



CALIFORNIA BRIDGE ENGINEERS SEMINAR

ADVANCING BRIDGE ENGINEERING THROUGH INNOVATION



CABES 2026

Presentation 4 - Innovative Independent Quality Assurance for Fracture-Critical Bridge Members





Innovative Independent Quality Assurance for Fracture-Critical Bridge Members



Maged Armanuse, Office Chief
Office of Quality Assurance and Source Inspection
Division of Engineering Services

02/25/2026

Slide

1

DES Guiding Principles

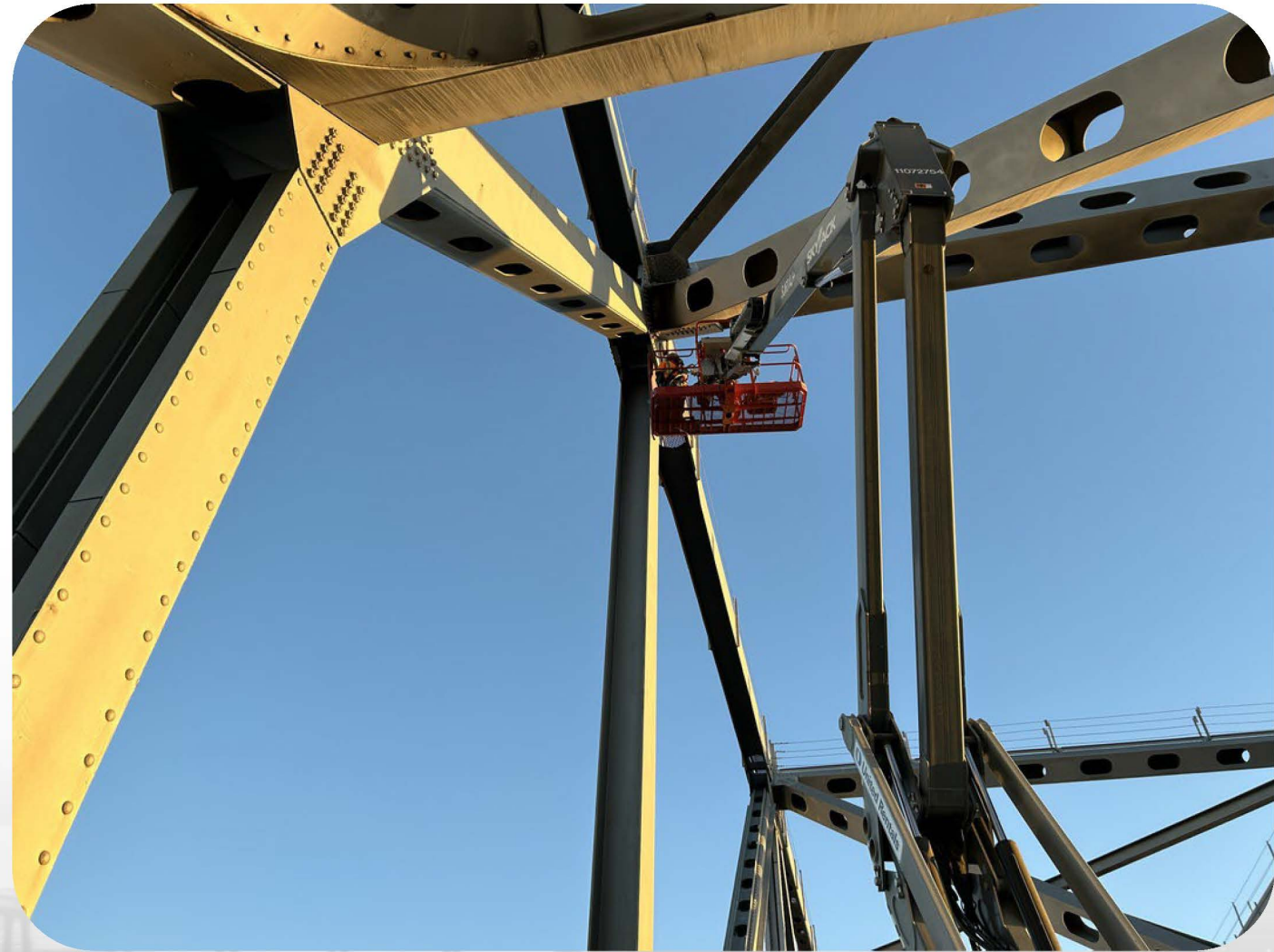
Collective Values Based Decisions; Fostering Success and Expertise; People First Culture; Culture of Service; Collaborative and Shared Responsibility





Agenda

1. History of issue
2. Caltrans Response
3. Testing Approach
4. Findings
5. Challenges/Solutions
6. Acknowledgments
7. Thank You & Feedback



Carquinez Bridge





Cracks are found

2021

Hernando de Soto
Bridge (built 1973)

I-40, Mississippi River
Tennessee

Root Cause

Hydrogen Cracking





FHWA Memo

2021

FHWA ACTION MEMO

- Inventory T-1 FCM welds by March 2022
- If no records, perform UT by March 2024

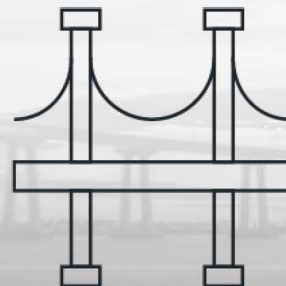
Caltrans Plan of Corrective Action – March 2026

AWS D1.5 Section 12.2.2 Fracture Critical Member (FCM)

Primary Member

Tension

Failure = entire bridge collapse



Memorandum

Subject: **ACTION:** Non-Destructive Testing of Fracture Critical Members
Fabricated from AASHTO M244 Grade 100 (ASTM A514/A517) Steel

Date: December 13, 2021

From: Hari Kalla
Associate Administrator, Office of Infrastructure

HARI KALLA

Digitally signed by HARI KALLA
Date: 2021.12.13 11:01:42 -05'00'

In Reply Refer To: HIBS

To: Division Administrators
Directors of Field Services

The purpose of this memorandum is to provide direction regarding the in-service inspection, inventory, and testing of butt welds in fracture critical members fabricated from AASHTO M244 Grade 100 (ASTM A514/A517) steel, more commonly known as "T-1" steel.

Constructed between 1960-1961, the I-64 Sherman-Minton Bridge is a fracture critical bridge which consists of two 800-foot tied arch truss main spans that carry six lanes across the Ohio River between Louisville, Kentucky, and New Albany, Indiana. As the result of a 2011 in-service inspection of the bridge, several cracks were found in the butt welds, or their associated heat-affected zones, of the tension ties of both spans, which were fabricated from T-1 steel. Discovery of the cracking resulted in the closure of the bridge. It was subsequently determined that the cracking was very likely caused by hydrogen that was introduced into the weld as the result of inadequate fabrication procedures.

In response to issues discovered on the Sherman-Minton Bridge, FHWA issued Technical Advisory 5140.32 which included recommendations to verify through visual and non-destructive testing, unless this verification had been previously conducted, the soundness of all butt welds in tension components fabricated from T-1 steel where cracks due to a lack of hydrogen control during welding had previously been found.

