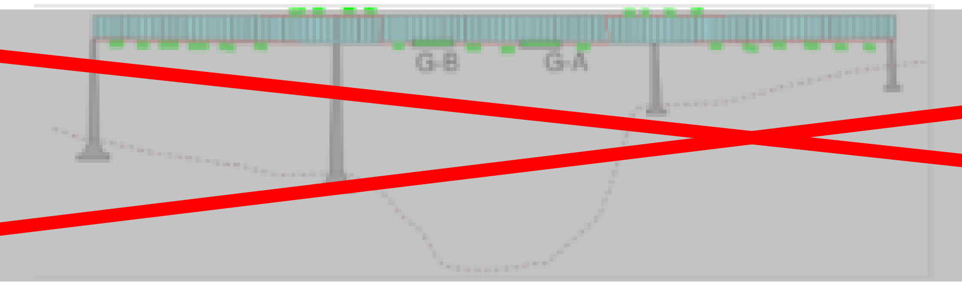
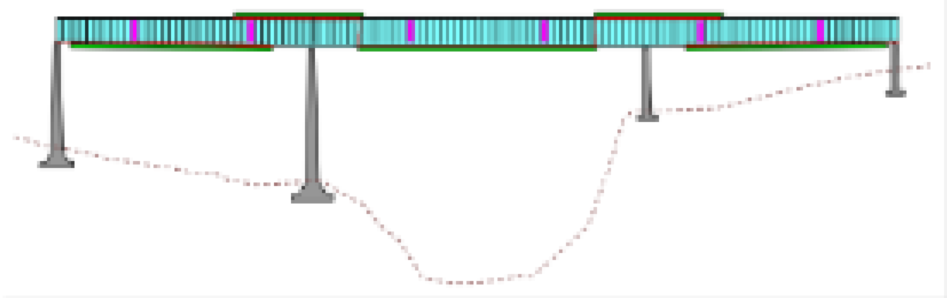
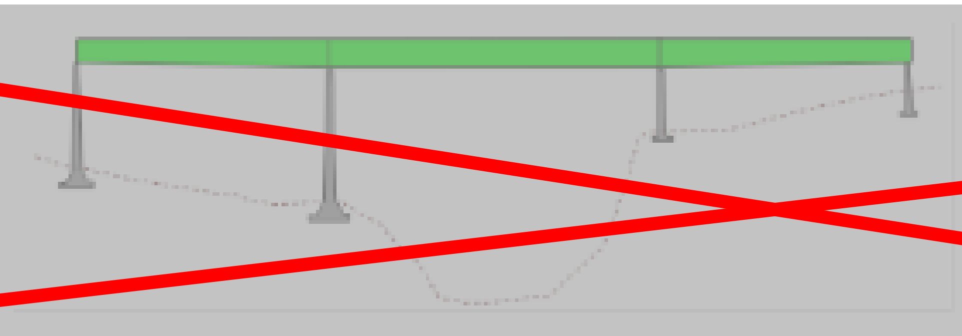


Bridge B 1st Determined Crack Span 6, GB, BF 11



Bridge B Permanent Repair Options Drivers

- Prevalence of fillet weld cracks
- Availability 100 ksi material
- Substructure capacity
- Schedule risk
- Historic bridge

Options	Sketches	Risks or unknowns	Schedule[1,2]	Relative cost[3]
Local Plating		• Increased complexity if additional defects are later found. • Relative costs increase with the number of defects found.	1 – 3 Months	$ - $$$
Global Plating		• Material availability • Sequence of construction • Negative effects of additional weight • Schedule risk due to design complexity	4-7 Months	$$$
Superstructure Replacement		• Long material lead times • Strength and condition of existing piers and foundations.	6-12 Months	$$$$
Full Bridge Replacement		• Environmental, geotechnical, and other considerations	>12Mo	$$$$$

Timeline

April

__Inspection and Design__
April 8 - Start of visual inspection
April 11 - Visual finding of first crack
April 18 - Visual finding of second crack
April 18 -Bridge closed to traffic
April 20 - Benesch, BDI, Michael Baker & Kiewit retained
April 22 - Begin NDE inspection & design

May

__K-07-B Inspection and Design__
May 24 - UT butt weld inspection completed
May 25 - K-07-B MT fillet weld testing
May 31 - Critical repair plans issued

June

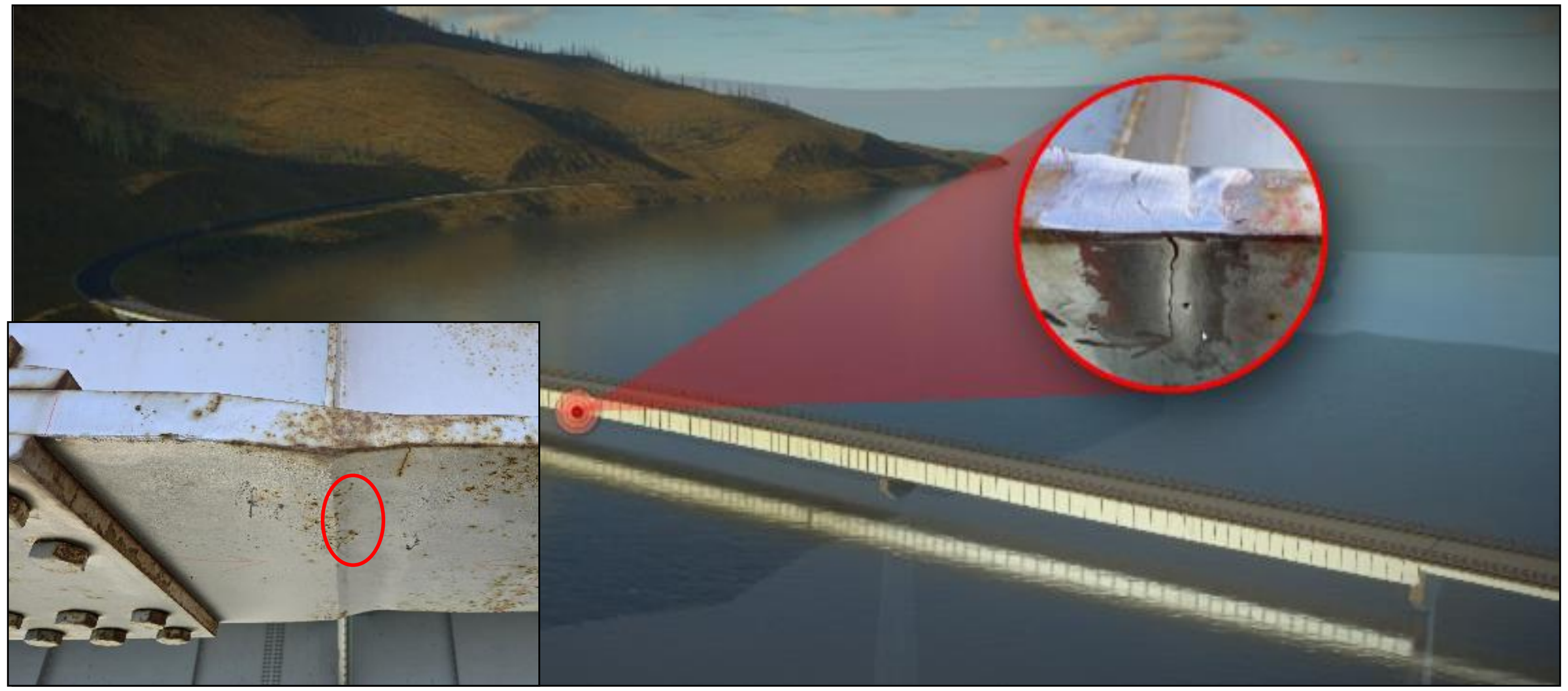
__Inspection and Design__
K-07-B MT fillet weld testing

