The Unwanted Discovery on the Hernando de Soto Bridge in Memphis

Interstate 40 Hernando de Soto Bridge

Orientation

Arkansas
Looking North
Tennessee

Nomenclature

High Truss
Suspension
Cables
Floor Beams
Tension Tie
Girder
Fracture

Looking at North Side of Bridge

Timeline of Events

Day 0

- Fracture discovered on Tuesday - May 11th during a routine inspection.
  - Immediately closed to traffic (interstate and river traffic) at 2:00 PM
- TDOT has responsibilities for repair project development
  - Selected Michael Baker International on Tuesday - May 11th
  - Initial task was to evaluate bridge in current state
  - Develop preliminary plan to stabilize structure
  - Work with CM on approach to complete fracture repair
- TDOT and ArDOT collaborated on a three-phase approach
  - Evaluate for stability and resumption of river traffic
  - Evaluate and complete repairs for initial fracture
  - Evaluate existing bridge tension members for similar issues & complete any needed repairs

Day 1

- MDOT & ArDOT supplied bridge data to MBI
  - Plans, Shop Drawings & Weld Inspection Report (TDOT)
  - Inspection Reports (ArDOT)
  - Approved development of Phase 1 plating plans & model development
- MBI provides Preliminary FEA results to TDOT (with No Recommendation)
  - TDOT does a risk assessment using model data, historic photos & former staff insight
  - Construction photos suggest favorable sequence of loading during construction

Day 2

- Project Team
  - TDOT
    - Lead Agency over Contract Maintenance, Design, & Construction
  - ArDOT
    - Lead Agency over Inspection Services
  - Michael Baker International (MBI)
    - Lead Design (TDOT) & High Tuss Inspection (ArDOT)
  - HNTB
    - Off-Team Design Check & Deck and Below Special Inspection (ArDOT)
  - Kiewit Infrastructure South Co.
    - Construction Manager / General Contractor
  - WJ E - Wis Janey Elstner
    - Testing and Material Sciences Evaluation (ArDOT)
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Timeline of Events – Cont’d

- TDOT & ArDOT supplied bridge data to MBI
  - Plans, Shop Drawings & Weld Inspection Report (TDOT)
  - Inspection Reports (ArDOT)
  - Approved development of Phase 1 plating plans & model development

- MBI provides FEA model results to TDOT
  - TDOT does a risk assessment using model data, historic photos & former staff
  - Construction photos suggest favorable sequence of loading during construction
  - TDOT provides risk evaluation to USCG who opens river to traffic.

Day 1

Day 3

Day 5

Day 6

- Repair Project – CM/GC Contractor Selection Process
  - Advertised on Friday - May 14th
  - 8 Contractors were invited to provide submit interest packages
  - Preliminary plating plans were provided as part of the invitation
  - Selection of CM/GC was based on the following
    - Qualification
    - Related Project Experience
    - Availability of Team and Equipment
    - Approach on Repair Options

- Awarded to Kiewit Infrastructure South Co. on Monday - May 17th

- Design Challenges for Phase 1 –
  - 100 ksi plates in tie girder and select high truss members
  - Thin [1.375"] plate sections limited bolting options due to net section limitations
  - Geometry [height] of current tie girder impacted plating design

- Daily Events –
  - 9:00 AM - Detailed “In-the-Weeds” design call (DOT Engineers, Consultants, Contractor)
  - 1:00 PM – Media and Social Media updates issued
  - 3:00 PM – Project status call (DOT’s leadership, USCG, design and contractor)
  - 3:30 PM – Traffic update call (local EMs, USCG, DOT’s)
  - 4:00 PM – Engineering & Construction update with partner (FHWA) agencies
I-40 Hernando de Soto Bridge

- Design Challenges for Phase 1 –
  - 100 ksi plate in tie girders and select high truss members
  - Thin (1.375”) plate sections limited bolting options due to net section limitations
  - Geometry (twist) of current tie girders impacted plating design

"All Models are Wrong, but some are useful"

- Unkowns
  - Actual force in the tie
  - Redistribution of Load
  - Transient loads
  - Strength of Materials
  - Condition of Welds

"All Models are Wrong, but some are useful"
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- Design Challenges for Phase 1 –
  - 100 ksi plate in tie girder and select high truss members
  - Thin (1.375”) plate sections limited bolting options due to net section limitations
  - Geometry (twist) of current tie girder impacted plating design
  - Models suggested that remaining tie section was near 90% capacity

Fracture Details

Phase 1: Design Concept

- Install steel plates over the fractured member to strengthen and provide global stability to the structure.
- Plating limits were controlled by the bolting requirements and the minimal net section area available in the existing tie girder.
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Phase 1: Design Plans Available
- MBI provided final design plans with suggestions from the CM included.
- Shop drawings were submitted and reviewed as the design progressed.