Constructed in 1973, the I-40 Hernando de Soto Bridge is also a fracture critical tied arch truss bridge that consists of two 900-foot main spans and carries four

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Background on T-1

T-1 steel, introduced 1952

- AASHTO M244 Grade 100 steel
- very high yield strength (double A709 Gr 50!)
- excellent toughness
- good weldability

But...

- sensitive to electrode (weld metal) selection, heat & workmanship
- susceptible to hydrogen cracking in tension welds





Background on T-1

Prior 1978

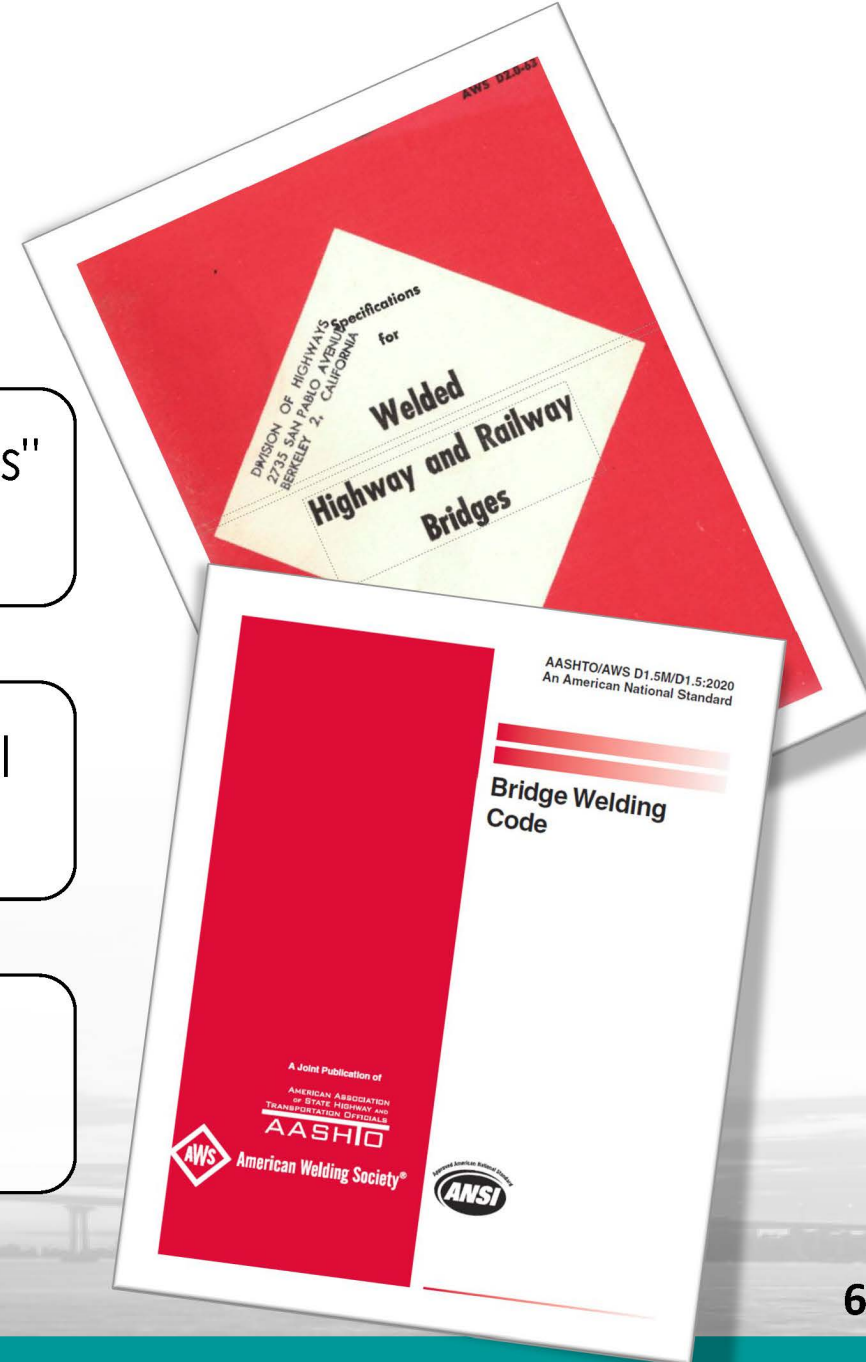
- AWS D2.0 "Welded Highway and Railway Bridges"
- Fracture Control not addressed

1978

- AASHTO Guide Specification for Fracture Critical Non-Redundant Bridge Members

1995

- AWS D1.5 Bridge Welding Code
- Clause 12 Fracture Control Plan

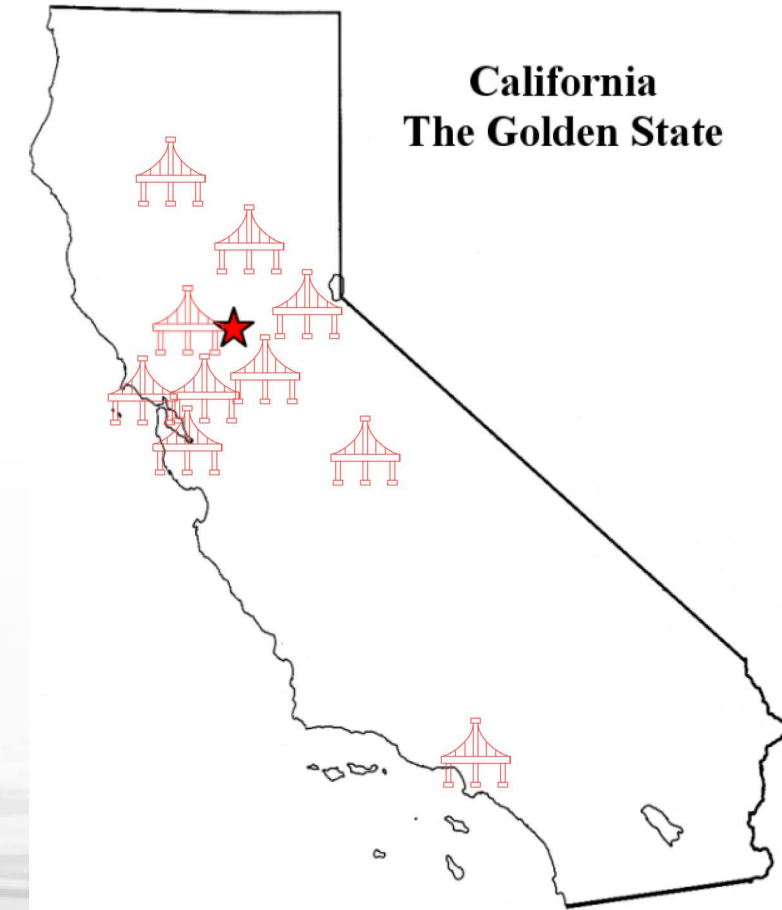




Caltrans Response

T-1
Inventory
March
2022

	Name	Year	Owner
1	Carquinez Straits Bridge	1958	CT
2	Whiskey Creek Bridge	1961	CT
3	Benicia-Martinez Bridge	1962	CT
4	San Mateo-Hayward Bridge	1967	CT
5	Canyon Creek Bridge	1967	DWR
6	Queensway Drive Bridge, Left	1969	CITY OF LONG BEACH
7	Queensway Drive Bridge, Right	1969	CITY OF LONG BEACH
8	Old US 50 OC	1970	CT
9	Bryte Bridge, Right	1971	CT
10	Bryte Bridge, Left	1971	CT
11	Don Pedro Reservoir Bridge	1971	CT
12	Auburn-Foresthill Bridge	1973	Placer County





