Project Background
Louisville Metropolitan Area

- **Location**
  - I-64 over Ohio River
  - Link between IN & KY
Sherman Minton Bridge

- **Structure Information**
  - Tied Arch
  - 2 – 800 foot spans
  - Double-deck structure
  - Navigable waterway underneath
Inspection History

- Initial construction – 1961
- NBIS requires 2-year Inspection Cycle
- Previous Inspection Yielded Various Findings
  - Cracks detected in multiple welds
What is a Tied Arch?
What is a Tied Arch?

Think of a bow and arrow....
- Stand it on a table like shown
- Push down on the bow
- What would happen if we cut the string?
Tied arches are FRACTURE CRITICAL bridges.
Loss of the tie = likely collapse of the entire span
What Are The Problems?
Why Sherman Minton?

- **Type of Material**
  - “T1” Steel
    - VERY high strength steel
    - Susceptible to FRACTURE at cold temperatures and with small cracks

- **Sensitive Details**
  - Tie girder welds
  - Diaphragm plates
  - Lateral bracing details
Tie Girder Welds

176 Individual welds per tie x 2 ties x 2 spans = 704 potential fracture sites
Tie Girder Welds
Tie Girder Concerns

- ...the serious consequences of weld cracking associated with the tie girder of a tied arch structure should not be overlooked.

- Fracture Critical Tie Girder

- Lack of Internal Redundancy of the welded Tie Girder

Source: 1978 FHWA Technical Advisory
Diaphragm Lugs

33 diaphragms per tie x 2 ties x 2 spans x 8 lugs per diaphragm x 2 legs = 2112 welds
Diaphragm Lugs

Web Plate
Diaphragm
Flange Plate

Diaphragm lug
Lateral Bracing Plates

11 panels x 2 plates per panel x 2 ties x 2 spans = 88 connection plates
Lateral Bracing Plates
First-Hand Response
Inspection & Testing

- COMPLETE hands-on visual inspection of EVERY INCH of weld metal on the tie girder
  - What can we find?
- Nondestructive testing
  - What can we find that we can’t even see?
- Extensive sampling of bridge materials
  - How strong, how tough, how big of a crack is “too big”?
- Current effort MOST comprehensive visual, nondestructive testing and physical testing program, ever conducted
Hands On Visual Inspection
Non-Destructive Testing

- Performance Testing of Technicians
Tie Girder Welds

- It's what we CAN’T see that’s the problem....

- 75% of web plate welds contained “rejectable” indications
Tie Girder Welds – Past Repairs

- Use of selected “coring” repairs
Why Even Small Cracks Can Matter

![Graph showing the relationship between flaw size and critical stress. The graph illustrates how even small cracks can significantly affect the basic material strength.](image)
Bridge Closed
Retrofit Options Considered

- Option #1  Local Plating
  - 50 / 100 ksi local plating of joints

- Option #2 – Global Plating
  - Extension of Option #1 with extra full length plates

- Option #3 – Tie Post Tensioning
  - Full length PT of the tie to fully or partly decompress the section

- Option #4 – Tie Replacement
  - Sequential replacement of the tie in place
3D Model
Local Model Details
PT Deformations x50

Vertical and horizontal deformations approximately 6” each
Global Plating Alternate
Local Plating Alternate

NOTE. SPLICE IS SYMMETRIC ABOUT CL. BRACING CONNECTIONS VARY AT EACH JOINT.
Tie Replacement Alternate

1. Install Joint Reinforcing plates at joint L0 as indicated on sheet GS9-294.
2. Install Type A Jacking Assemblies near L0 and between T3-T4.
3. Stress Tendons to external-apply 5000 kips.

Stage 1:
1. Install temporary support for exiting Tie Girder near Jacking assembly at T3.
2. Remove exiting Tie Girder between L0 and T3 as shown.

Stage 3:
1. Elevation View from West Elevation View E. A. D. C.

REPLACEMENT SEQUENCE
SEGMENTAL TIE GIRDEN REPLACEMENT

NOT FOR CONSTRUCTION

PRELIMINARY

PROJECT: 1176989

09-21-11

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## Comparison Matrix

<table>
<thead>
<tr>
<th>Working Options</th>
<th>Description</th>
<th>Duration in Months</th>
<th>Open to Traffic Date</th>
<th>Estimated Cost</th>
<th>Remaining Service Life</th>
<th>Value</th>
<th>Level of Public Safety</th>
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<tbody>
<tr>
<td>1</td>
<td>Local Plating</td>
<td>xx</td>
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<td>Global Plating</td>
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<td>Superstructure Replacement</td>
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<td>Bridge Replacement</td>
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Discovery & Solution Timeline

- Inspection NTP to Intermediate Repair
  - 3.5 months

- Intermediate Repair to Finding which closed the bridge
  - 3 weeks

- Bridge Closure to Complete NDT work
  - 3 weeks

- Bridge Closure to Advertisement of Contract Documents
  - 3 weeks
Sherman Minton Bridge Solution

- Global plating
  - Bolt supplemental/alternate tie (plates) along side both sides of ties
  - Complete redundancy / alternate load path
  - $13.8 Million (+/-)
  - 4.5 months (+/-)
  - Open bids 18 October 2011
High Profile
Lessons Learned - Teamwork / Trust

OWNER  CONSULTANT
Procurement & Process

**DESIGN**
- Expedited Contracts
- Shifting Staff
- Long Hours
- Independent Review
- Aggressive Deadlines
- War Room

**CONSTRUCTION**
- Design / Bid / Build??
- Procuring Unexpected $$$
- Design Addendums
- Short Advertisements
- Incentives & Disincentives
Thank You