__Construction__
June 5 - Shop drawings & fab start
June 11 - Begin critical repairs

July-December

__K-07-A Inspection and Design__
July 8-Aug 3 - K-07-A MT fillet weld testing
Aug 1 - K-07-B permanent repairs plans issued
Aug 11 - K-07-A permanent repairs plans issued

July 2 - Critical repair complete
July 3 - K-07-B open to limited traffic
July 6 - K-07-B begin permanent repairs
August 12 - K-07-A begin permanent repairs
November 12 – Last Bolt Installed



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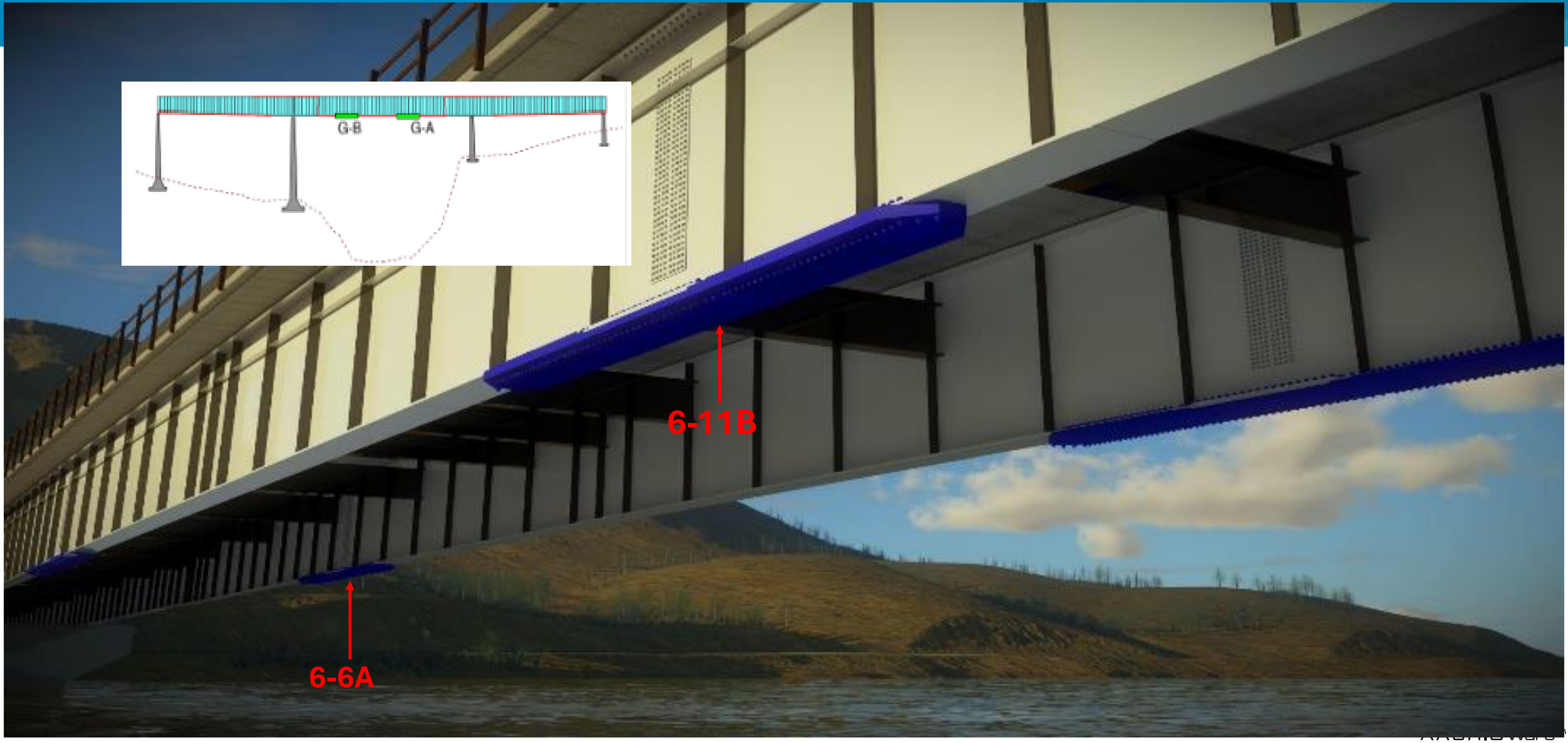
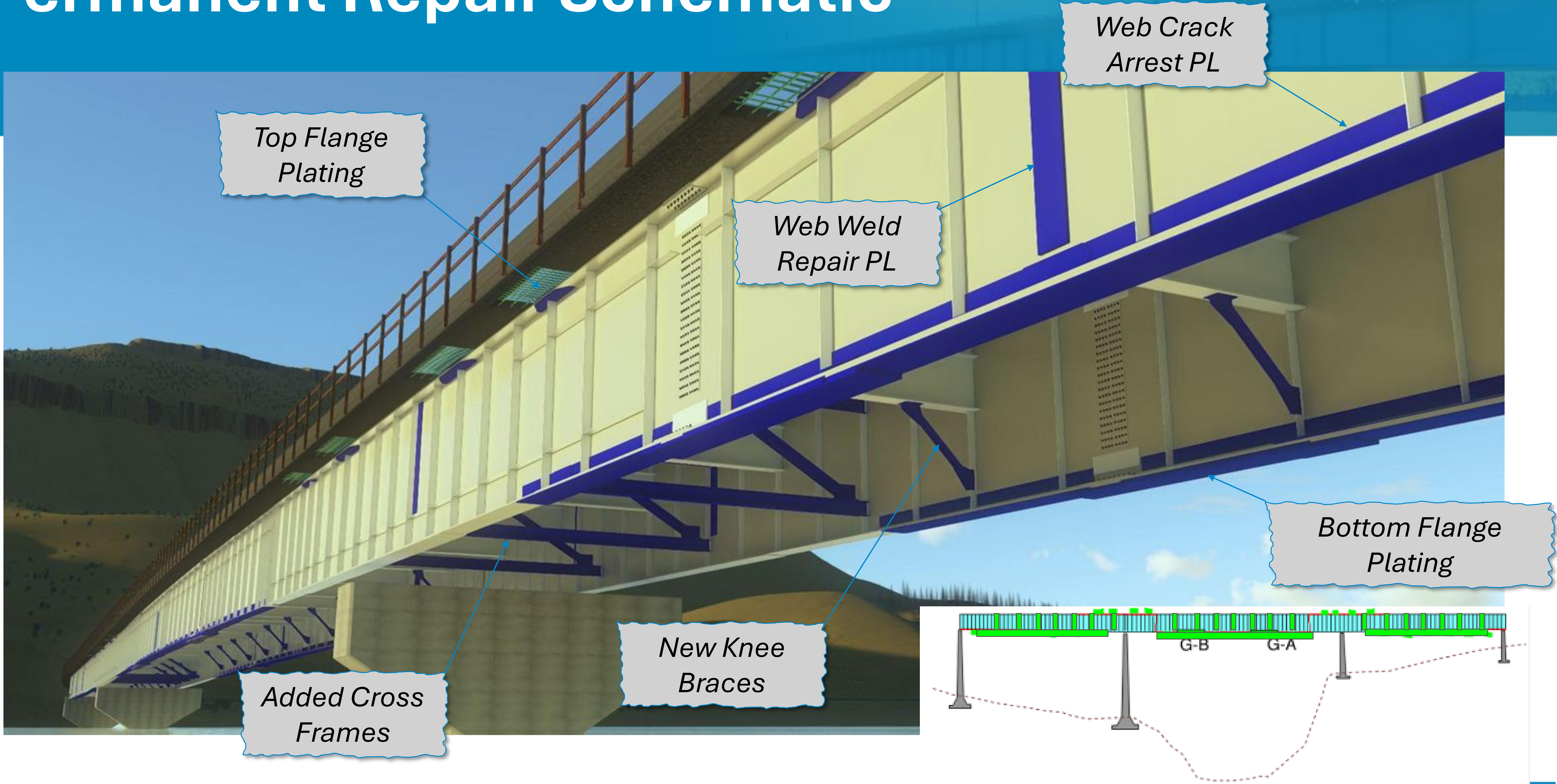
Bridge B Critical Repairs - Designed for speed