Updated Inventory

Bridges
removed
from list

	Name	Year	Owner
1	Carquinez Straits Bridge	1958	CT
2	Whiskey Creek Bridge	1961	CT
3	Benicia-Martinez Bridge	1962	CT
4	San Mateo-Hayward Bridge	1967	CT
5	Canyon Creek Bridge	1967	DWR
6	Queensway Drive Bridge, Left	1969	CITY OF LONG BEACH
7	Queensway Drive Bridge, Right	1969	CITY OF LONG BEACH
8	Old US 50 OC	1970	CT
9	Bryte Bridge, Right	1971	CT
10	Bryte Bridge, Left	1971	CT
11	Don Pedro Reservoir Bridge	1971	CT
8	Auburn-Foresthill Bridge	1973	Placer County



Don Pedro Bridge



Caltrans approach...

Collaborative and Shared Responsibility

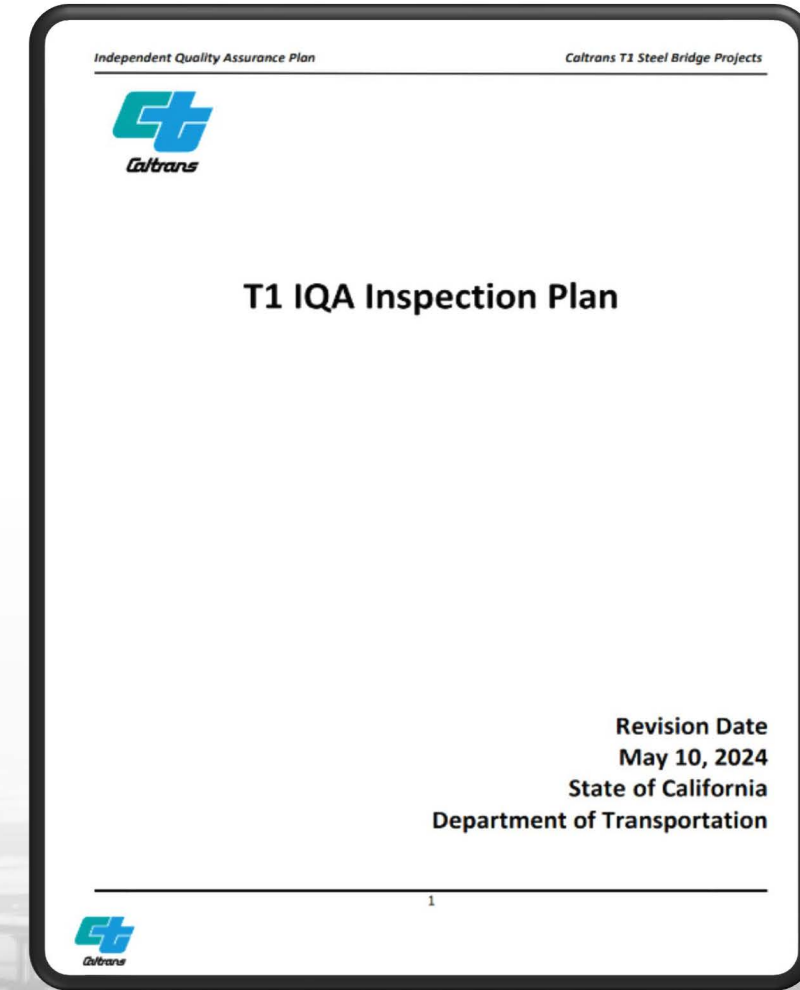
- Collaboration with federal and state divisions
 - Stakeholders:
 - FHWA
 - BATA
 - SM&I (Structure Maint)
 - METS
 - District Construction
 - Design
 - DWR
 - Placer County
 - City of Long Beach
 - Advisory Council





Testing Approach...

- Independent Quality Assurance (IQA) Plan
 - Rejectable with current AWS Standards
 - UT Technician Qualification
 - Defined Roles and Responsibilities
 - Contractor UT, QC UT & IQA (Caltrans) UT / PAUT
 - Escalation Ladder
- Jointly Construction, METS, Structure Maint.
- FHWA Concurrence





Pre-qualification for Level II Techs

Minimum Experience

5+ years of experience conducting UT
conducting UT on steel bridge
structures

Certification

ASNT Level II certification in
UT

Practical Demonstration

Successful demonstration of UT on
UT on steel test samples with known
known defects with D1.5 plates

First attempt: 42% pass rate
After retest: 60% pass rate



STATE OF CALIFORNIA • CALIFORNIA STATE TRANSPORTATION AGENCY
DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING SERVICES
MATERIALS ENGINEERING AND TESTING SERVICES
OFFICE OF QUALITY ASSURANCE AND SOURCE INSPECTION

Contract #: METS
EFIS #: _____
Vendor #: v

REPORT OF UT TECHNICIAN APPROVAL FOR T1 STEEL

To: Maged Armanuse, Certifying Authority Date: 1/3/2024
From: Michael Foerder, ASNT Level III 83755
Prime Contractor: _____ NDT Firm: METS
Bridge No.: Carquinez Bridge Overhead (Br. No. 23-0015R), Benicia-Martinez Bridge Overhead (Br. No. 28-0153L), and San Mateo-Hayward Bridge (Br. No. 35-0054)
Material to be Tested: Groove Welds in Butt Joints of Fracture Critical Bridge Members in Tension Governing Code: AWS D1.5 (2020)
Base Metal: T1 Steel (AASHTO M244, Grade 100 / ASTM A514) Thickness Qualified: Unlimited

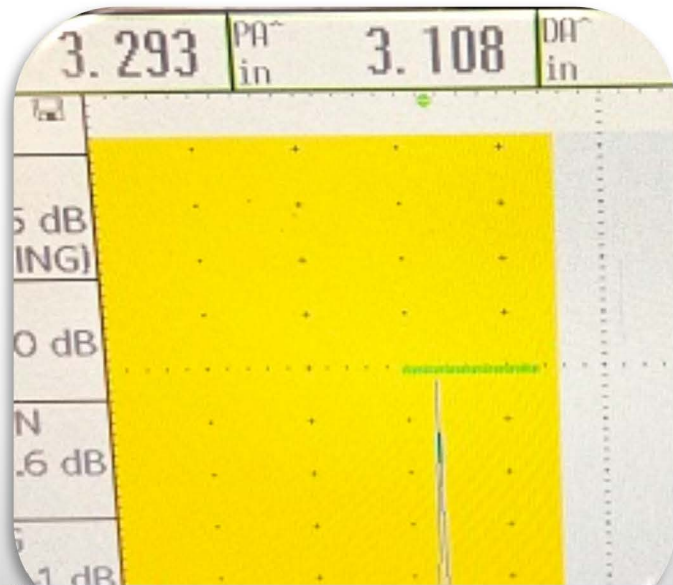
The following NDT personnel records provided for use on this contract have been reviewed by this office based on
earning AWS Code and contract documents.

