Blue Water Bridge #1 Anchor Link Replacement

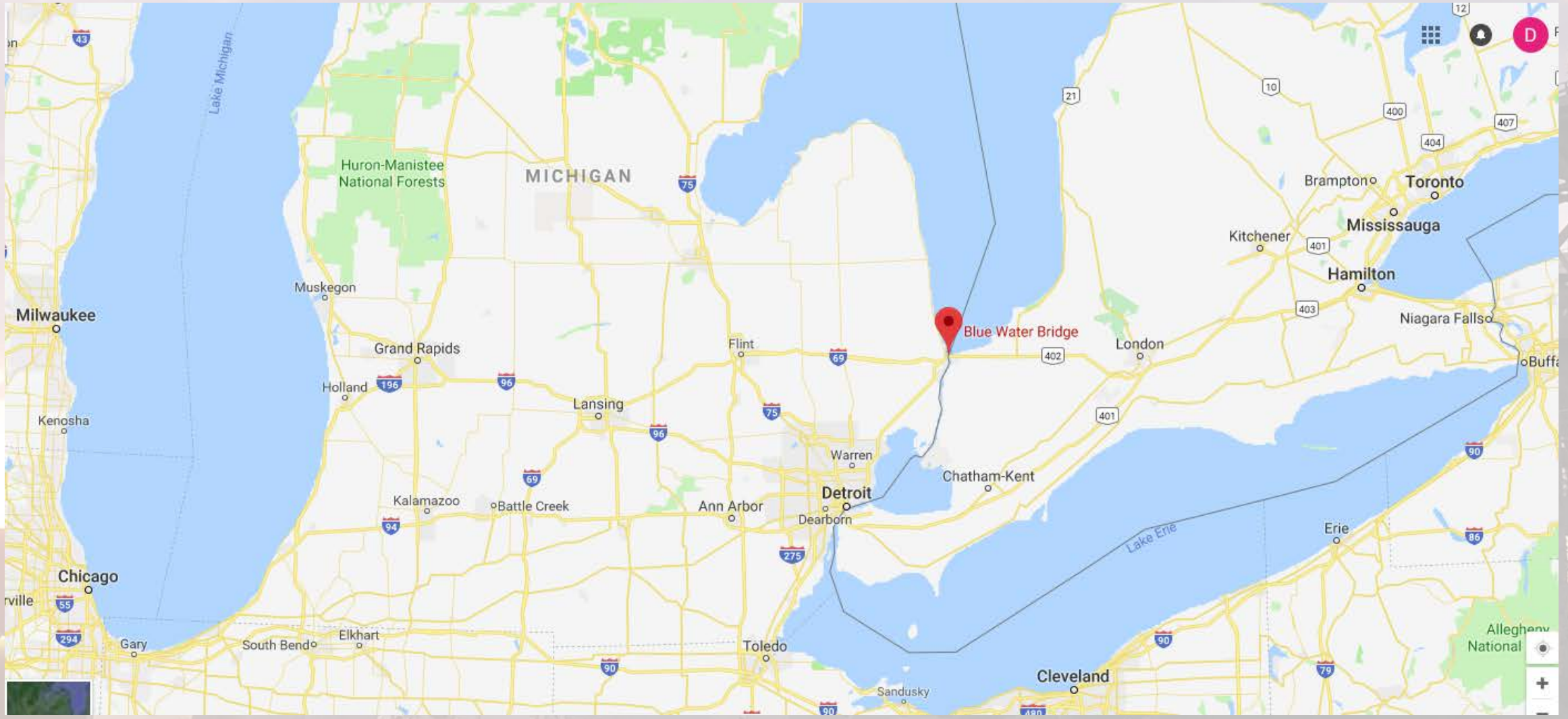
Presenters

Craig Dashner, P.E.
Construction Manager/Partner

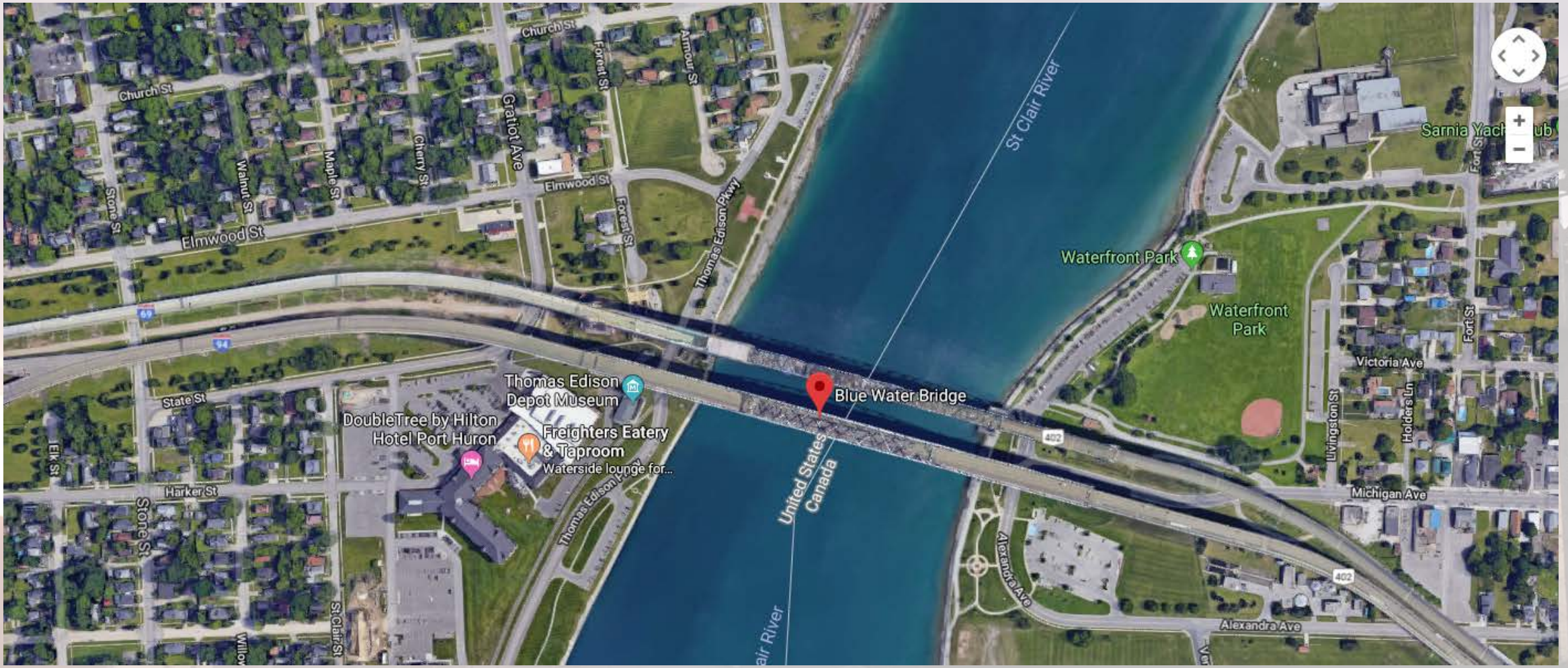
Thomas Bachmayer
Engineer

OHM Advisors

Project Location

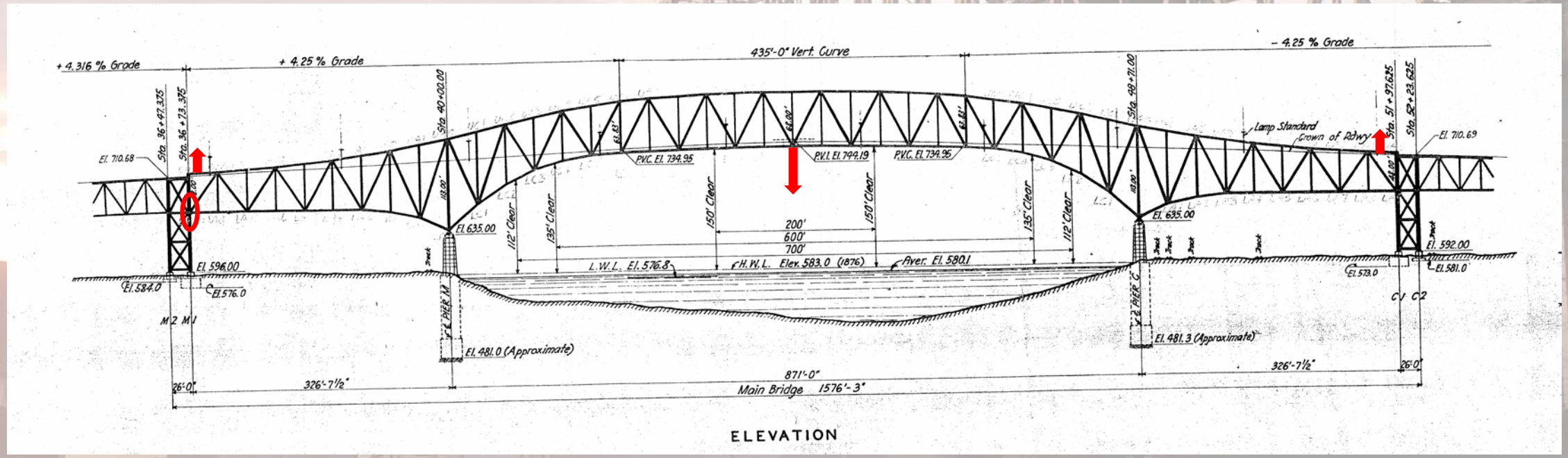


Project Location



Bridge Information

- Built 1938
- Spans the St. Clair River at the mouth of Lake Huron
- Spans: 326’-871’-326’



Design Challenges and Solutions

- Link is *INSIDE* the tower leg
  - Temporary support outside
  - Durable materials and coatings
    "get in, get out, stay out"
- Link is a Fracture Critical member
  - Multiple link plates: A709 GR HPS 70W
  - Forged Pin Material: Stainless Steel A705 UNS S45000/XM-25/Custom 450
- Geometry and alignment
  - Did not re-use existing bearing surfaces
  - Slotted holes in lower pin plates