Permanent Repair Schematic



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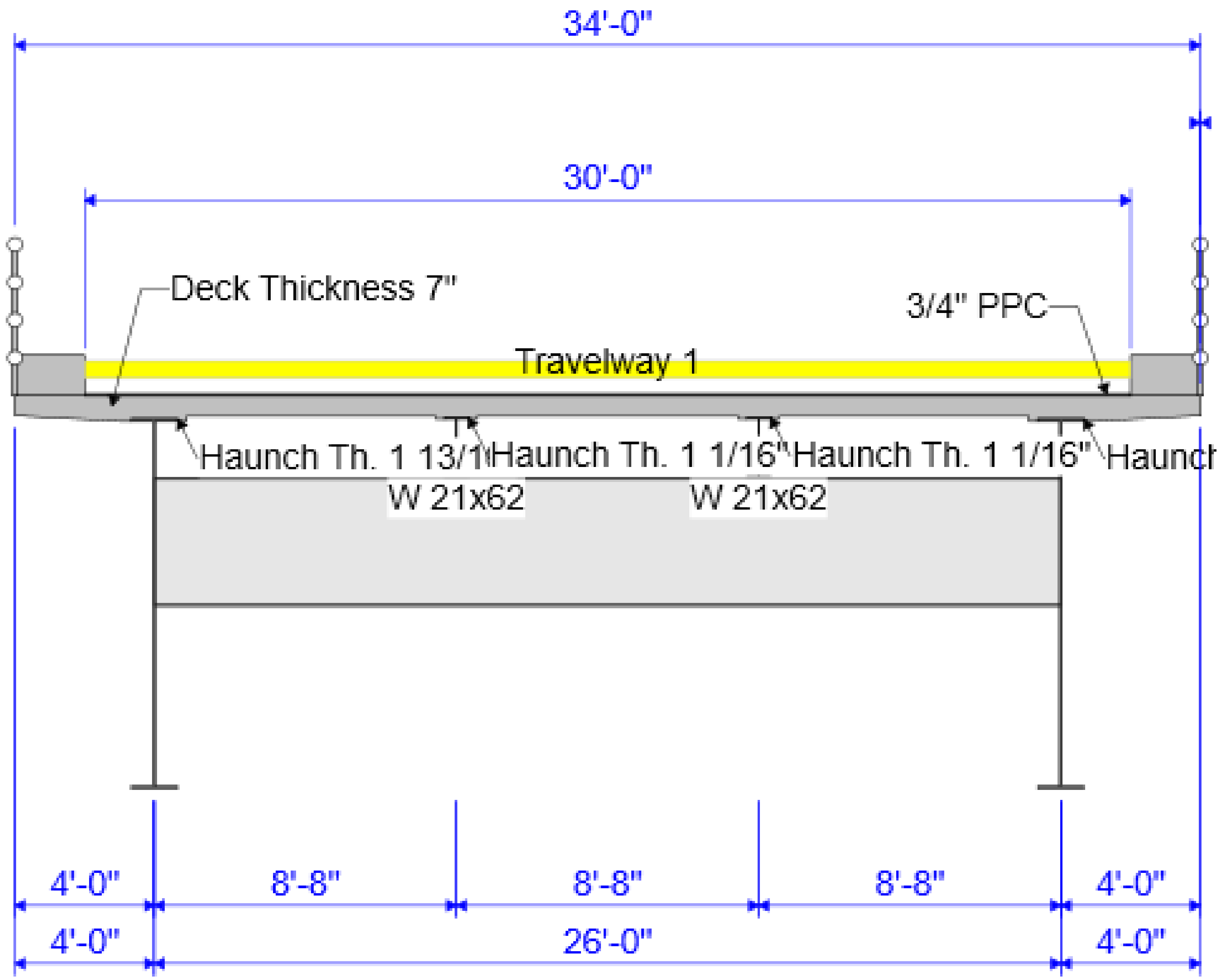
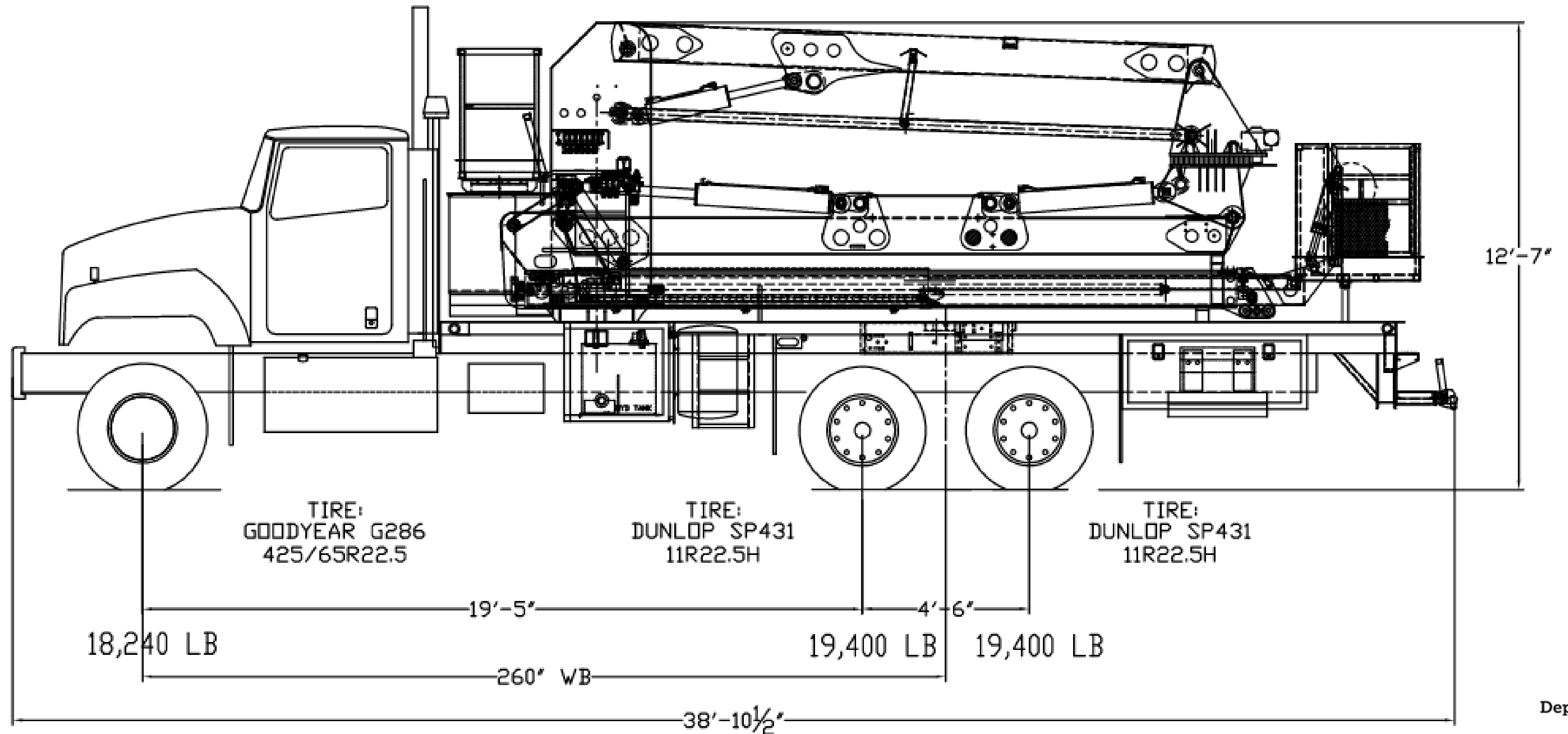
Analysis Goals

1. Determine the safe loading limits for inspection (and later construction) equipment
2. Update CDOT's existing rating file
   - BrR is CDOT preferred load rating tool
   - Rating on file was not current
3. Revise the updated rating to require NO posting requirements based on BrR ratings