Technician's	Technician ID	Qualified	Date	Date
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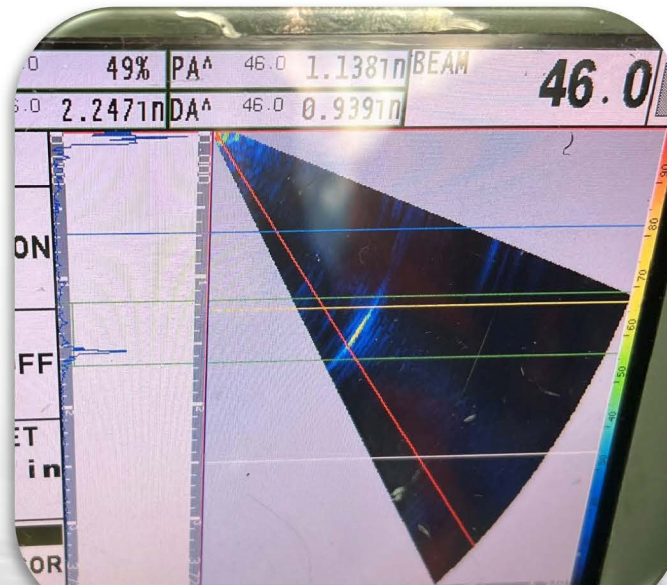
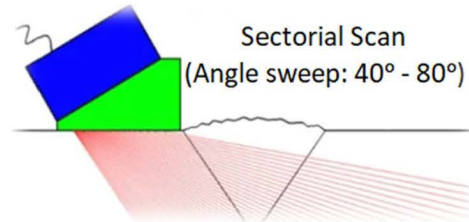
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How Are Welds Inspected?



Conventional UT



PAUT

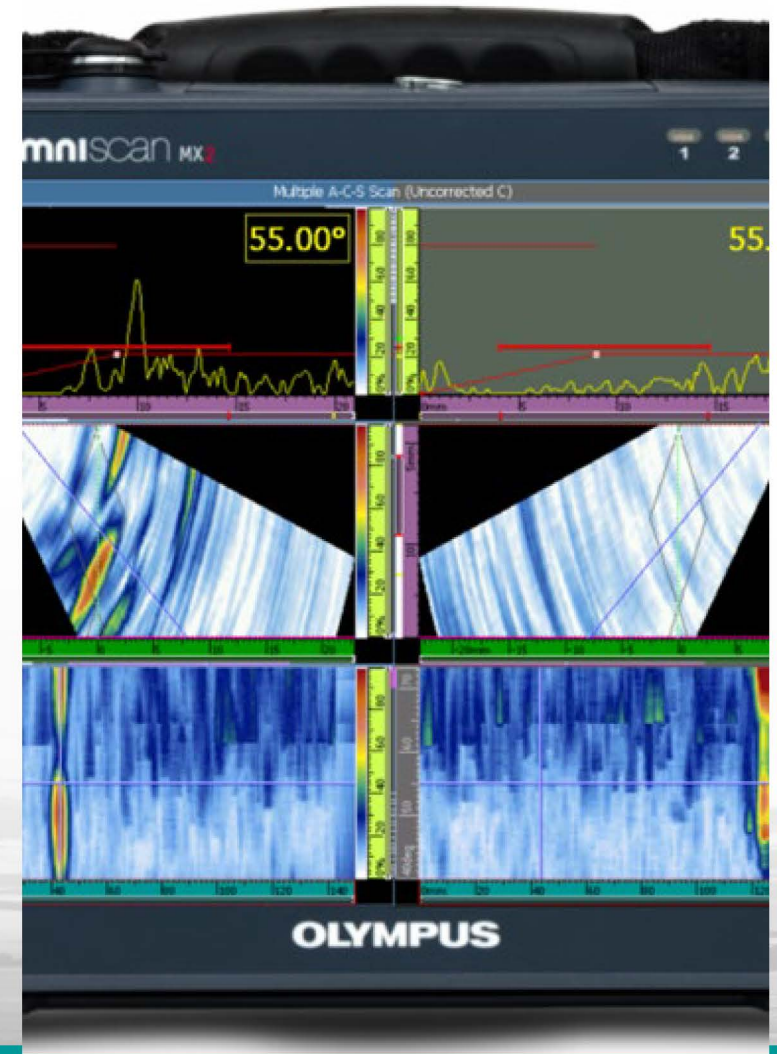


MT



Why not just Phased Array Ultrasonics for Inspection?

- FHWA memo required UT per AWS D1.5
- PAUT was not utilized during initial scanning for fabrication
- A transverse scan would still need to be performed to comply with D1.5
- Eliminating any potential inconsistencies between technician scans for applying root face criteria





Inspection of a weld



STATE OF CALIFORNIA - CALIFORNIA STATE TRANSPORTATION AGENCY
DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING SERVICES
MATERIALS ENGINEERING AND TESTING SERVICES
OFFICE OF QUALITY ASSURANCE AND SOURCE INSPECTION

Contract #: 02-0K2804
EFIS #: 0223000133
Vendor #: v1406

ULTRASONIC TEST REPORT FOR T1 STEEL

Contractor: Steelhead Constructors	Date: 1/25/2024
Location: Whiskeytown, CA	
Cal Block SN# 17-3733	Instrument SN# 19040023
Transducer SN# 19060037	Scanning Level: +35
Accept Criteria AWS TBL: 8.4	Material Thickness: 1.750"
Zero Degree Transducer: 200011CH	Diameter: 750"
	Frequency: 2.25 MHz

Weld Identification: Girder #2 Span #1 location 55.4 Bottom Flange

Scanning Pattern: X Coordinate: Distance from center of weld measured perpendicular to weld. Positive direction follows bridge panel joints. X coordinate was taken as approximate center line of butt joint.
Y Coordinate: For flanges, Y zero location taken from outboard edge. For webs, Y zero location taken from connecting flange.

Scanning Face: For flanges, face A taken as bottom face. For webs, face A taken as outboard face.