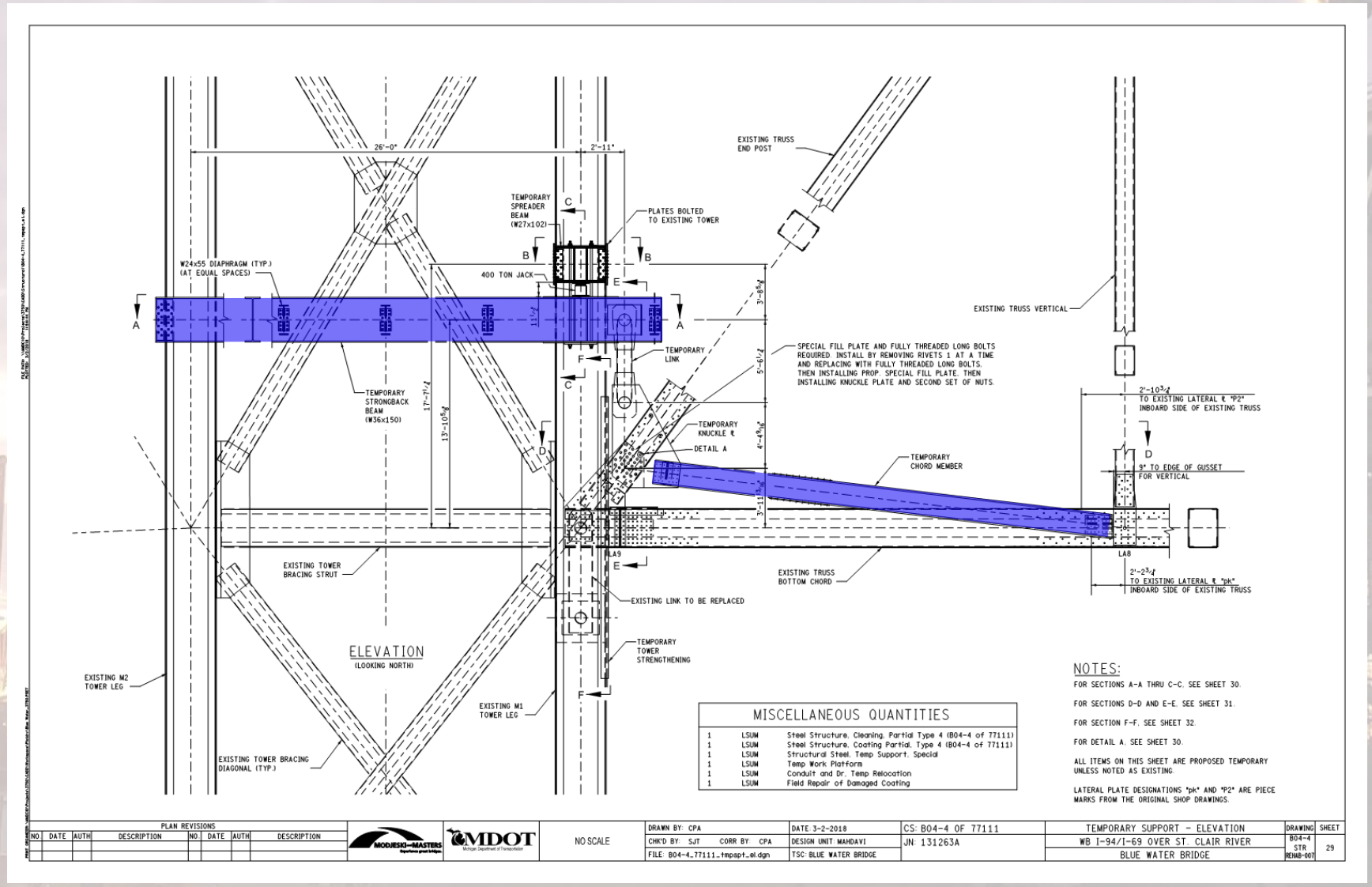
Design Challenges and Solutions

Design Challenges and Solutions

- Temporary support away from work
  - Connect to gusset using special cheese-plate fill and long bolts

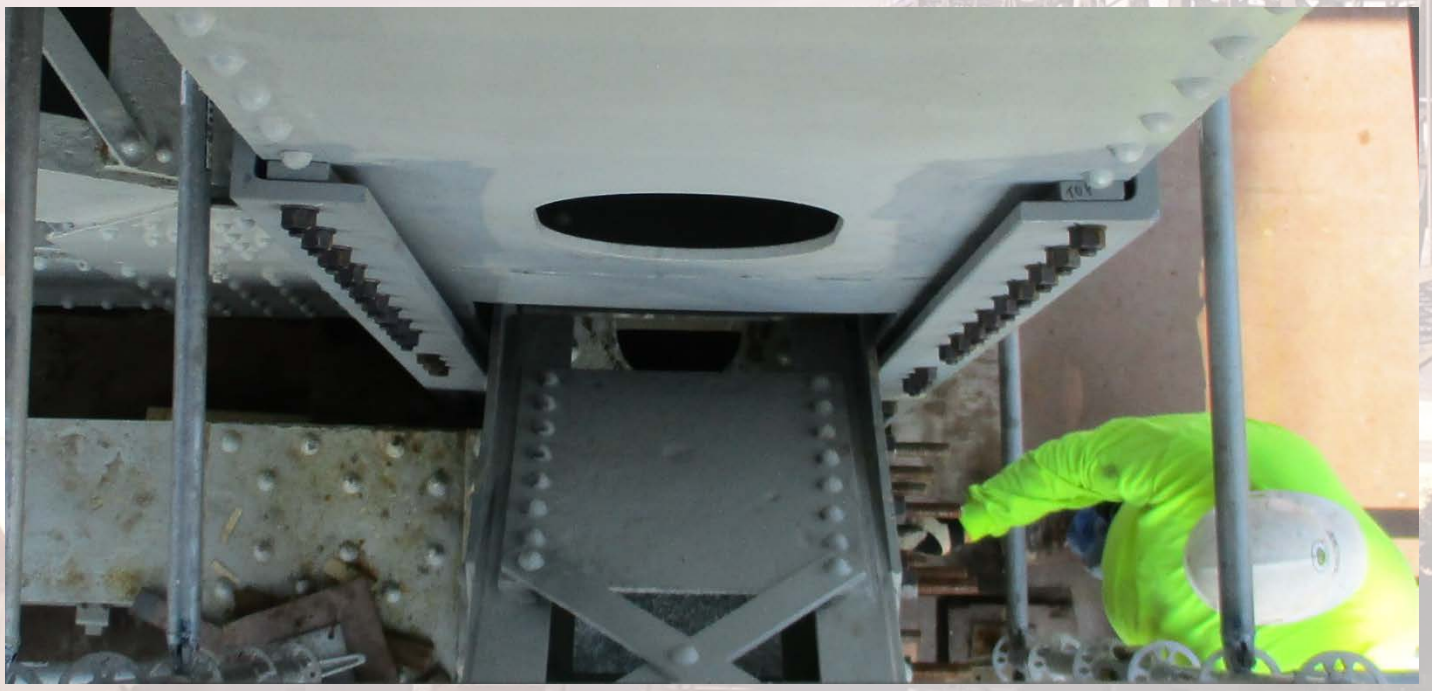
Design Challenges and Solutions

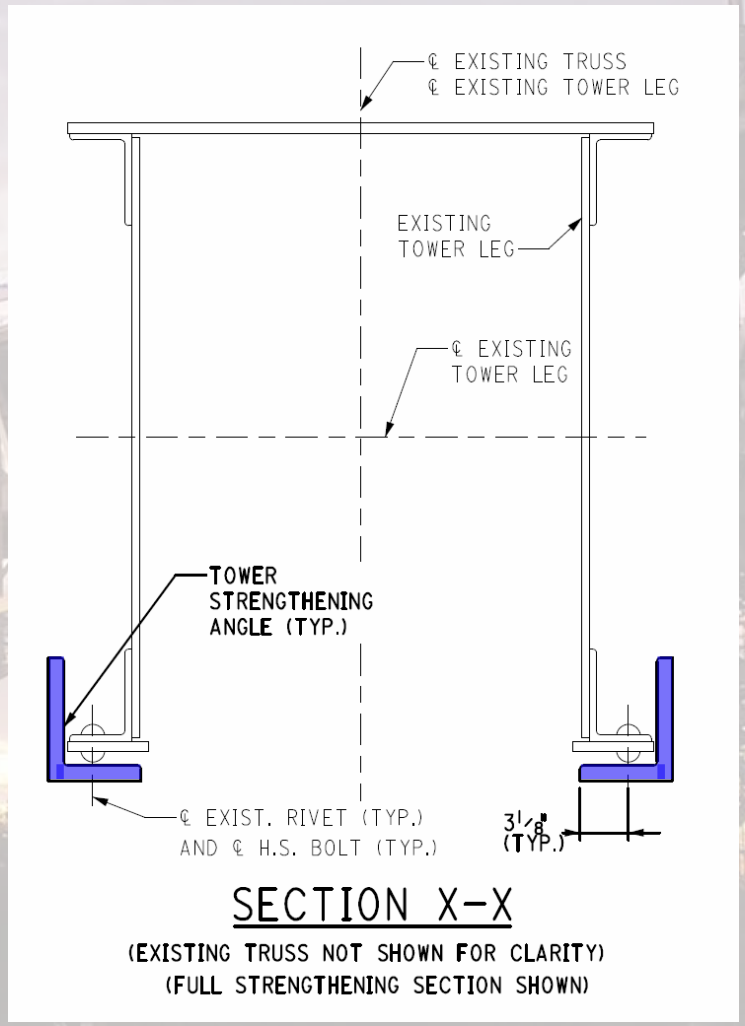
- Temporary support Eccentric connections
  - Temp bot. chord
  - Temp strongback



Design Challenges and Solutions

- Removal of tower cover plate for access
  - Lane closure for removal
  - Temp. strengthening angles for work duration





Design Process - CMGC

- Early involvement
- 30%, 60%, 90% Review and Cost Estimates
- Avoid unknowns
- Ensure feasibility
- Eliminate double work
- Decrease construction issues and RFI's
- Guaranteed Maximum Price (GMP)

- Owner
  - MDOT, Blue Water Bridge
- Designer
  - Modjeski and Masters
  - DLZ
- Contractor
  - PCL, Toebe

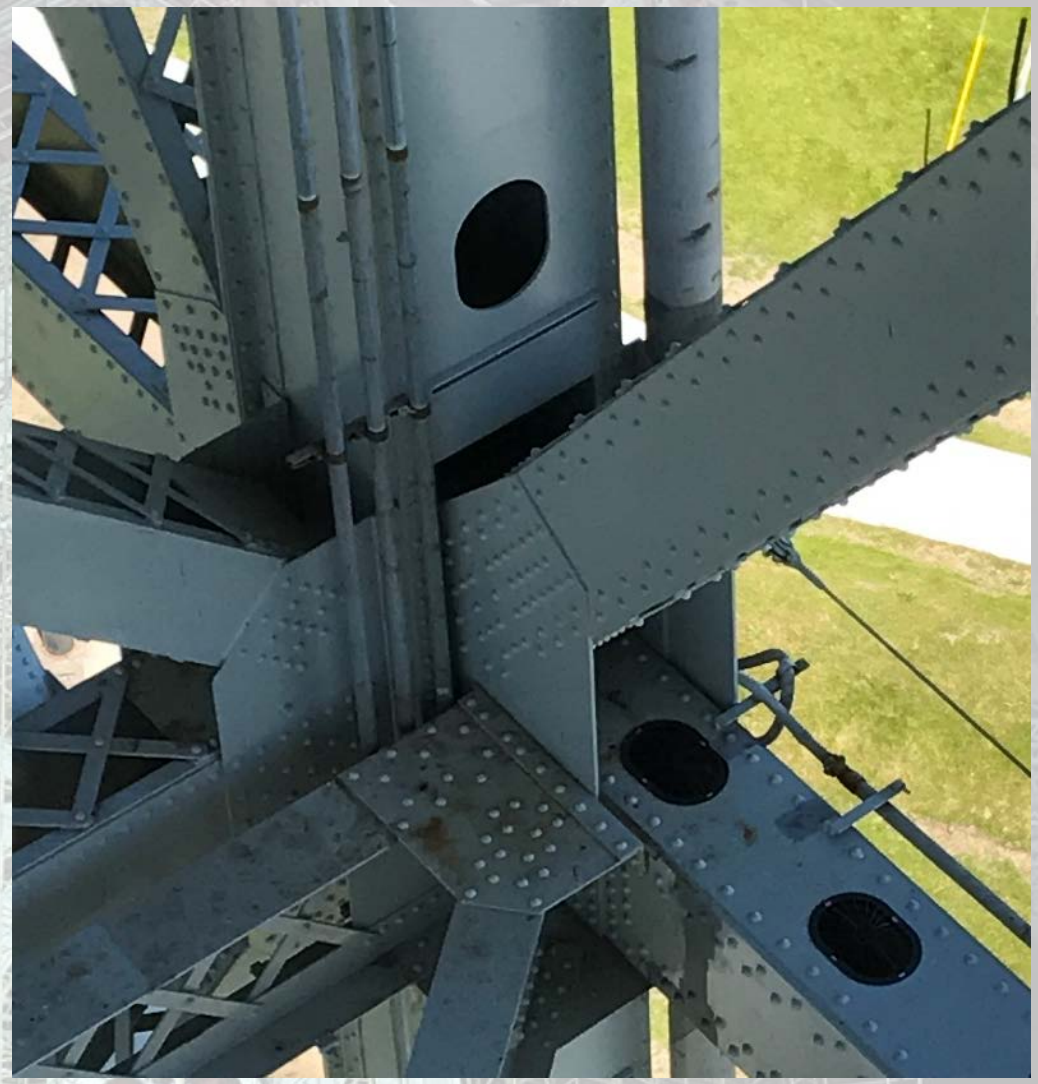
Construction Challenges

- Utility Conflicts
- Access
- Installation of Temporary Support
- Load Transfer
- Removal of Existing Links and Pins
- Operator/MITA Issue
- Installation of New Links and Pins