   - Incorporate all the repairs into the final load rating
   - Incorporate any workaround to reduce conservatism in results

Bridge B – Safe Working Loads

- Required to have agreeing results from 2 analysis software programs
  - Use AASHTOWare BrR
  - Verified with Midas Civil
- Known loading from Aspen A-40 Snooper
- Potential loading increase from recent permit vehicle





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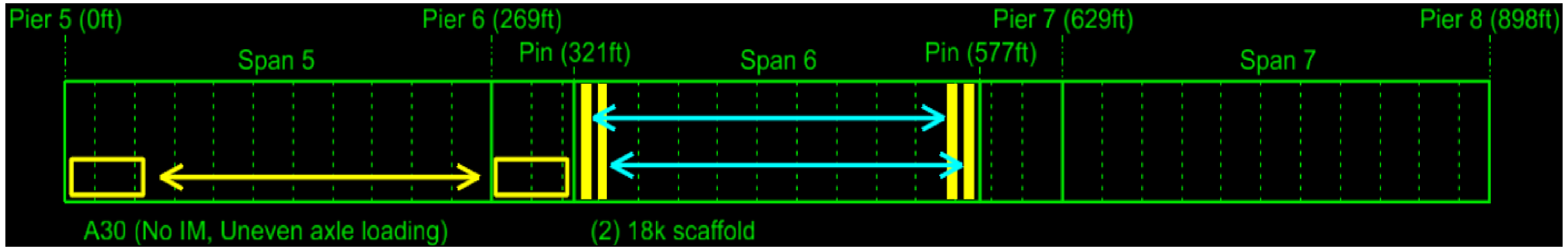
Bridge B – Safe Working Loads