Lamination Scan: ☒ Scan performed on base metal, no lamination observed
☐ Lamination observed, action taken: _____

Weld Access: ☒ No obstructions, weld fully scanned by LUT
☐ Obstruction observed
Description: ☐ Choose an item ☐ Other: _____
Length affected: _____
Action Taken: ☐ Choose an item ☐ Other: _____
☐ Inaccessible weld observed, describe: _____

Information on Rejectable Indications
Description: _____ Discontinuity: _____

State of California
DEPARTMENT OF TRANSPORTATION
California State Transportation Agency

Memorandum

To: Doug Johnson, Resident Engineer
Attn: Nestor Angelo Perez, Jr. Structure Representative

Date: February 19, 2025

File: 04-3Y4104
Bericio-Martinez, Carquinez and San Mateo Bridges
NDT T1 Steel Welds

From: Mark Woods, Statewide T1 NDT Coordinator
Structure Maintenance & Investigation
DIVISION OF MAINTENANCE

Subject: REPAIR FOR WELD ON Bridge No. 28-0153L
West Truss, Span 12, Member 12-110, CBF2

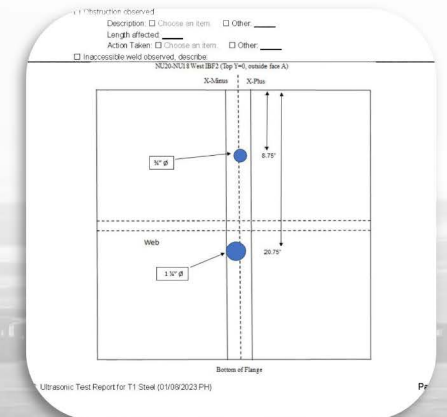
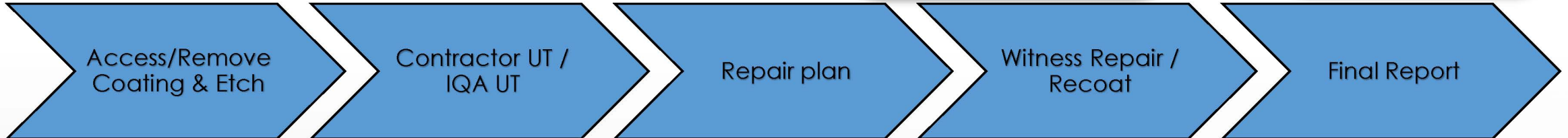
The weld at this location is shown to have multiple transverse indications (rejectable or recordable) throughout the length of the weld. These are consistent with base metal indications (or stringers). If also has a recordable indication described as 1-inch long, located at x = +0.025, y = 15.075.

Mark the location of these non-relevant transverse base metal indications (stringers) and the recordable indication with a point pen using a 2-foot offset and mark the offset marks so that they are not painted.

Mark P. Woods, PE
Office Chief
Structure Maintenance & Investigations -
Statewide T1 NDT Coordinator
DIVISION OF MAINTENANCE

02/19/2025
Date

*Provide a safe, accessible, integrated and efficient transportation system to enhance California's economy and mobility.



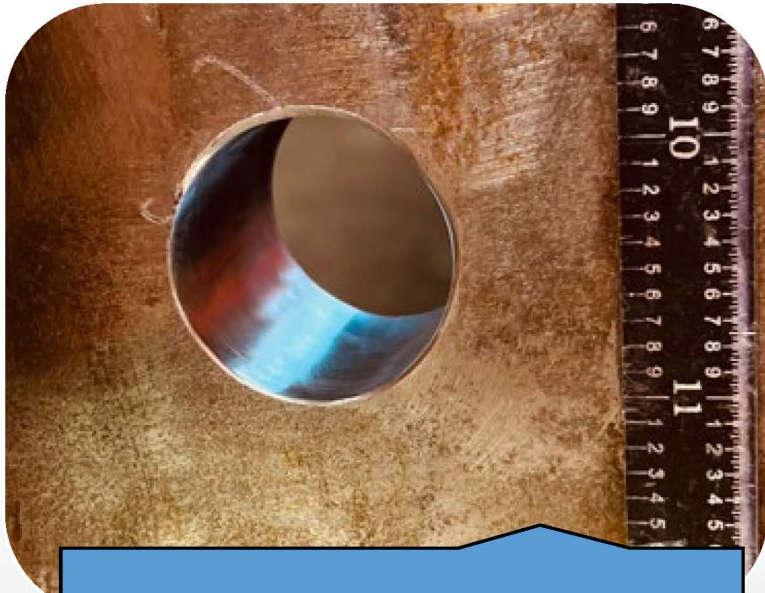
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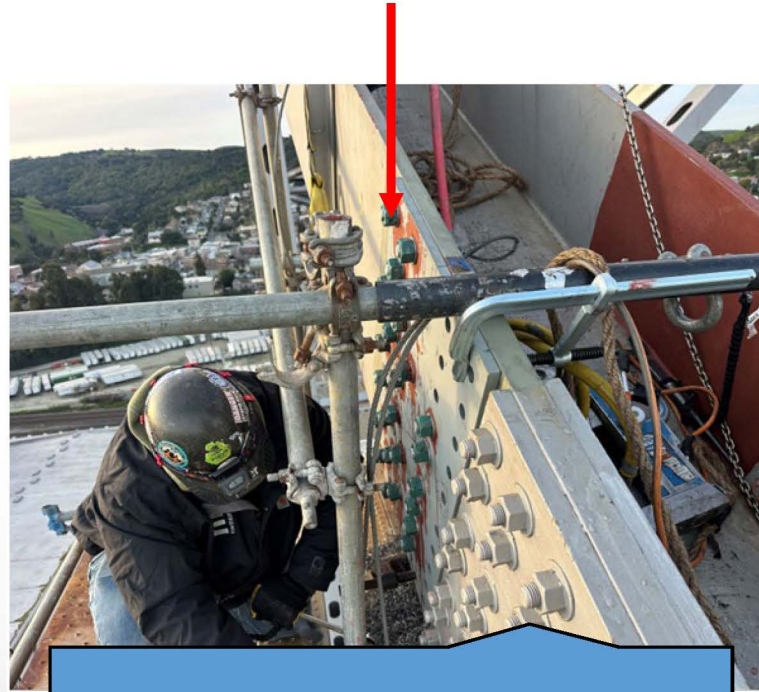




Typical Repairs



Drill outs



Plates



Crack Arrest with
Dog Bone Repair



Findings

	Name	Status	# of Welds
1	Whiskey Creek Bridge	UT Complete	96
2	Canyon Creek Bridge	UT Complete	72
3	Auburn-Foresthill Bridge	UT Complete	288
4	Carquinez Straits Bridge	UT Complete	262
5	Benicia-Martinez Bridge	Repairs Complete	1,186
6	San Mateo-Hayward Bridge	Final Report Complete	20
7	Queensway Drive Bridge, Left	Repairs Complete	8
8	Queensway Drive Bridge, Right	Repairs Complete	8

