Blue Water Bridge #1
Anchor Link
Replacement
Presenters

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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

6/18/18
Drainage, Temp. Relocation
Toole Construction
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
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
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
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

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

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