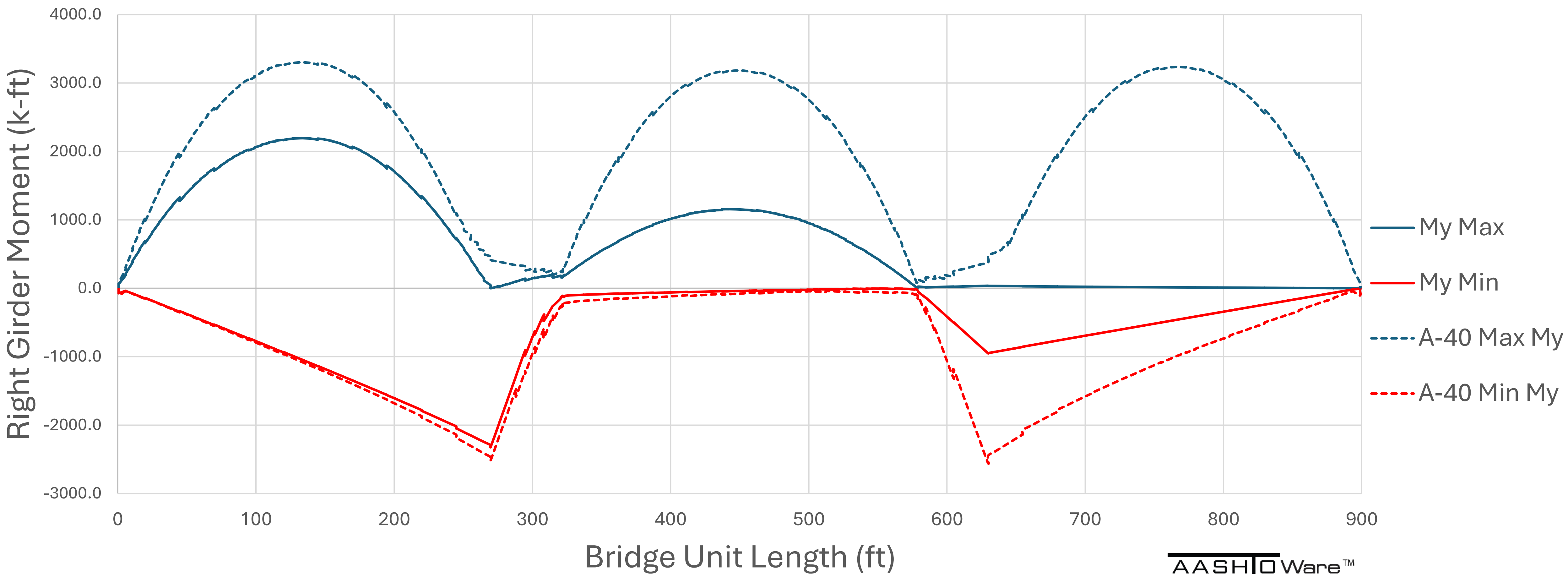
Additional considerations

- Working scaffolds (rolling and then underhung)
- Removing three to four inches of asphalt wearing surface to increase load envelope

Bridge B – Safe Working Loads
Allowable Loading Configuration

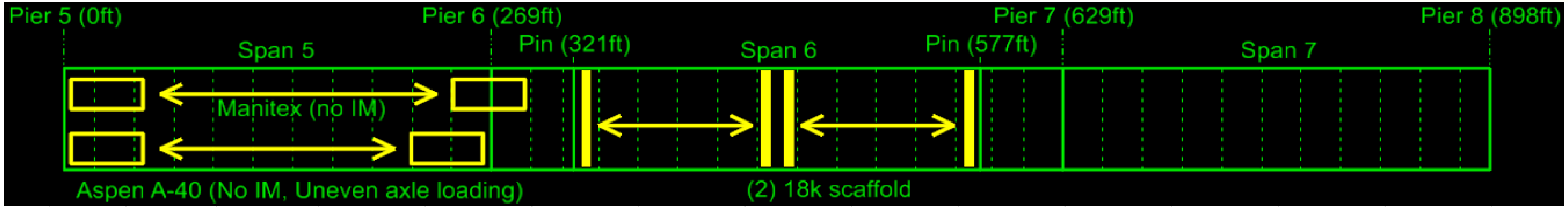
- Heavy equipment needed but weight a concern
- Each configuration required analysis
- Loading variables
  - Vehicle IM
  - Uneven axle load (deployed)
  - Location
    - Which span?
    - What side of bridge?
    - Concurrent loading?
    - Scaffold present?