Highest reject rate: 88% rejectable Canyon Creek 1966

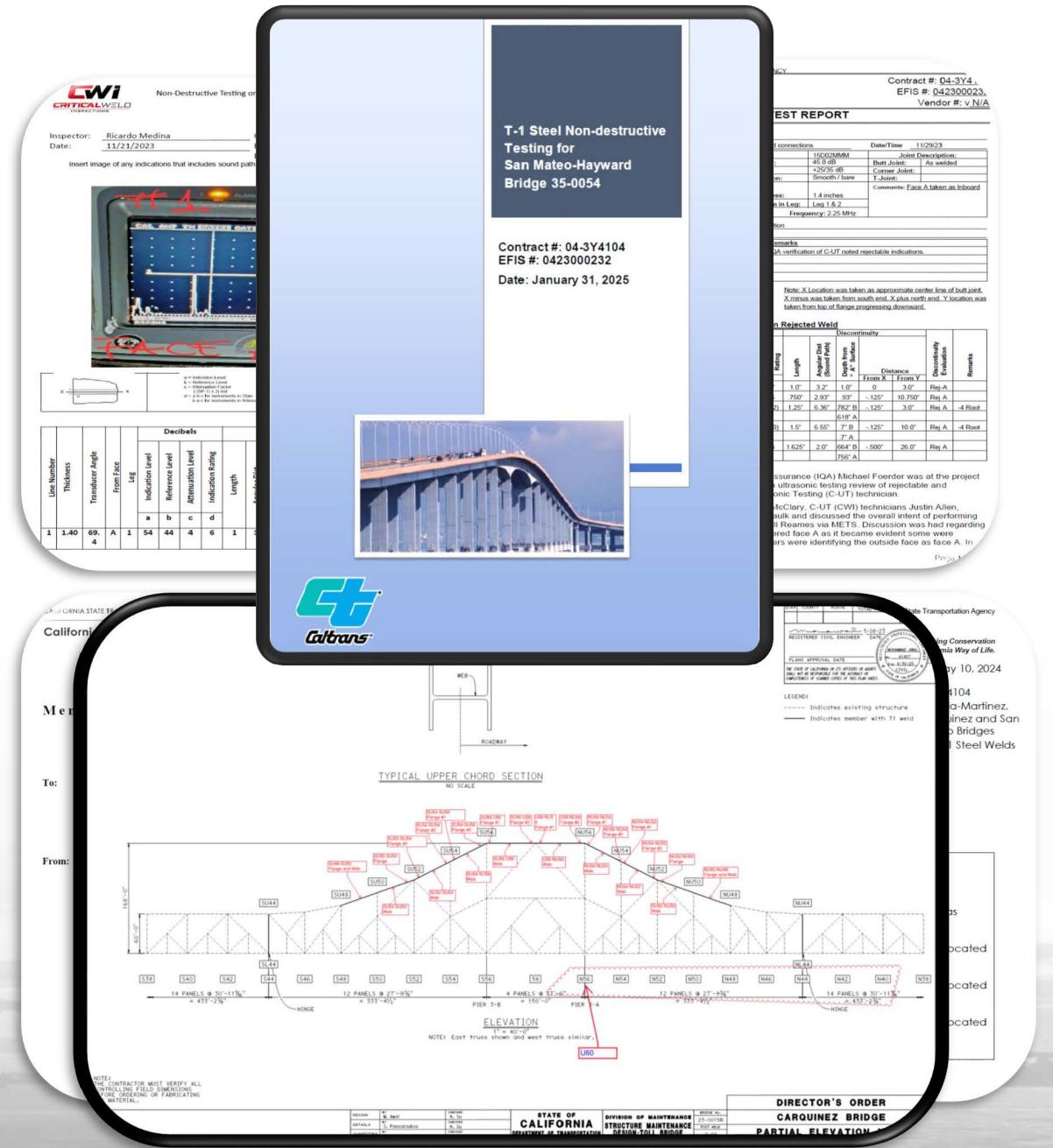
Lowest reject rate: 15% Foresthill and Benicia-Martinez



Final Product

What do we get with all this work?

- UT reports from METS/ Contractor
- Repair memos
- Repair reports
- Plate repair reports
- Final Reports
- As Built

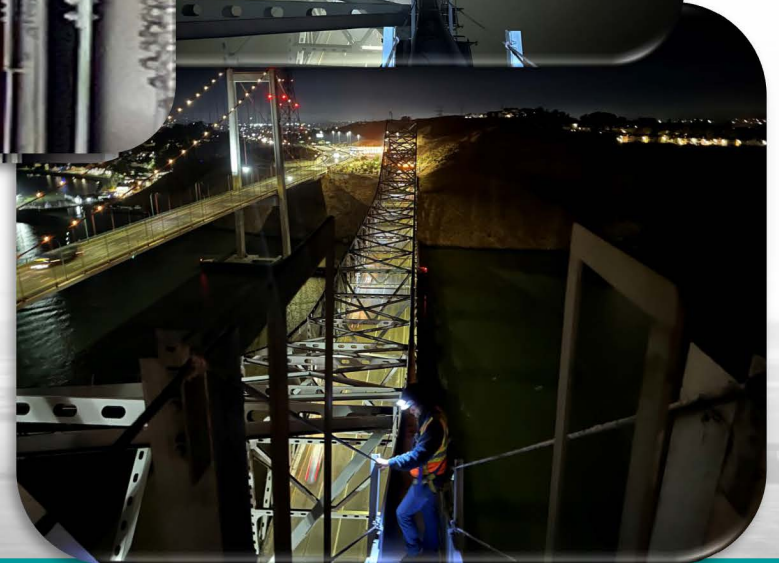
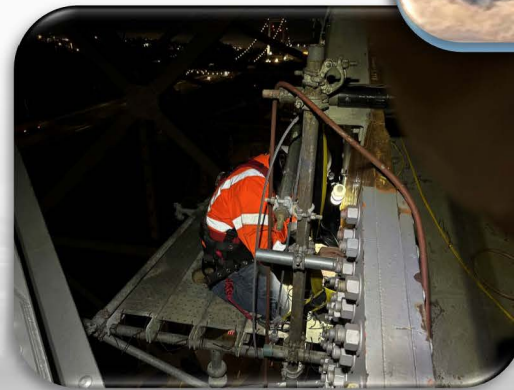
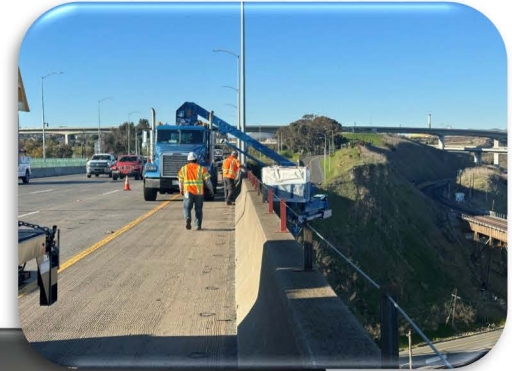




Challenges: Access

(Benicia-Martinez & Carquinez)

- Lane Closures
- UBIT & Platforms
- Nightwork & Weather
- Ped Access & Traveler Use