Utility Conflicts and Solutions

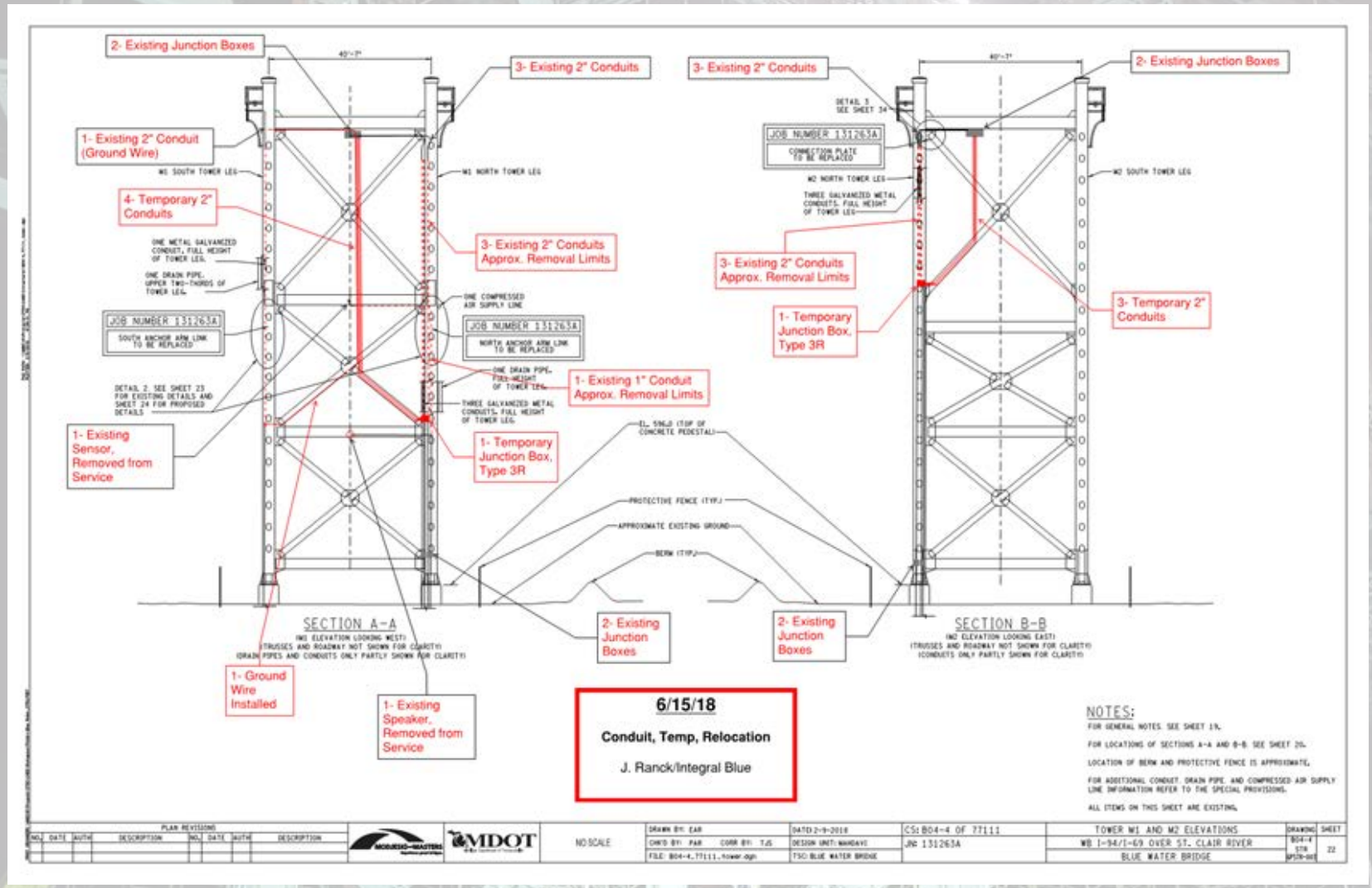
- Conflicts:
  - Electric, fiber optic, ITS
  - Storm water drainage
  - Fire Suppression Line
  - Limited to man lifts

- Solutions:
  - Relocation of:
    - Fiber Optic
    - ITS
    - Electrical
    - Drainage
- Two weeks to relocate



Utility Conflicts Solutions

Temporary Conduit Relocation

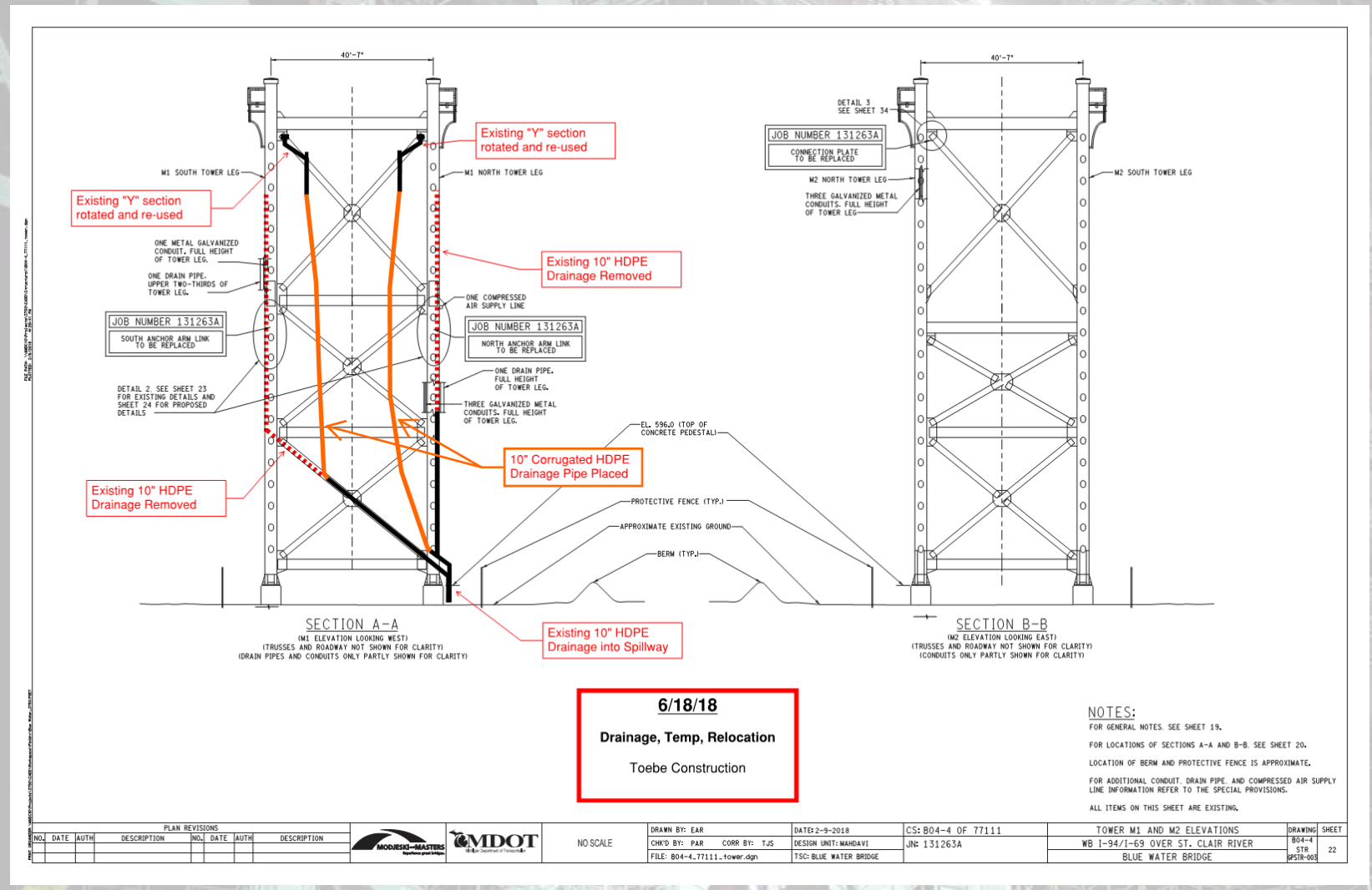


Utility Conflicts Solutions

Temporary Conduit Relocation

Utility Conflicts Solutions

Temporary Drainage Relocation



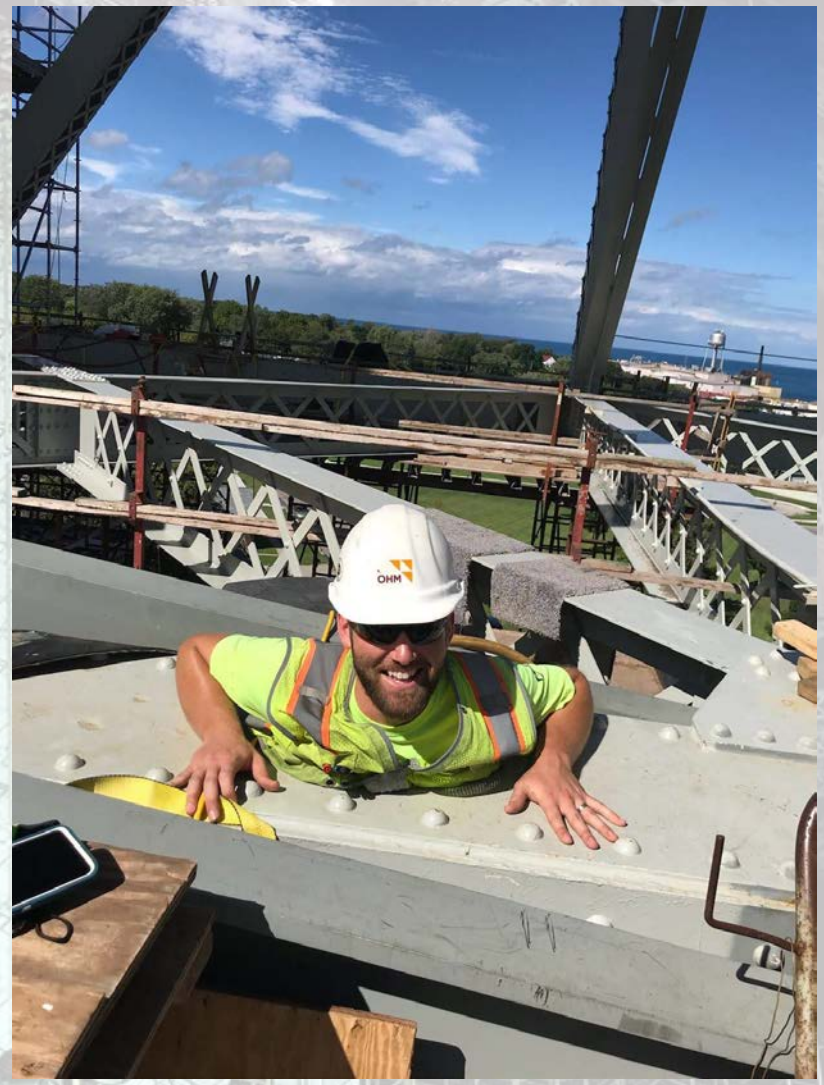
Utility Conflicts Solutions

Temporary Drainage Relocation

Accessing the Bridge

- Location of anchor links
  - 85 ft +/- above ground
  - 20 Kip Shoring/Scaffolding
  - Man Lifts
- Limited access at tight spots
  - Inside tower legs (roughly 2’5” x 3’3”)
  - Inside horizontal chords of truss tower
  - Inside existing truss bottom chord