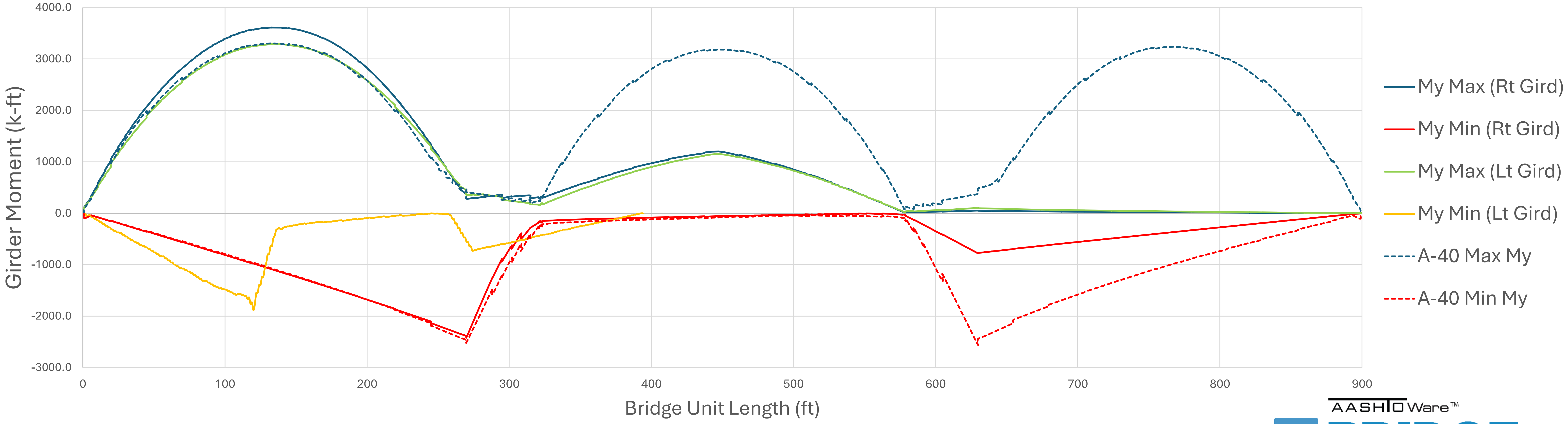




Bridge B – Safe Working Loads

Rejected Loading Configuration





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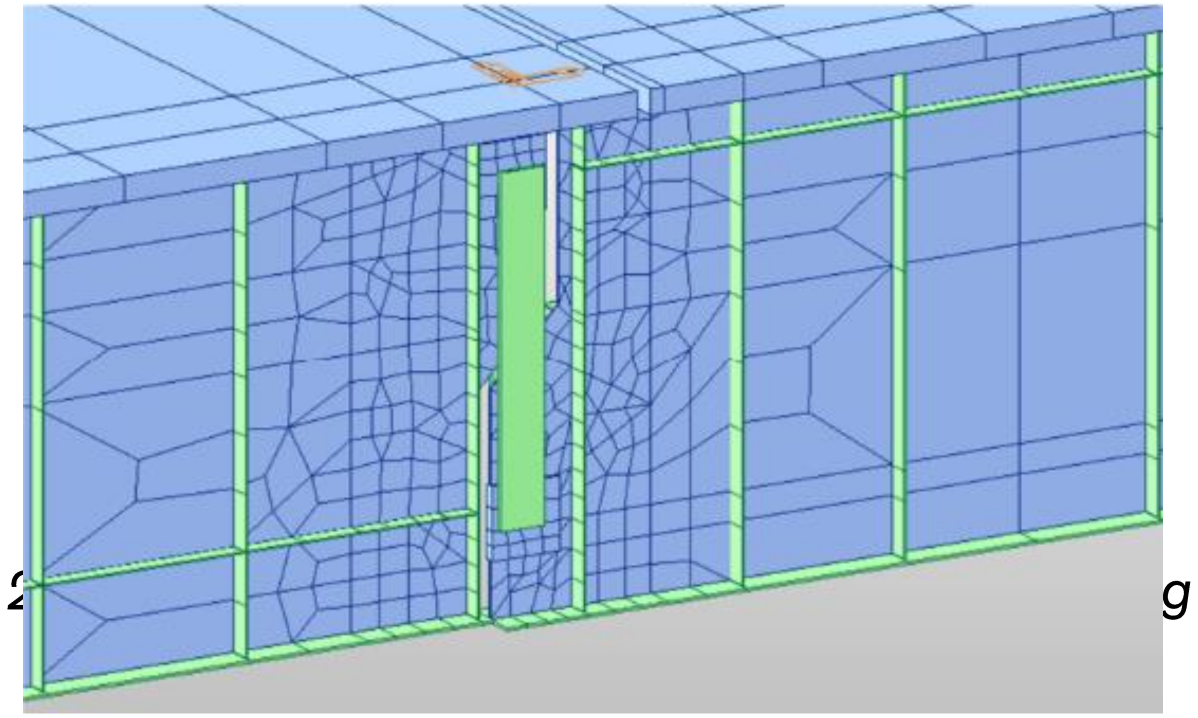
Bridge B – Baseline Ratings

Goal to rate entire bridge in BrR (v7.2)

GIRDER LIMITATIONS

1. 2D Girder-Floorbeam-Stringer system with hinges
2. Cannot rate pin and hanger system
3. Girder lateral torsional buckling (LTB) ratings extremely low



GIRDER SOLUTIONS

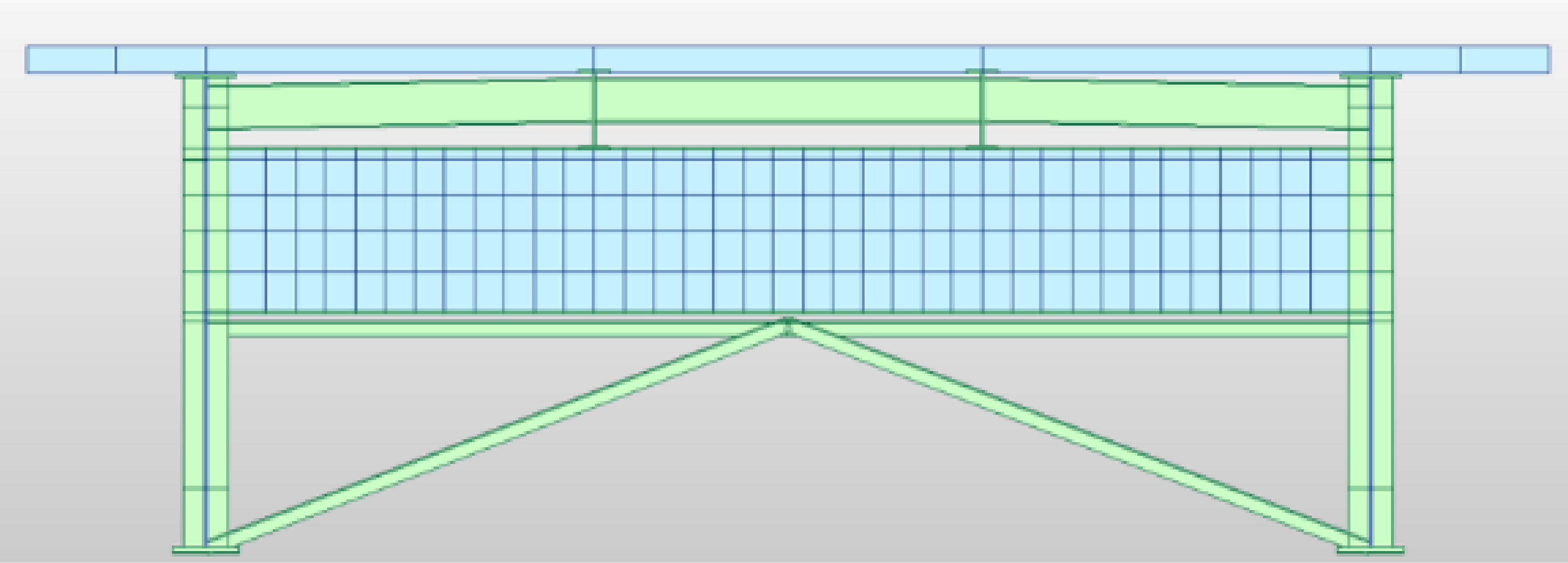
1. New definition treating girder as line girder
2. Used model results to rate in spreadsheet
3. Utilized BrR point of interest (POI) overrides
   - Performed LTB hand calculations per 10th Edition of AASHTO and input
   - Determined additional cross frames still required