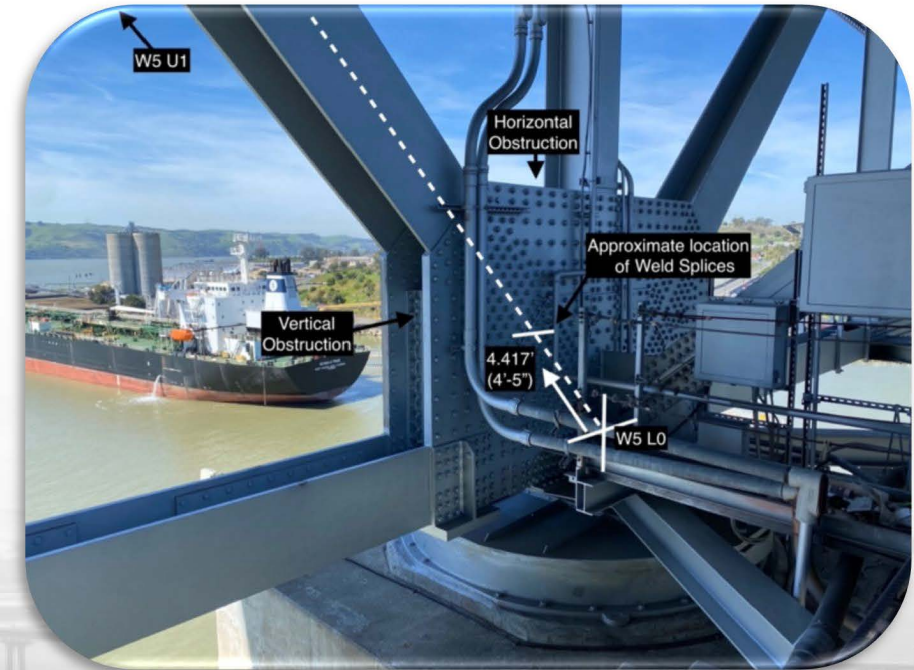


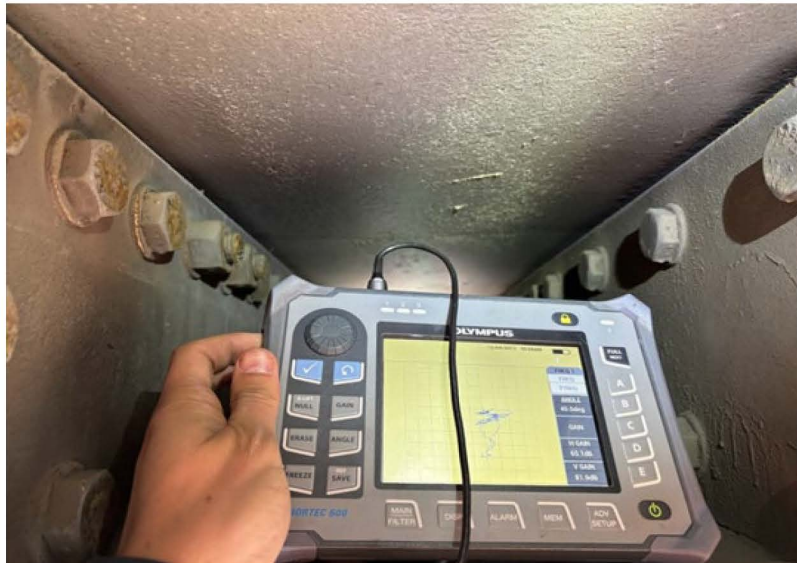
Challenges: Inaccessible welds

On Benicia-Martinez - Over 100 initially Inaccessible welds

Addressed:

- Custom solutions to each of the four scenarios





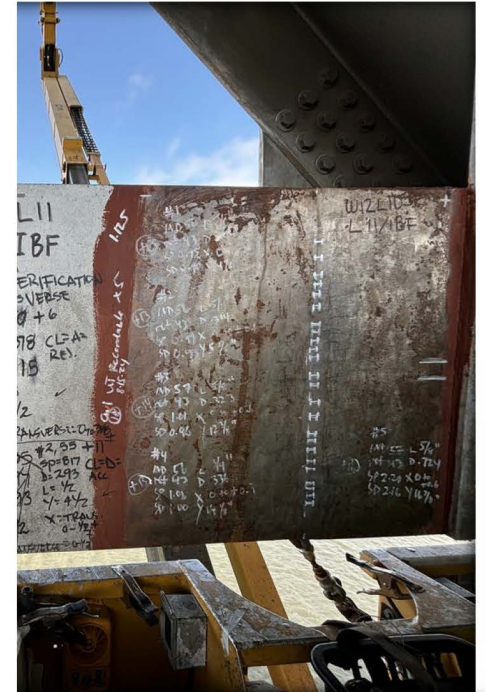
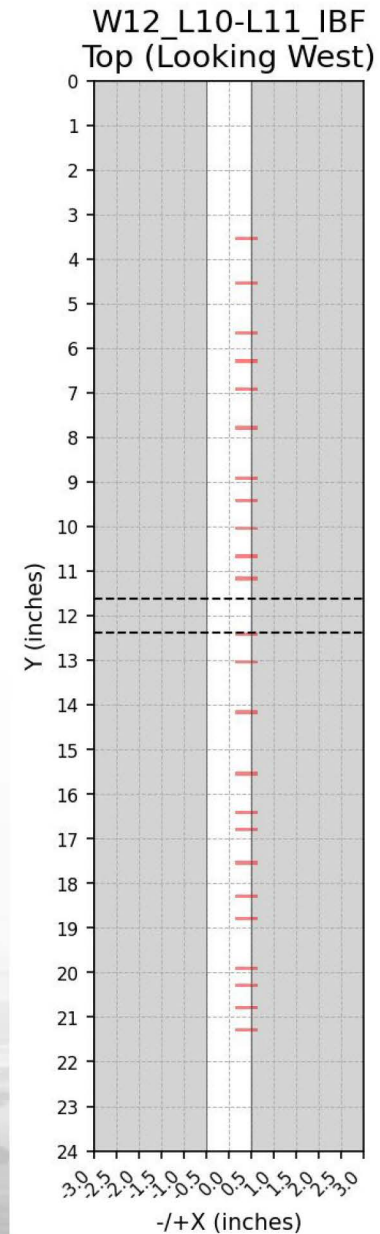
Challenges: Identifying welds through thick paint

- **Issue:** Weld locations obscured by paint
- **Solution:** Eddy Current confirmed weld location through thick paint systems.
 - Eliminated the need for large-scale paint removal
 - Reduced preparation time.
 - Reliable foundation for subsequent UT examinations.



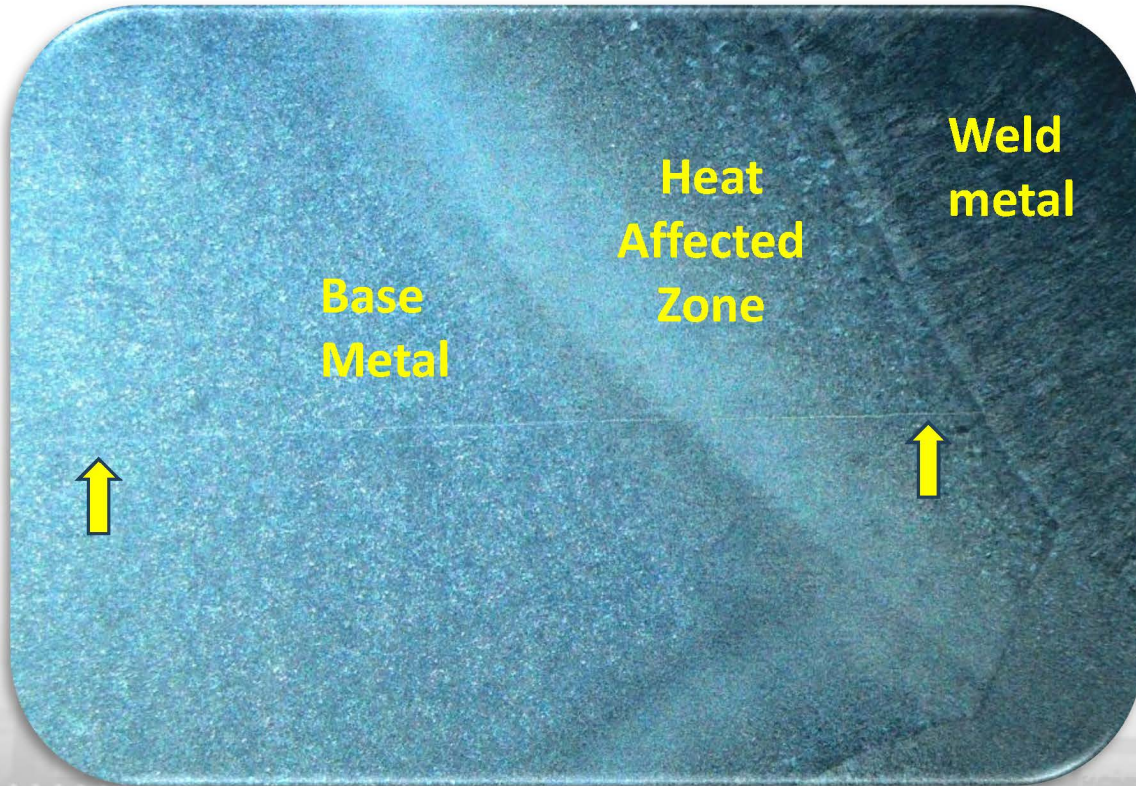
Transverse Base Metal Indications and Use of Metallography