Accessing the Bridge



Access Solutions

Work Platform

- 20 Kip Shoring/Work Platform
- Stair Tower
- 32 Scaffold Towers total, capacity of 20 kips each
- 4 weeks to install

Access Solutions

Work Platform

Access Solutions

Work Platform

Access Solutions

Work Platform

Access Solutions

Work Platform

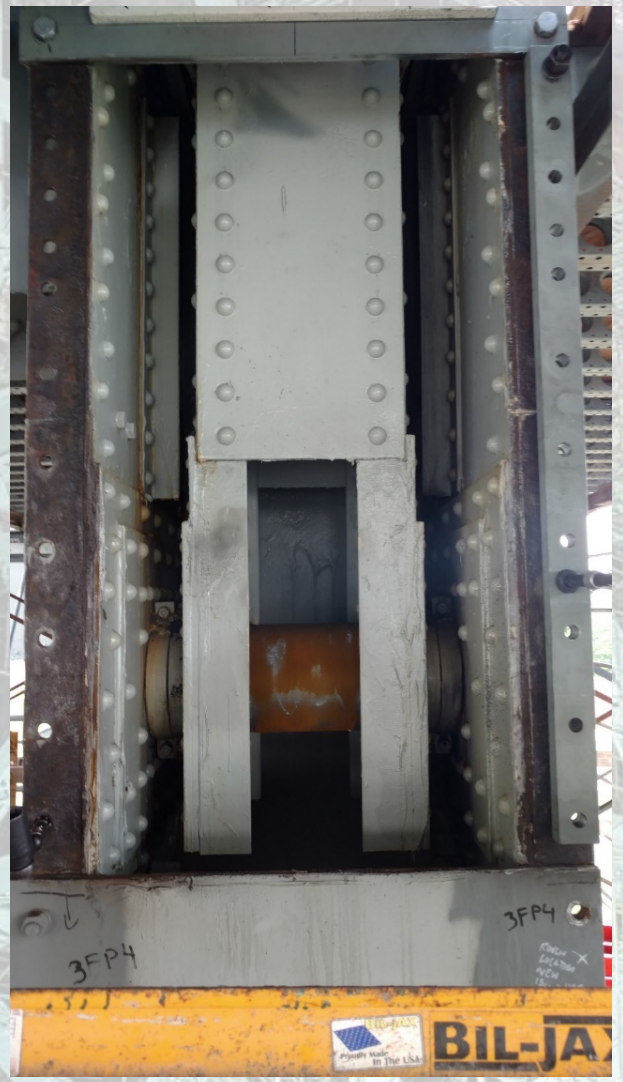
Access Solutions

Perforated Cover Plate Removal

- M1 Tower Legs at Links
- Allowed for removal of old links, placement of new links
- Coincided with Tower Strengthening

Access Solutions

Perforated Cover Plate Removal



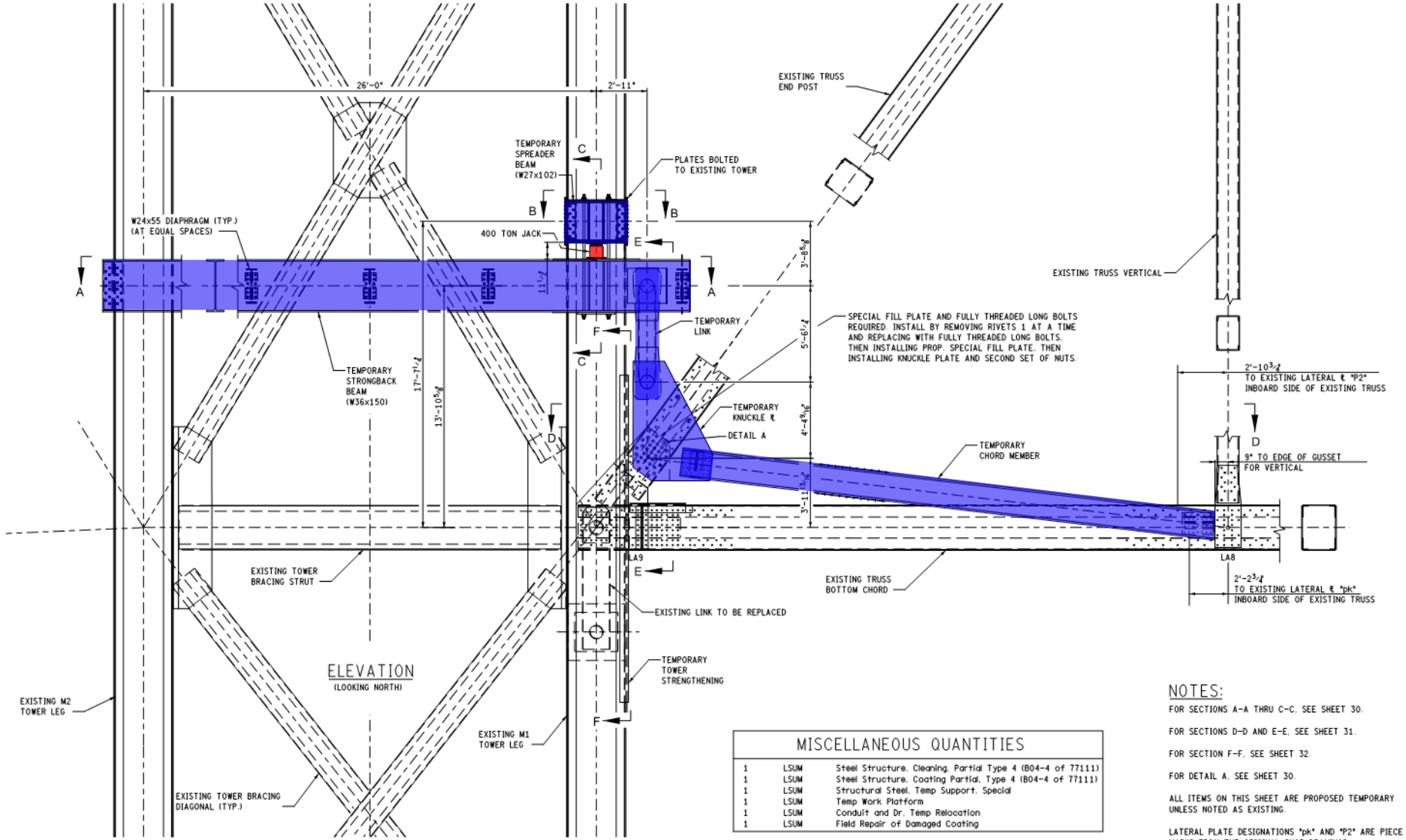
Access Solutions

Temporary Lacing Removal

- Approved for removal (wind loading member)
- Access to:
  - upper pin for removal
  - line boring
  - painting
  - placement of new pin

Temporary Support System

- Multiple components:
  - Tower Strengthening
  - Connection Plates to Tower Legs
  - Strong Back Beams/Diaphragms
  - Spreader Beams
  - Pins/Links
  - Knuckle Plates
  - Lower Cords/Diaphragms



MISCELLANEOUS QUANTITIES

1	LSUM	Steel Structure, Cleaning, Partial Type 4 (B04-4 of 77111)
1	LSUM	Steel Structure, Coating Partial, Type 4 (B04-4 of 77111)
1	LSUM	Structural Steel, Temp Support, Special
1	LSUM	Temp Work Platform
1	LSUM	Conduit and Dr, Temp Relocation
1	LSUM	Field Repair of Damaged Coating

NOTES:

FOR SECTIONS A-A THRU C-C, SEE SHEET 30.

FOR SECTIONS D-D AND E-E, SEE SHEET 31.

FOR SECTION F-F, SEE SHEET 32.

FOR DETAIL A, SEE SHEET 30.

ALL ITEMS ON THIS SHEET ARE PROPOSED TEMPORARY UNLESS NOTED AS EXISTING.

LATERAL PLATE DESIGNATIONS "pk" AND "P2" ARE PIECE MARKS FROM THE ORIGINAL SHOP DRAWINGS.

PLAN REVISIONS							
NO.	DATE	AUTH	DESCRIPTION	NO.	DATE	AUTH	DESCRIPTION

MODJESKI—MASTERS

MDOT Michigan Department of Transportation

NO SCALE

DRAWN BY: CPA	DATE: 3-2-2018	CS: B04-4 OF 77111	TEMPORARY SUPPORT - ELEVATION
CHK'D BY: SJT CORR BY: CPA	DESIGN UNIT: MAHDAVI	JN: 131263A	WB I-94/I-69 OVER ST. CLAIR RIVER
FILE: B04-4_77111_tmpspt_el.dgn	TSC: BLUE WATER BRIDGE		BLUE WATER BRIDGE

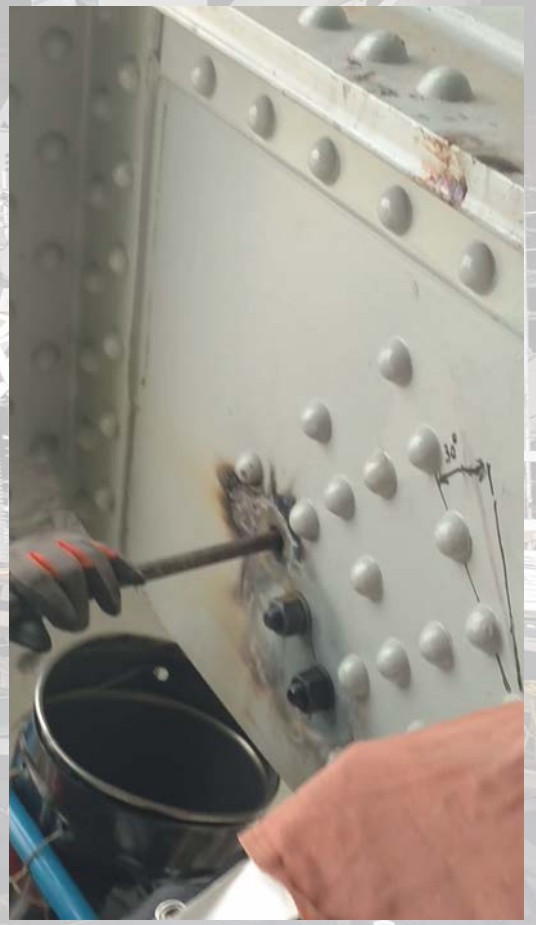
DRAWING	SHEET
B04-4 STR REHAB-007	29

Temporary Support System – Rivet Removal

- Rivet Removals Required at:
  - Connection Plates
    - 72 Rivets
  - Tower Strengthening Angles
    - 72 Rivets
  - Knuckle Plates
    - 140 Rivets
  - Lower Cords
    - 12 Rivets