Phase 1: Plate Fabrication and Delivery
- Stupp Bridge Company in Bowling Green, KY fabricated plates that TDOT direct procured. A TDOT maintenance crew picked up the order on Saturday - May 22.

Phase 2: Initial Design
- Proposed to remove fractured tie girder section
- Use Post-Tensioning to transfer load
- PT would provide a factored capacity for all DL + Construction Loads
- Concern for lack of redundancy is the any of the PT failed

Phase 3: Began Inspection & Ultrasonic Testing of all tie girder welds.
- 484 weld locations + statistical sample of welds on high truss.
- Phased Array and single beam UT were used – required paint removal.
- More details later
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Phase 2: Final Design
• Proposed to remove fractured tie girder section
• Use Post-Tensioning to transfer load
• CM proposed to plate both sides of tie girder with existing to remain

• Existing tie girder would be partially unloaded prior to adding 70 ksi plates

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Phase 1: Work Platform Installation
Day 9
• Kiewit Infrastructure installed a specially designed work platform and chain hoists instead of barges from the river. This was the lower risk and less negative impact option.

• Chain falls used to move plates on Span 2
• Maximum load during construction was limited to 80,000 lbs. based on modeling a single truck traveling across the bridge.
• Actual applied load during the project did not exceed 66,000 lbs.

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Phase 2: Prep for Weldments and PT System
• Designed to carry full factored load approaching 6,000 kips – applied load was less
• Each weldment is 7’-8” foot tall and 20,000 pounds – total of four were required
• Fabricated by G&G Steel in Russellville, Alabama

• Weldments were delivered to the job site June 11th

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Phase 1: Plate Installation from Platform
Day 9
• Kiewit Infrastructure began installing of platform on May 17th – No Navigation Interference
• Plate installation began the afternoon of Saturday, May 22nd
• Plates were installed by the end of the day on May 25th – Two Weeks after the fracture was discovered

• Existing splice bolts replaced (one at a time) working 24/7
• Cheese plates fabricated as filler plate over first nut

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**Phase 2: Prep for Weldments and PT System**
- PT bars (3" diameter) and hardware were delivered
- All segments were installed within 5 days
- All work is being done on a 24/7 schedule

**Phase 2: Squaring the Box**
- Dressing Chair
- Anchor Plate
- Spherical Nut

**Phase 3: Began Inspection & Ultrasonic Testing of all tie girder welds.**
- 484 weld locations + statistical sample of welds on high truss.
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Phase 3: Design / Constructability Aspects
- Contractor Input on Constructability
  - Even Joint – 4 bolts to remain
  - Odd Joint – Floorbeam/Tie Connection

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Phase 3: Typical Repair Types
- Core & Plate
  - 12 locations
- Grinding
  - 12 locations

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Phase 3 Installation
- Eastbound lanes were open to traffic at 10:00 PM on July 31st.

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Forensic Evaluation – Assessment of the Fracture
- Sample under white light showing MT filings at crack locations.
- Sample under black light during wet fluorescent MT inspection with four MT indications.
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**Lessons Learned**

- **Collaboration**
  - Everyone with a Common Goal, “Safely Reopen”
  - Designers, Contractors, Owners, Public
- **Ensuring Quality is Critically Important!**
  - Multiple Teams working simultaneously
  - Check and Re-Check
- **Communication**
- **CM/GC Benefits**
  - Risk Reduction
  - Improved Constructability
  - Material Procurement / Schedule
### Interstate 40 Hernando de Soto Bridge

**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 | 1,434 Feet of 3” diameter high strength post tensioning utilized in the repair procedure | 1.2 Million + Pounds of tension removed from the fractured section and put on the composite section |
| PHASE 3 | 17 Welds were plated for a total of 76,000 LBS of structural steel | Over 6,000 Permanent bolts used to connect the plates | 1,240 ft of welds inspected and tested in the 472 butt welds of Tie Girder | 39 Additional weld defects ground or cored out |

Total Repair Cost = $9.7M