- PAUT and refined weld depictions revealed linear indications within base metal (not weld flaws).
- Confirmed by microscopy and cross-checking with inspection data.
- Documented and separated from weld rejects to avoid unnecessary repairs.
- Findings guided a refined inspection strategy for similar cases.

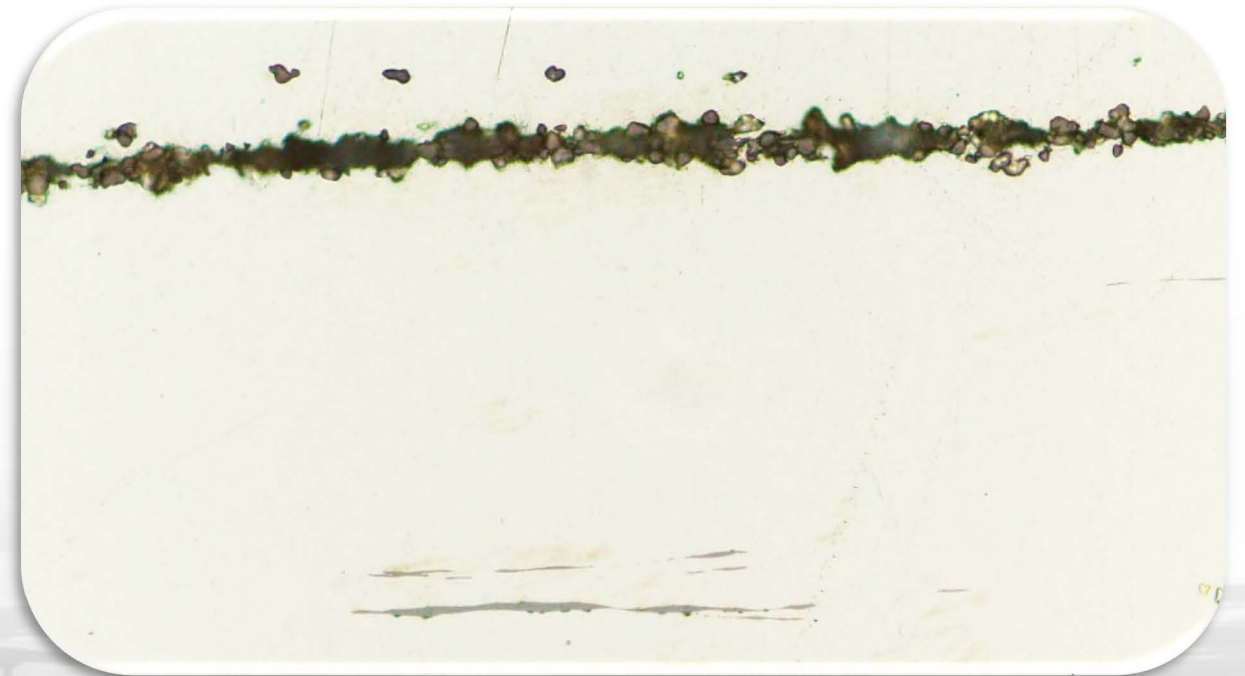


Challenges...

Base metal indications (San Mateo Bridge)



Magnification 1x

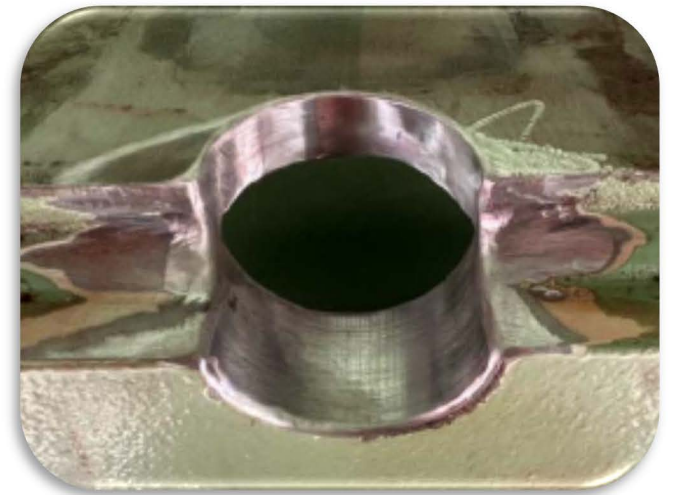


Magnification 50x



Challenges...

- Auburn-Foresthill Bridge
- Surface breaking linear indications
- Potential Hydrogen Cracking
 - Consistent with FHWA memo





Acknowledgements...

Collaborative and Shared Responsibility

- **FHWA** – Chris Long, Adam Fisher
- **SM&I** – Vassil Simeonov, Mark Woods, Mike Lee, Nick Semander, Diana Campbell
- **Structure Construction** – John Lammers, David Tenorio, Christian Santos, Elpido Perez, Jason Wilcox, Angelo Perez Jr, Matt Crete, Sonny Fereira, Eric Chaffee
- **METS** – Tim Greutert, Keith Hoffman, Maged Armanuse, Anshul Wankhede, Seyedhamed Sadati, Phil Latasa, Aaron Franklin, Justin Palmaymesa, Jinesh Mehta, Mike Foerder, Jason Gramlick, Ryan Parr, Paul Farinha, Cory Ehlert, David Weeks
- **BATA, City of Long Beach, County of Placer, DWR**
- **Advisory Council** – Rich Foley, Mauricio Serrano, Sarah Hartz, Sudhakar Vatti
- **Industry Expert** - Dr. Connor
- **Contractors** (CM, Primes, QC firms) – Golden State Bridge, Steelhead Inc., Serafix, Atlas Technical Consultants, Kleinfelder, Critical Weld Inspection, ISI Inc.





Acknowledgements...

Collaborative and Shared Responsibility



ASCE Sacramento Section
2024 Outstanding Bridge Project Award
T-1 Steel Bridge IQA Inspection Contract



Thank You!