Temporary Support System – Rivet Removal
Torch Method



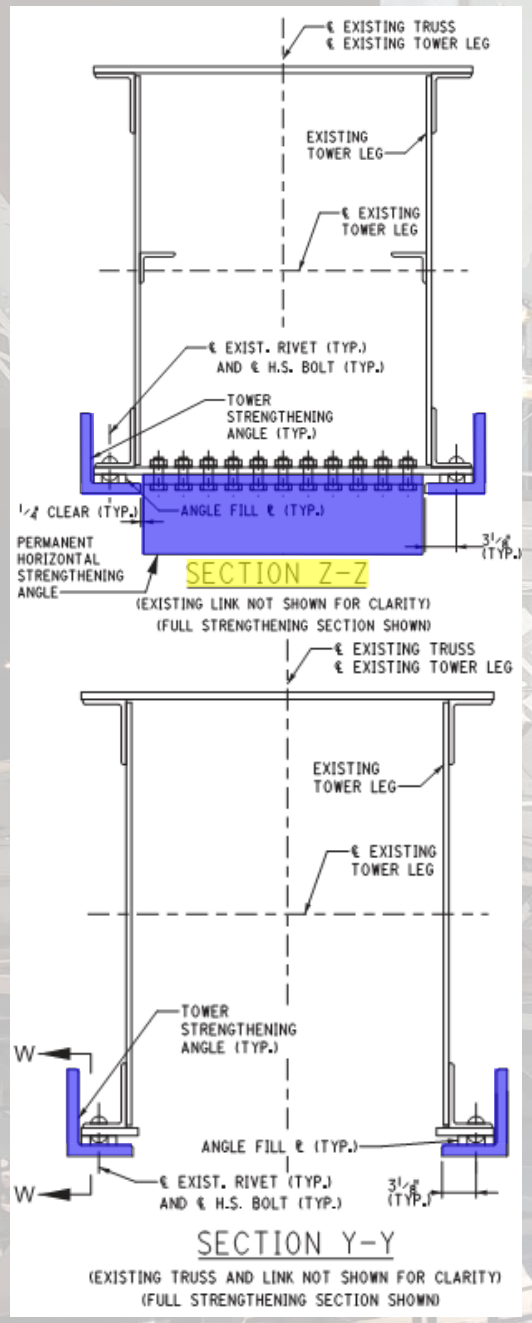



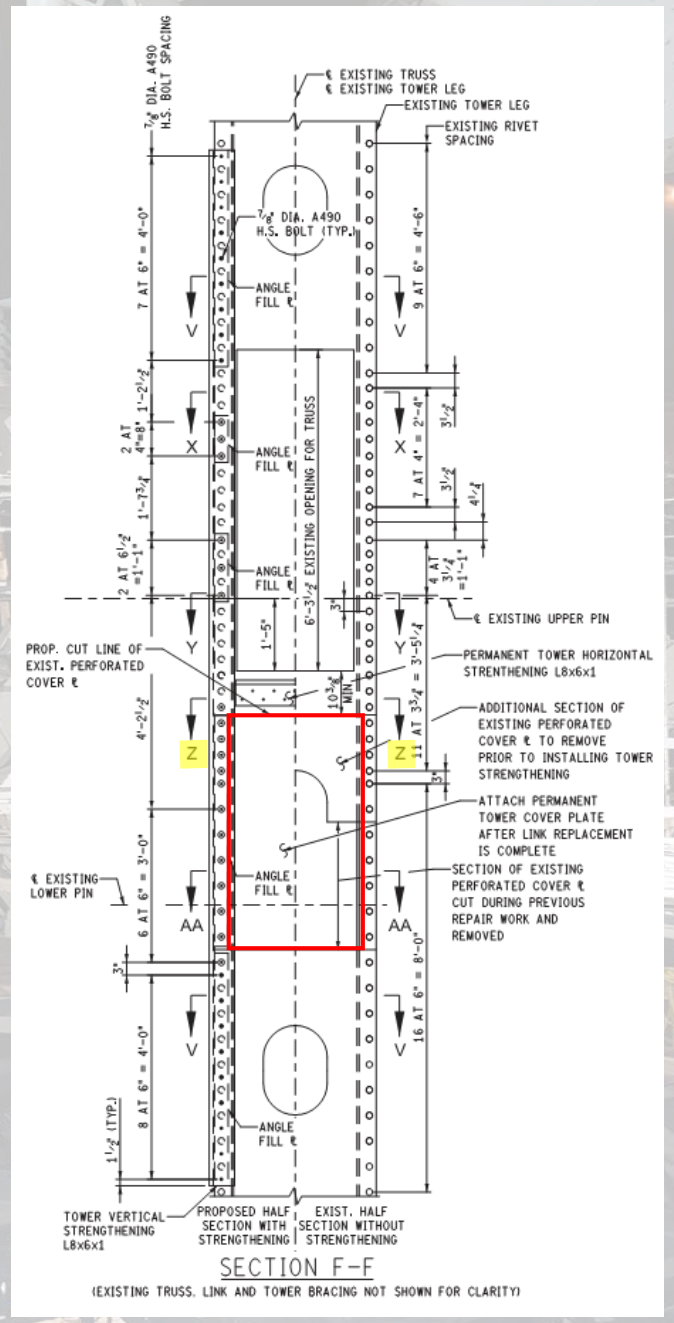
Temporary Support System – Rivet Removal

Rivet Buster Method

Temporary Support System
Tower Strengthening

- Tower Strengthening required after removal of perforated cover plate
  - Vertical Angles
    - Multiple Fill Plates
  - Permanent Horizontal Angle





Temporary Support System

Tower Strengthening

Temporary Support System

Tower Strengthening

Temporary Support System

Tower Strengthening

Temporary Support System

Connection Plates to Tower Legs

M1 Tower Legs:

- Connection Plates
  - Provided connection for Spreader beams
  - Both sides of Tower leg
  - Jacking forces transferred to tower leg through connection plate
  - Required field cut access hole

Temporary Support System

Connection Plates to Tower Legs

M2 Tower Legs:

- Stiffened Connection Plates
  - Provided connection for Strong Back beams
  - West side of Tower leg
  - Required field cut access hole
  - Conflict with existing rivet pattern

Temporary Support System
Spreader Beams (M1)

Spreader Beams

- Means for jacking truss during load transfers
- Threaded rods through spreader beams supported Strong Backs
- N and S sides of M1 tower legs

Temporary Support System

Strong Back Beams

- Strong Back Beams/Diaphragms
  - Installation challenging – Length of beams greater than width of Truss Tower
  - Scaffolding conflicted with placement
  - Heavy
  - Connected at M2 stiffened connection plates, suspended at M1 Spreader Beam
  - East end of Beams supported Temporary Pins/Links
  - Four Diaphragms each

Temporary Support System

Strong Back Beams

Temporary Support System

Strong Back Beams

Temporary Support System

Strong Back Beams

Temporary Support System

Strong Back Beams Positioned

Temporary Support System

Temporary Pins and Links

Temporary Support System

Knuckle Plates

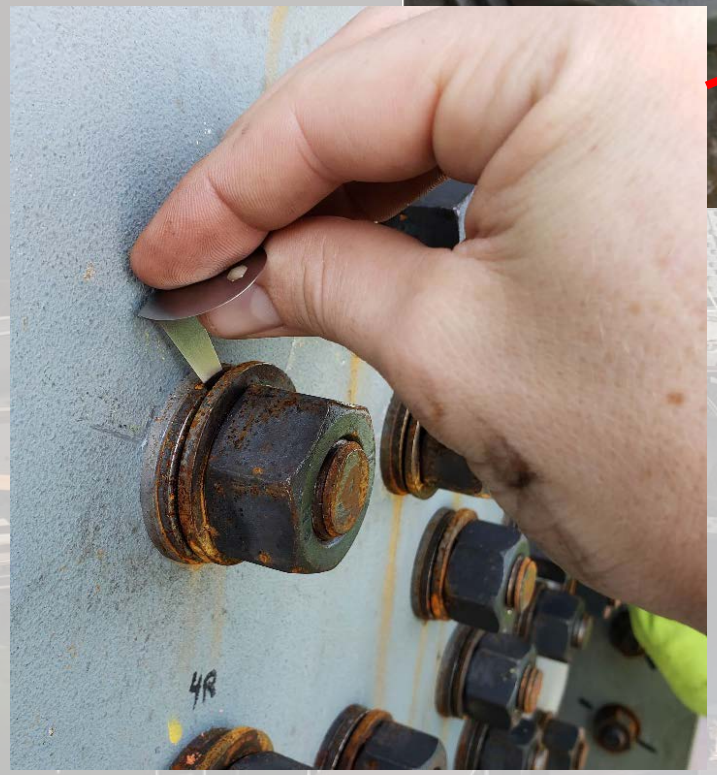
- A490 HS Bolts replaced rivets, removed one at a time
- Templates used to punch mark holes
- Required installation of temp pins/links prior to placement
- “Cheese” plate between truss diagonal and knuckle plate
- DTI Washers, did not function as desired
  - Used torque on wrench as guideline

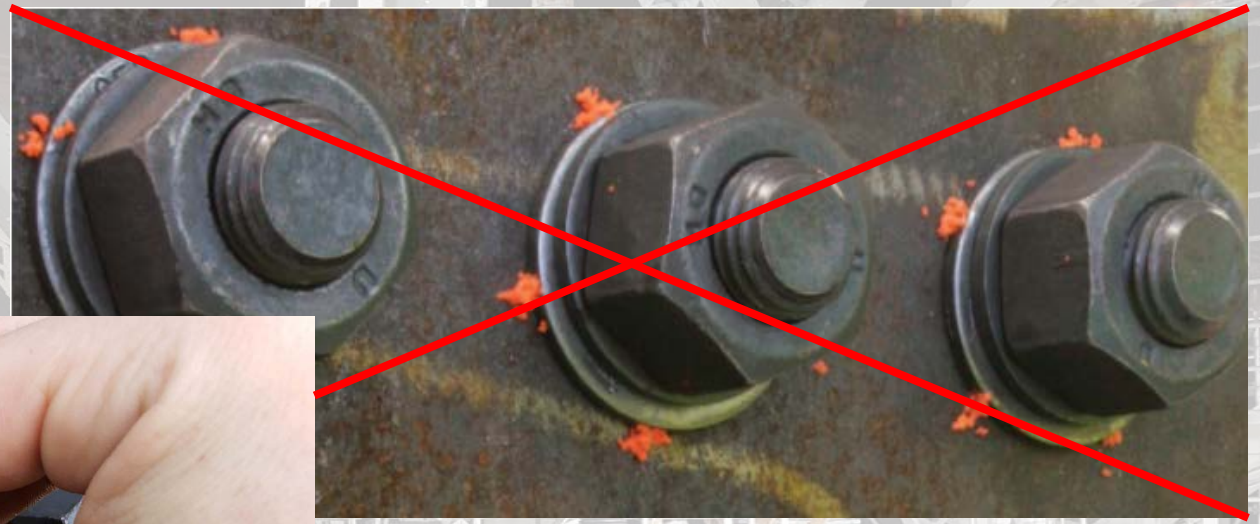
Temporary Support System

Knuckle Plates

Temporary Support System

Knuckle Plates- DTI's





Temporary Support System

Lower Cords

- Two diaphragms required
  - Between knuckle plates
  - Inside existing bottom cord
- Batten plates for bracing
- Tight spots challenging
- Field drilling 23 holes at existing bottom cord
- Field coping at inside lower cords for fitment