Bridge B – Baseline Ratings

Goal to rate entire bridge in BrR (v7.2)

FLOOR SYSTEM LIMITATIONS

1. Stringer ratings low
   - LTB conservative
   - Live Load Distribution Factors (LLDF) conservative
2. Floorbeam flexural ratings low



FLOOR SYSTEM SOLUTIONS

1. Utilized BrR POI overrides
   - Performed LTB hand calculations per 10th Edition of AASHTO and input
   - Stringers able to develop full yield
2. Finite element analysis (FEA) performed for floorbeams
   - Model fixities better and capture stiffness
   - Webs as plate elements and flanges & stiffeners as beam elements
   - Utilized LRFR specification overrides to reduce force effects based on from FEA

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Bridge B – As-Repaired Load Ratings

Girder Top Flanges

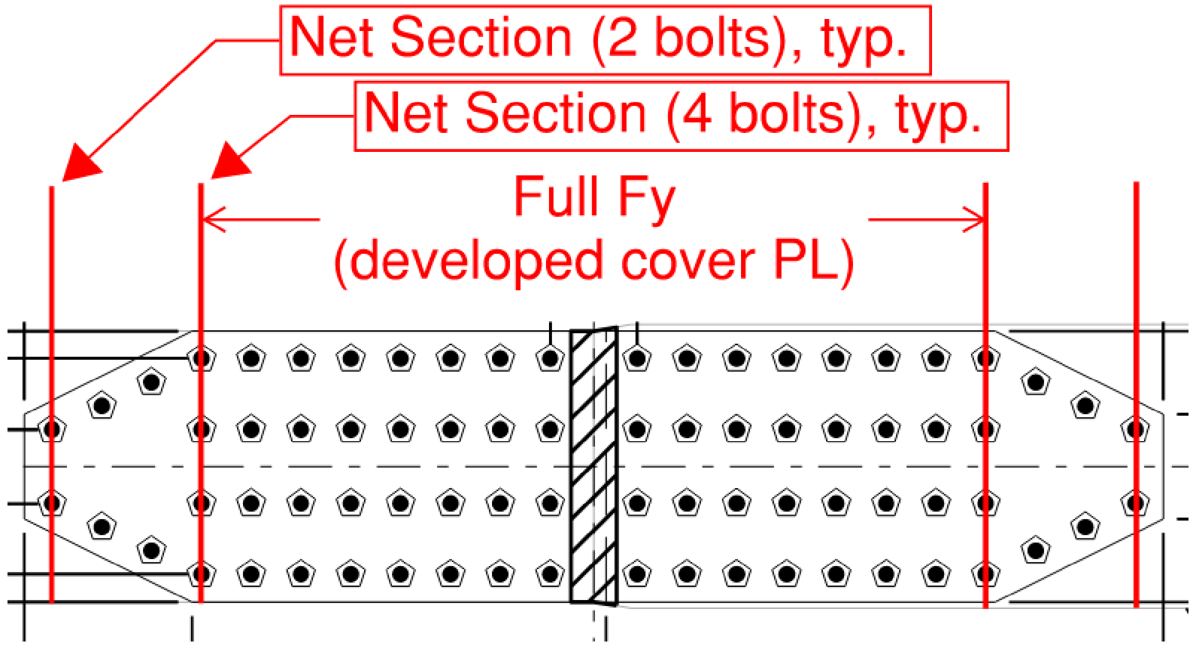
- Repair plate area assumed adequate since

  Fy*Ag of new splice plate > Fy*Ag existing top flange

- Reduced existing flange Fy if net section tension controlled over gross section tension of existing flange

  Fy applied at POI overrides = Min (0.84*Anet / Agross * Fu , Fy)

- Dead load (DL) of repair plates added as composite dead load (DC2) girder line load



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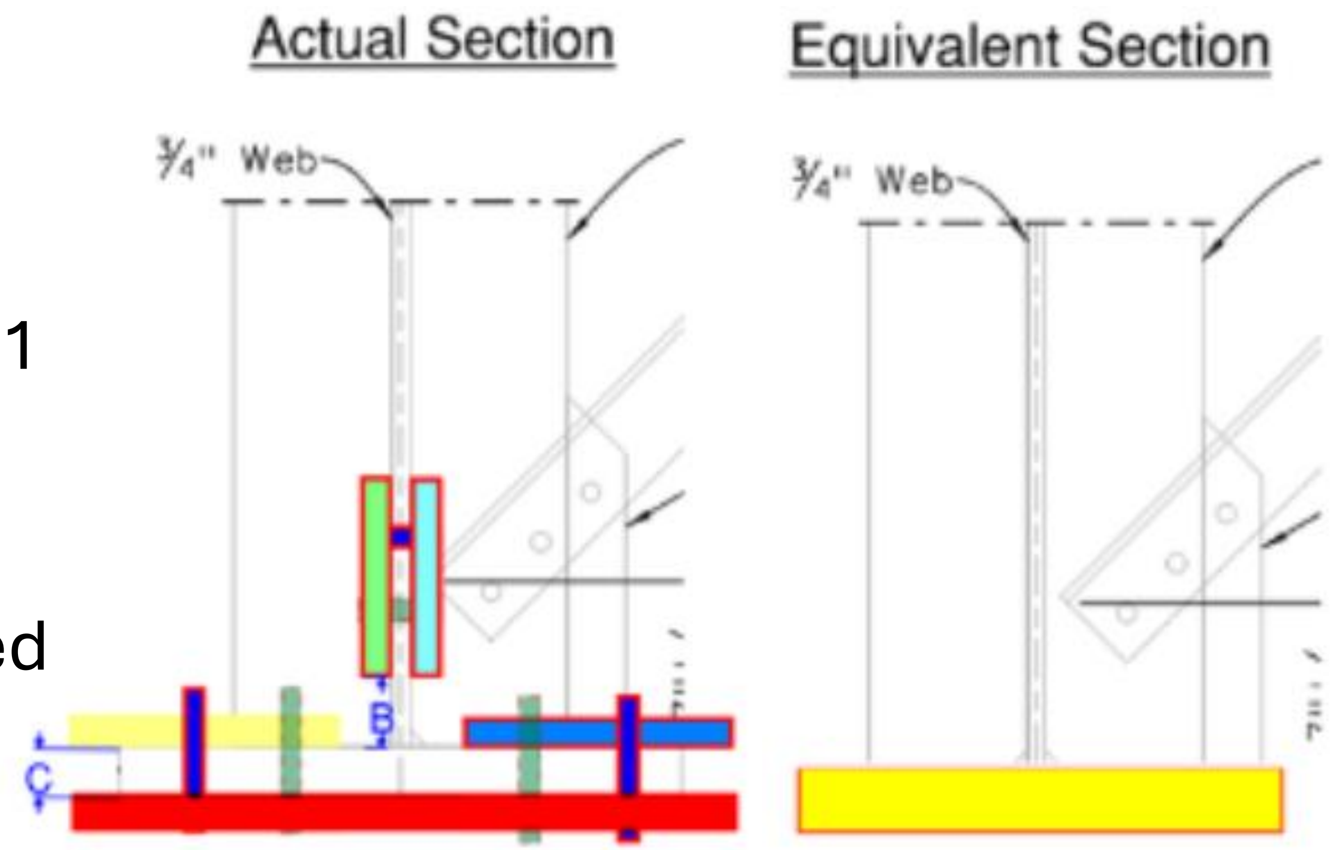
Bridge B – As-Repaired Load Ratings