Temporary Support System

Lower Cords

Temporary Support System

Lower Cords

Temporary Support System

Lower Cords

Load Transfer to Temp Support

- Bridge closure during jacking to enable assessment of Dead Load
  - Anticipated DL = 290 kips
  - Max allowable was 410 kips
  - Actual Jacking load ~350 kips
- Identifiers for point of "lift-off"
  - Nail polish cracking
  - Measurement of gaps closing up
  - Acceleration of movement observed with dial gauge
- Locked the collars on jacks tightened threaded rods

Load Transfer to Temp Support

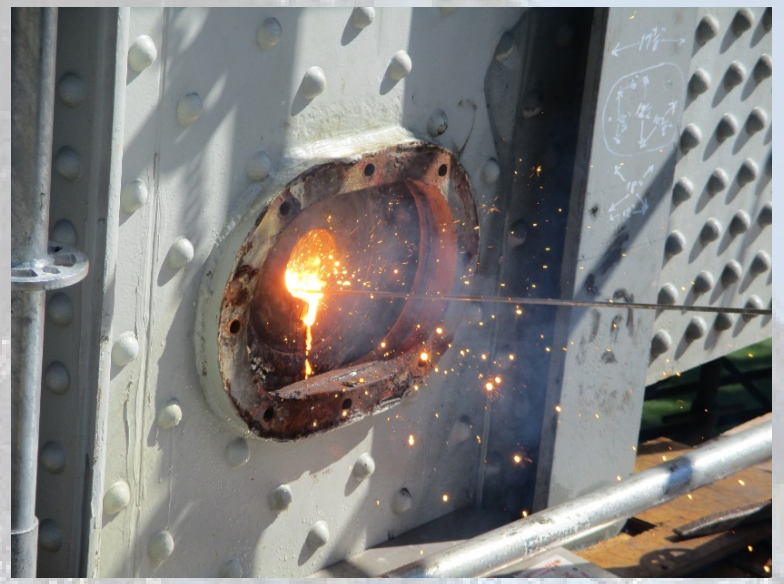
Load Transfer to Temp Support

Anchor Link Removal

- Torch cutting to remove portions of link
- Jack system used to pull pins
- Pipe struts to prevent bending during jacking
- Seized pins cut into pieces
- Oxygen Lance to burn out center of pin, relieve pressure on bores

Anchor Link Removal

Anchor Link Removal



Anchor Link Removed

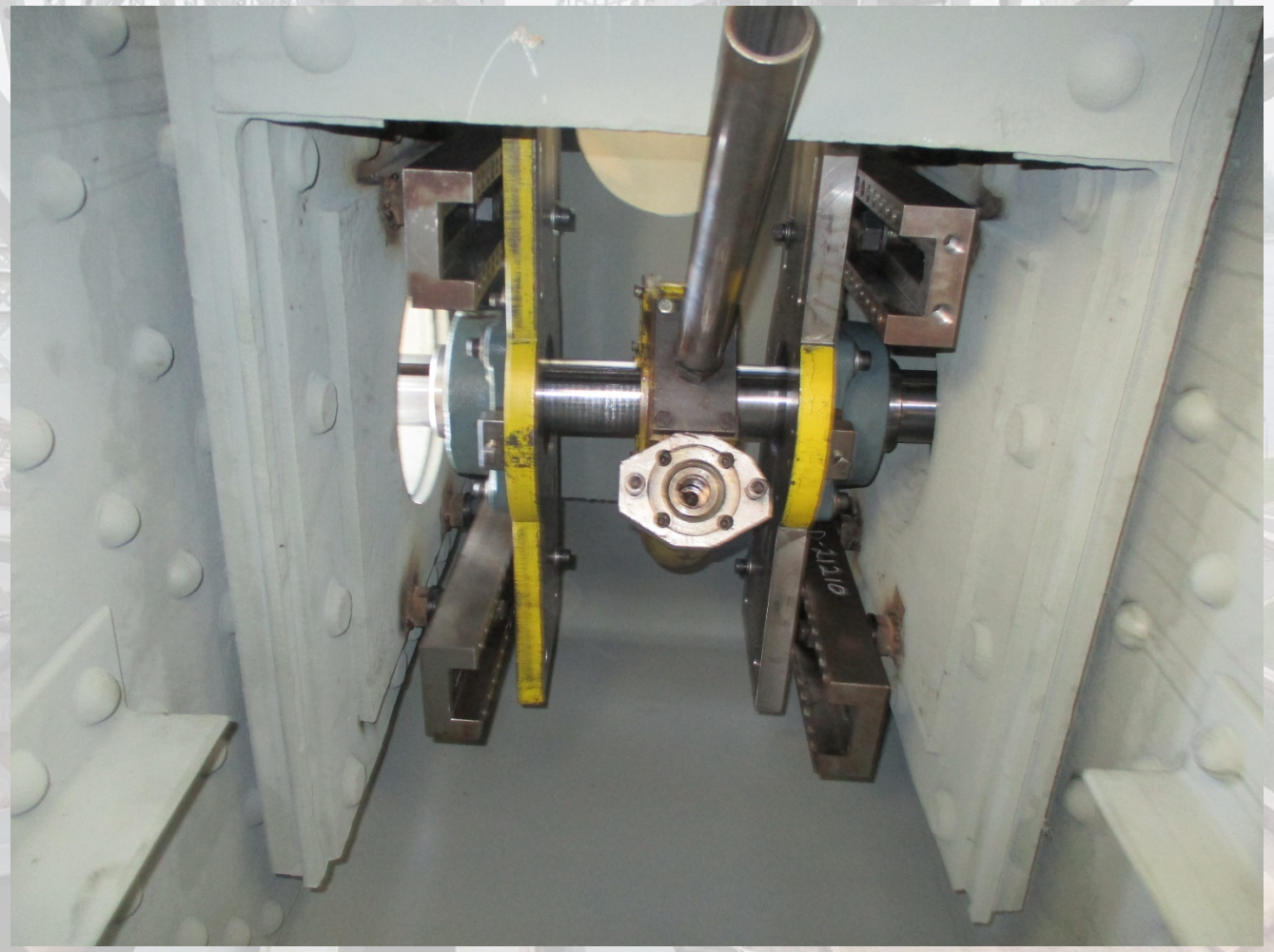
Anchor Link and Pin Placement

- Multiple Steps:
  - Upper Bores (truss)
    - Line Bore
    - Install Bushings
  - Remove/Replace Lower Pin Plates
  - Place Permanent Links Assembly
  - Install Upper Pin
  - Jack Truss
  - Adjust Lower Pin Plates, Install Lower Pin
  - Load Transfer
  - Replace Perforated Cover Plate

Line Boring

Upper Pin Bores (Truss)

- Bore to 9.875” dia (+0.002 to +0.005)
- Inner Pin Plate Conflict
- Bore Bar leveled to earth, verified centered with bores
- Rough cuts (20 thou) and final cuts (5-10 thou)
- Carbide Tip on Carrier

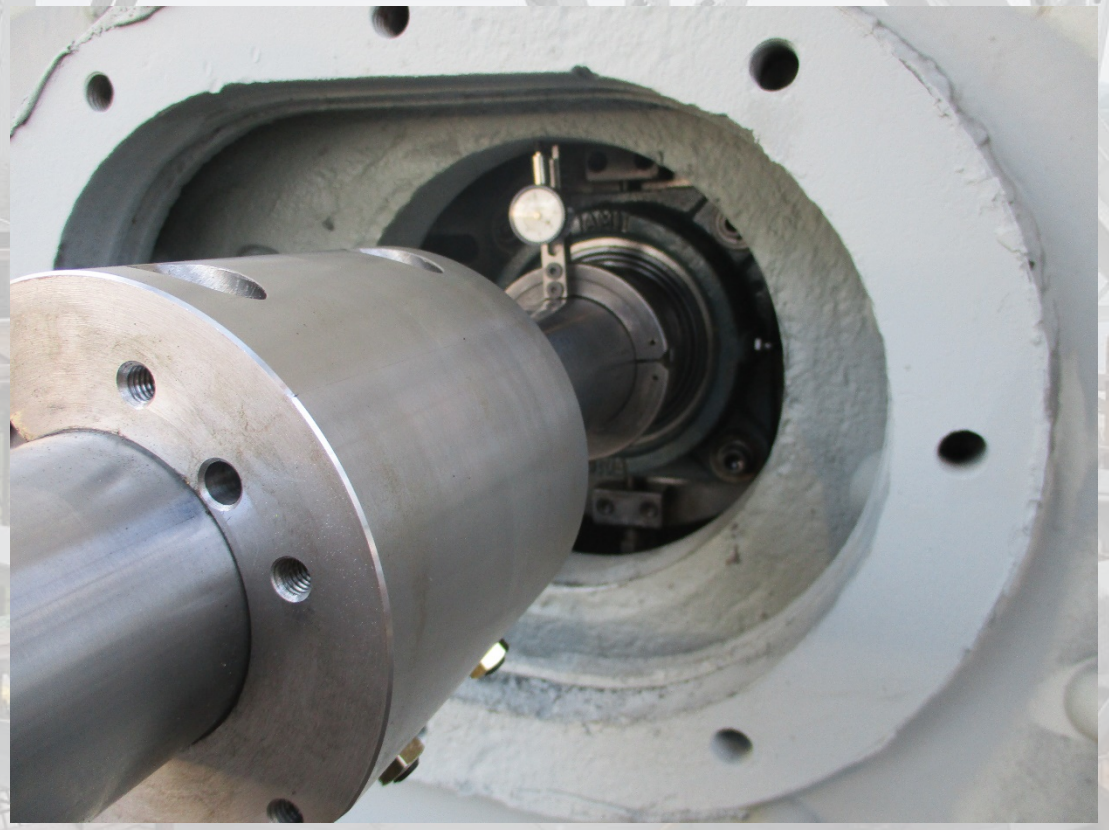


Line Boring

Upper Pin Bores (Truss)

Line Boring (Video)

Upper Pin Bores (Truss)



Line Boring

Upper Pin Bores (Truss)

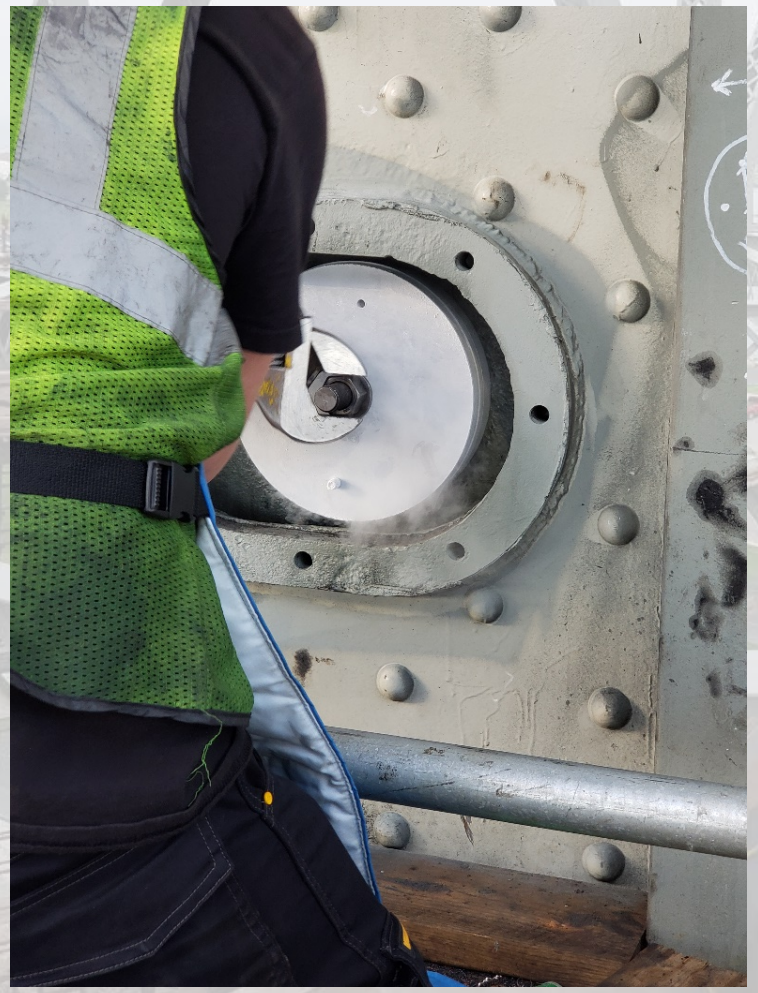
Line Boring

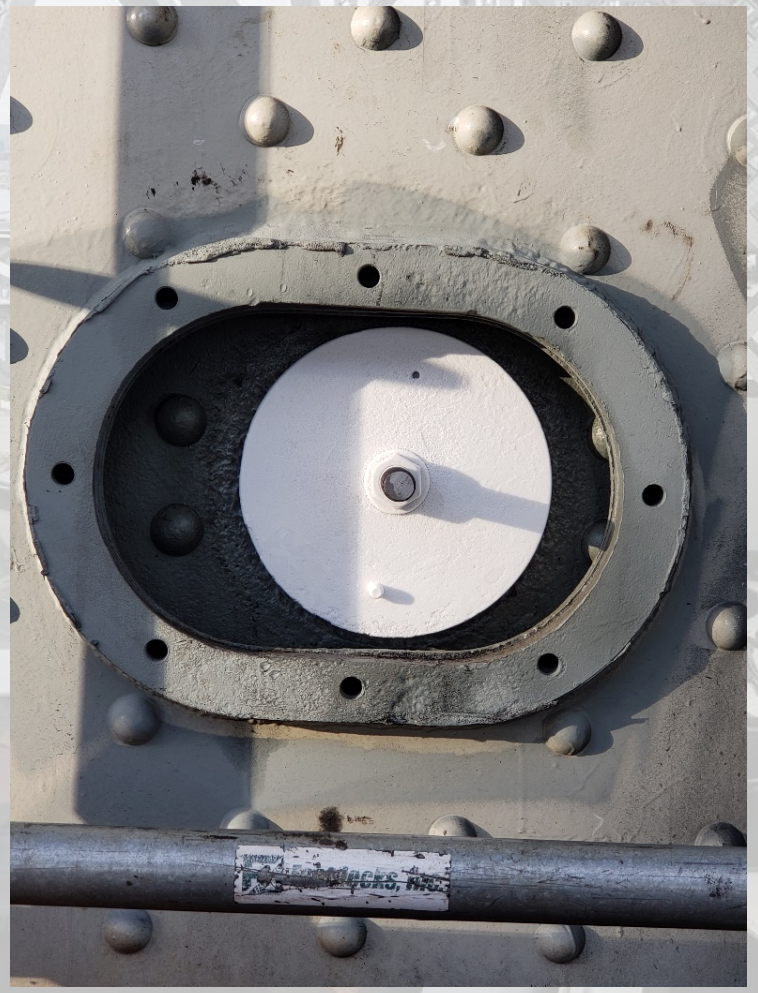
Bushing Installation - Upper Pin Bores (Truss)

- "Sandwich Plates"
- Liquid Nitrogen
- Example- North Bushing:
  - Initial O.D. = 9.882"
  - Bore machined to 9.878"
  - O.D. after Liquid Nitrogen = 9.864"
- 45 minutes submerged in Liquid Nitrogen

Line Boring

Bushing Installation - Upper Pin Bores (Truss)





Lower Pin Plates

Removal of Existing Pin Plates

- Rivet Removal Required
  - 112 Rivets each leg
- Thickness of multiple plates
  - Drilling to remove
- Blasting/Priming prior to placement of new pin plates
  - Complete blasting/priming inside tower leg

Lower Pin Plates Installation

Removal of Existing Pin Plates

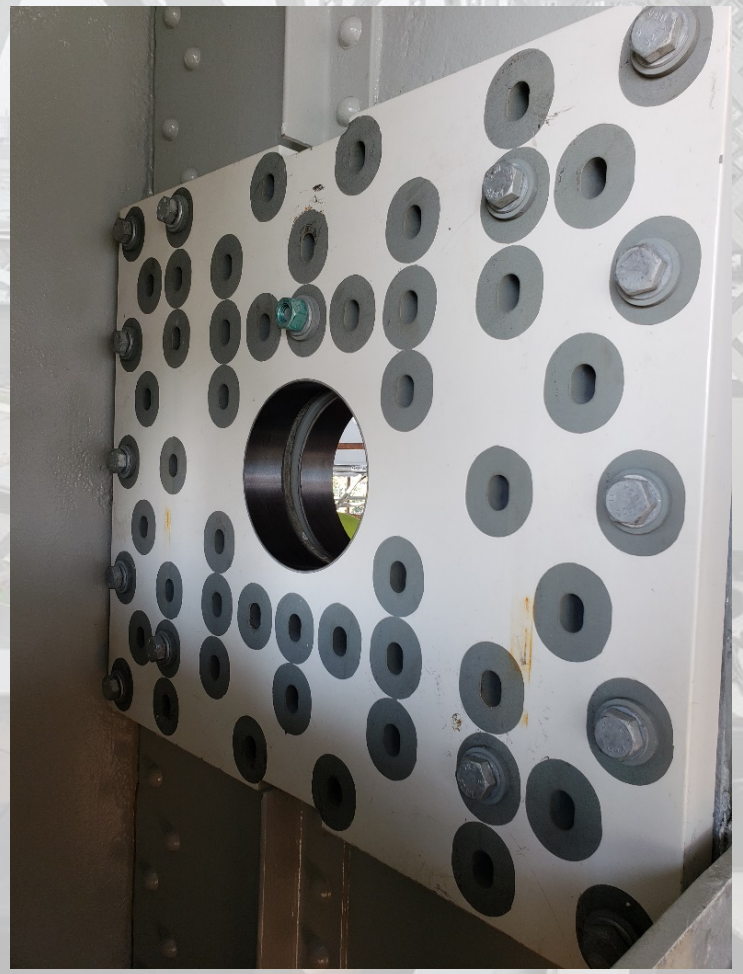
Lower Pin Plates Installation

Placement of Plates Prior to Link Installation

- Lower Pin Plates fabricated with slotted holes
- Outer Pin Plates required fill plates
- Plates heavy, 2.5” thick
  - Outer Plate: 337 lbs each
  - Inner Plate: 402.5 lbs each
  - Multiple come alongs used to position
- Temporary Strengthening Angle conflicted with bolts

Lower Pin Plates Installation

Placement of Plates Prior to Link Installation



Intermission

Union lockout could disrupt projects throughout Southeast Michigan

CHAD LIVENGOOD

TWEET SHARE SHARE SHARE EMAIL PRINT

Road construction firms to lock out heavy equipment operators Tuesday

It could impact more than 1,000 workers

Operating engineers union contract expired in June

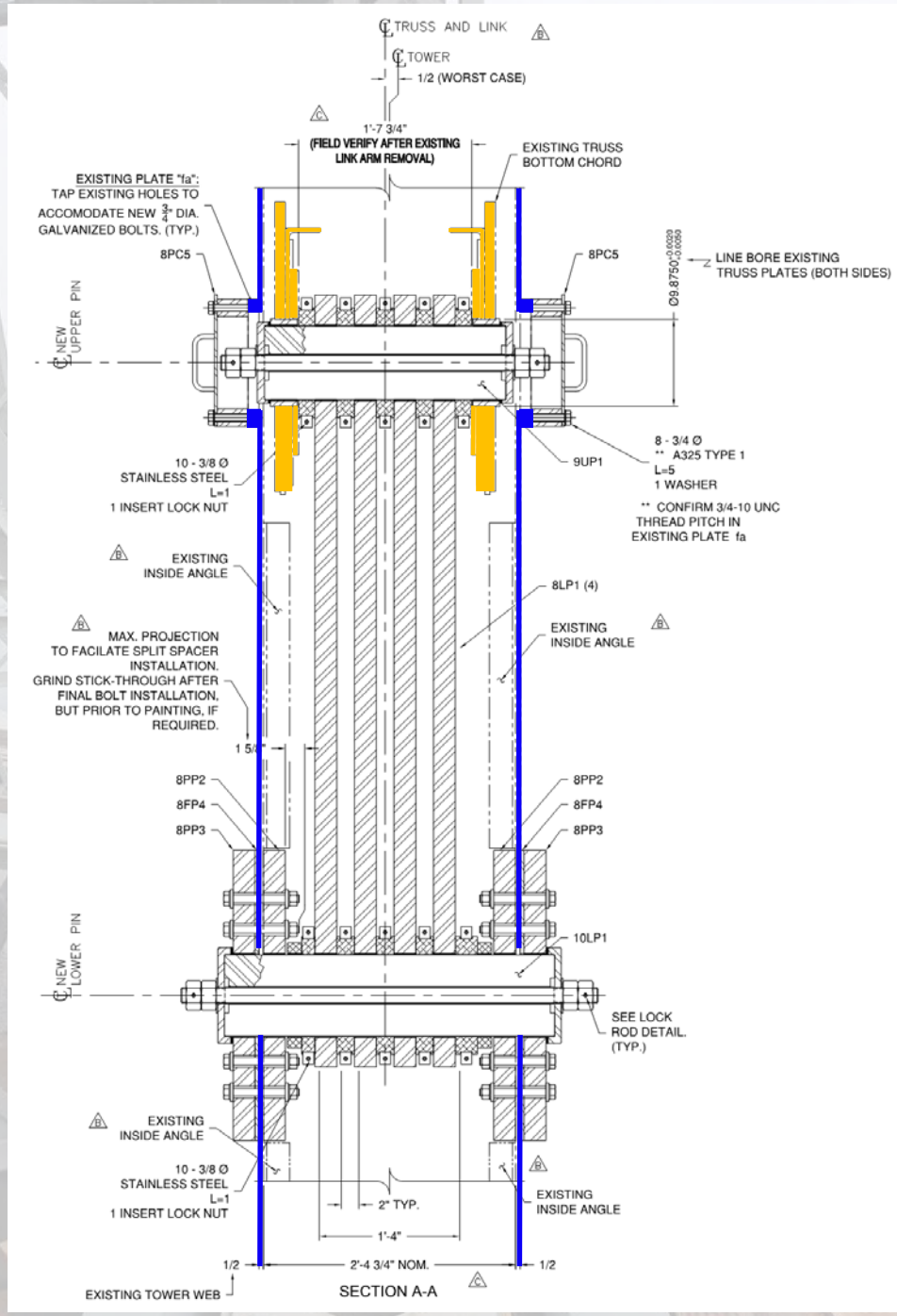
Michigan Department of Transportation

A summer-long labor dispute comes to a boil Tuesday and could disrupt road projects throughout Southeast Michigan.