Girder Bottom Flanges

- In repair regions, assume existing flange provides **no** capacity to girders
- Repairs vary from one plate to five plates at a cross-section
  - An equivalent bottom flange -> same area and section
  - Fy of the equivalent flange reduced for net section tension
- Loading
  - Existing flange weight applied as DC1
  - Equivalent repair flange weight removed by applying negative DC1
  - Equivalent repair flange weight added back in as DC2



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Bridge B – As-Repaired Load Ratings

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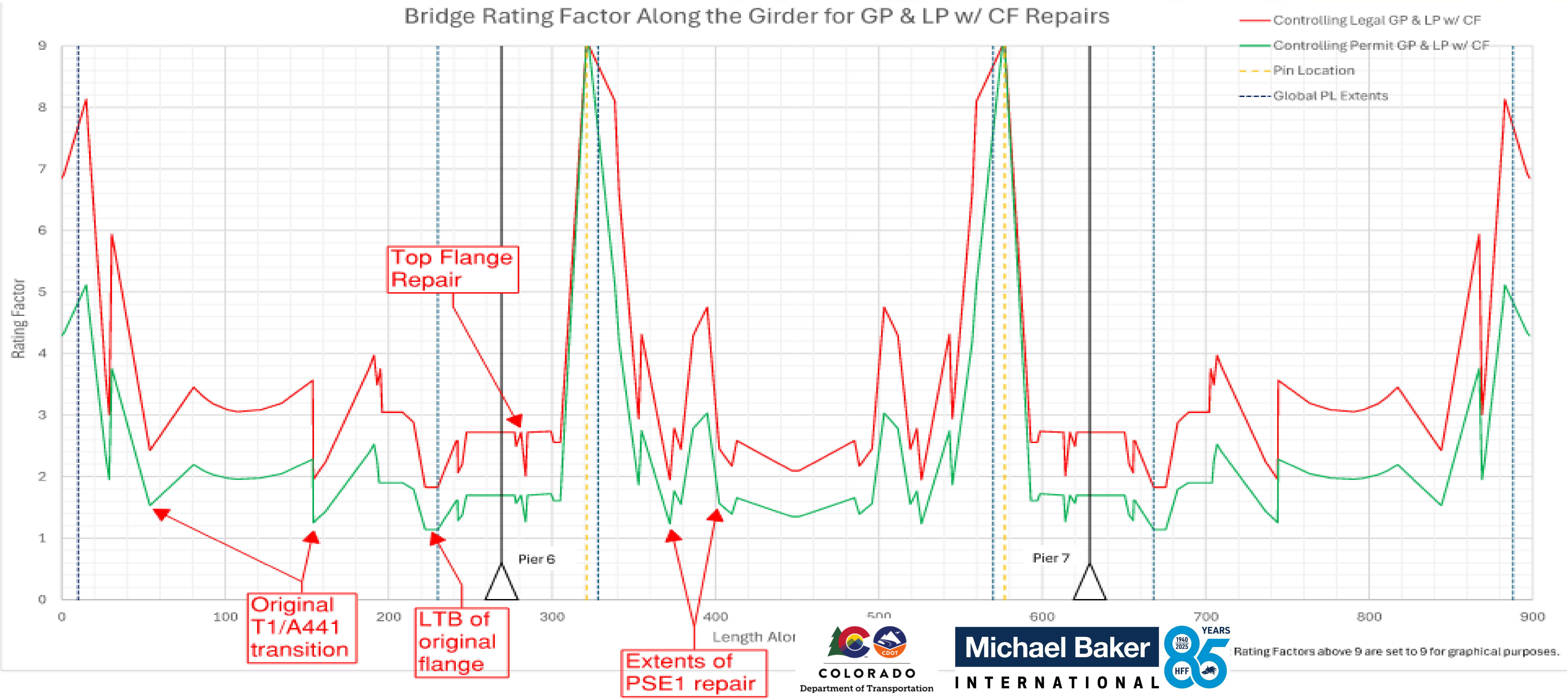
Bridge B – As-Repaired Load Ratings



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Lessons Learned

- Collaboration - *Everyone has a common goal*
- Girder bridges offered some very unique challenges
- Bridge A – Forgo testing and went straight to repair/reinforcement.
- Communication
  - Internal and externally
  - Many moving pieces and parts
- CM/GC benefits
  - Improved constructability
  - Material procurement / schedule

Fun Facts & Acknowledgements

Repairs at a Glimpse

- 118 splices tested
- 289 indications found
- 410 tons of additional steel
- 51,504 bolts

Partners

- CDOT Region 3 and Staff Bridge
- Kiewit
- Michael Baker International
- Benesch
- Bridge Diagnostics, Inc.
- Dr. Robert Connor
- Coating Specialists
- eO
- ICE
- KTA
- Stantec
- Ulteig
- W&W AFCO
- Gunnison County

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Questions?

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