Temporary Pins/Permanent Links

Unique Installation

- Contr. elected to assemble links prior to placement
- Steel “cage”
- Sheaves and cable through tower leg opening at truss
- Jack used inside tower leg to raise assembly
- Temporary Pins to be pushed and removed by permanent pins once positioned



Temporary Pins/Permanent Links

Unique Installation

Temporary Pins/Permanent Links

Unique Installation

- Come alongs and crane to pull into Tower Leg
- Set on Pancake Jack
- Jacked vertically to align Temporary Upper Pin
- Upper Pin installed, pushing out Temporary Pin
- Jack Truss (if needed) and install lower pin, pushing out Temporary Pin

Temporary Pins/Permanent Links

Unique Installation

Temporary Pins/Permanent Links

Unique Installation

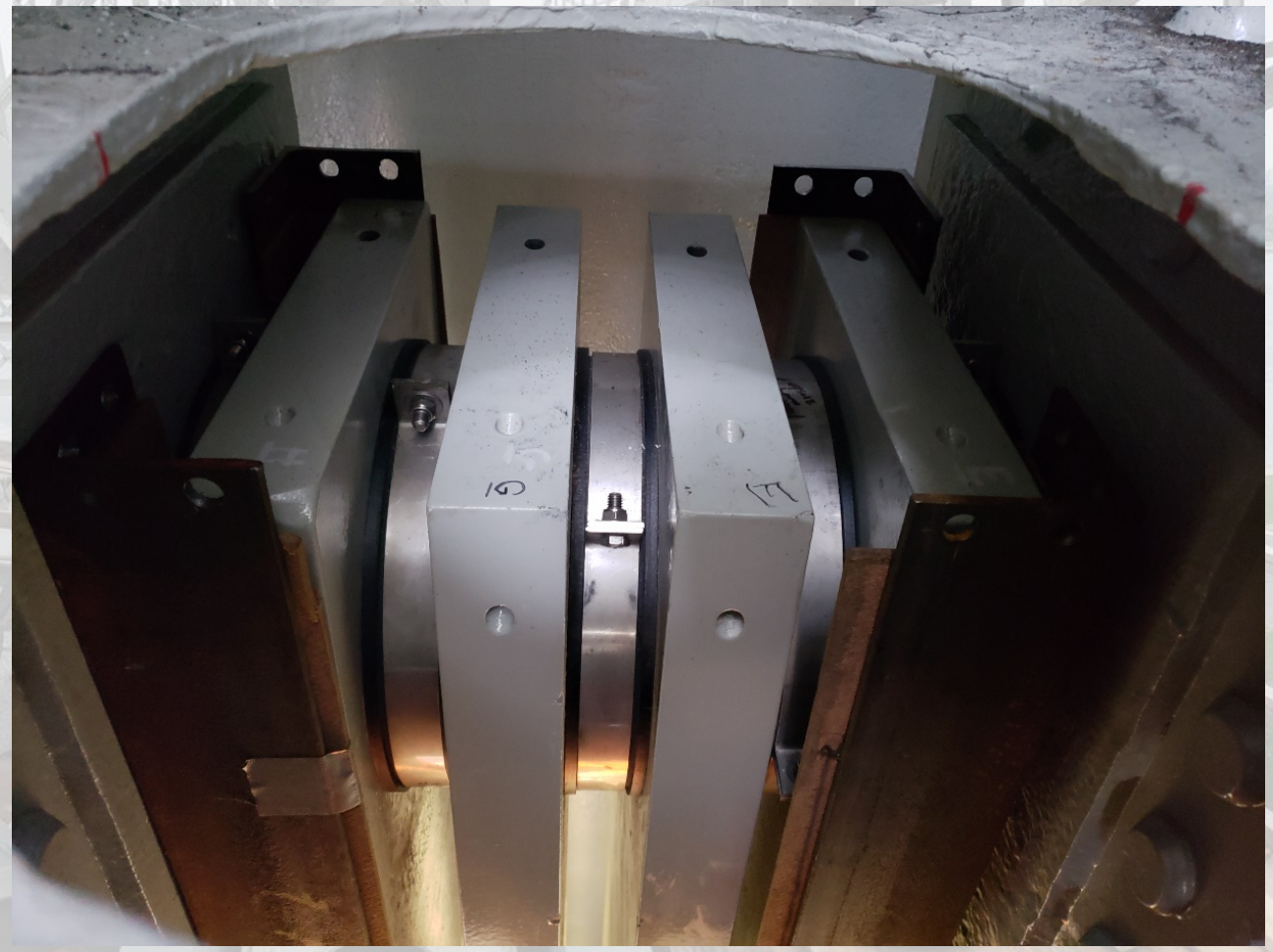
Temporary Pins/Permanent Links

Unique Installation

Temporary Pins/Permanent Links

Upper Pin Installation

- Chairs to support Pins (Heavy)
- PTFE Dry Lubricant only
- Threaded Rod and nut with wood “jack chair” on opposite end
- Protecting and monitoring Non-Metallic Bushings critical (5 Total @ Upper Pin)



Permanent Anchor Link Installation

Upper Pin Installation

Permanent Anchor Link Installation

Upper Pin Installation - Issue

- South M1 Issue:
  - Pin placed through south Bore and links/Spacers (0.002" tolerance)
  - Cone entered north Bore, off alignment
  - Upper Pin and Cone rested on Non-Metallic at N Bore while pulled through
  - Damage to Non-Metallic Bushing visible

Permanent Anchor Link Installation

Upper Pin Installation - Issue

Permanent Anchor Link Installation

Upper Pin Installation – Issue Resolved

- Spare Bushings, Non-Metallic bushing removed and re-used
- Local shop machined aluminum block for contr.
- I.D. of Steel Bushing checked vs. O.D. of new Non-Metallic, 3 thousandths difference, acceptable
- Liquid Nitrogen used to shrink Non-Metallic and insert

Permanent Anchor Link Installation

Upper Pin Installation – Issue Resolved

Load Transfer to New Links

Lower Pin Installation

- Links hanging
- Temporary Lower Pin not aligned with bores
- Truss jacked to original position plus 1/16”
- Threaded Rod to pull Permanent Lower Pin
- Steel Bushings on each end of Pin, PE spacer bushing between outer links and steel bushings

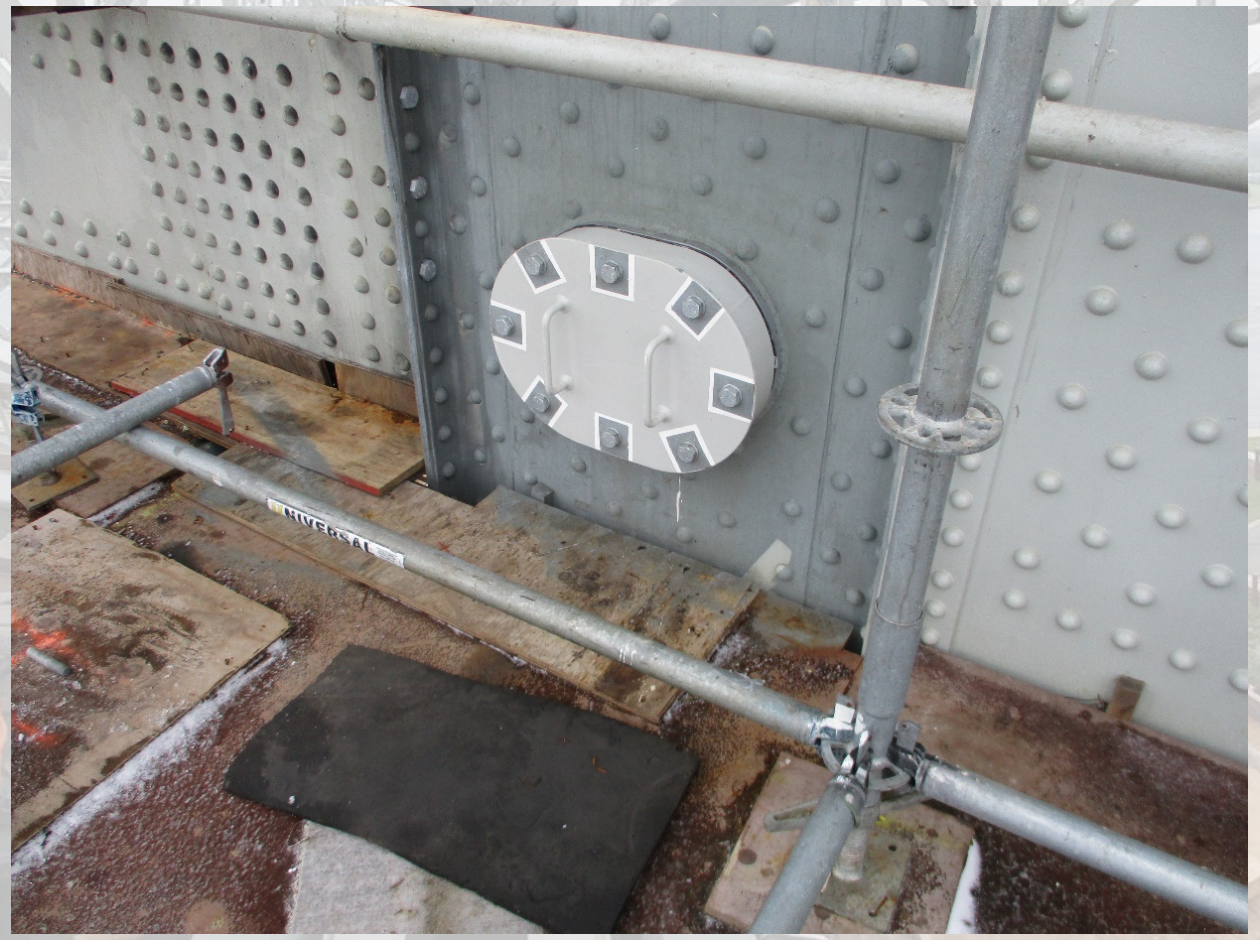
Load Transfer to New Links

Lower Pin Installation

Load Transfer to New Links

Bushings Installed

Installation Complete



Questions?

Thank you!

Craig Dashner, P.E.

Thomas Bachmayer

OHM Advancing Communities®