Fatigue Repair of the I-345 Bridges

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Bridge Presentation Webinar
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Fracture Critical Units

- Louise Ave.
- Ross Ave.
- NB & SB Mainlanes
- NB & SB Collectors
- Ramps & Connections
Fatigue Cracking
Distortion-Induced Fatigue

- Pre-1985 AASHTO Spec detail
- Does not usually cause catastrophic failures
- Largest source of fatigue cracking
Design Features

- AASHTO 1965 Spec Design
- Large girder spacing
- Floorbeam-girder connections field welded
- PT Deck on top of floorbeams
- Girder skew, curve, flare, haunch, etc.
- Unsymmetric column support

Typical Transverse Section
Floorbeam-Girder Connection

Top Flange Web Gap

Brg. Stiffener Web Gap
Previous Repairs

- Total **2237** connections

- **2000** emergency repair at **19** cracked connections
  - Welded retrofit stiffener

- **2004** repair at a total of **1077** connections
  - Only 87 actually cracked
  - Same repair as in 2000
  - Repair welds treated with UIT
As-Built Connection
Previously Repaired Connection

- Longitudinal Girder
- Floorbeam Overhang
- Retrofit Stiffeners
As-Built Connection

**SECTION THRU GIRDER**

- Floorbeam Web
- Floorbeam Int Stiffeners
- Concrete Slab
- Floorbeam Top Flange
- Girder Top Flange

- Lower Stiffeners: 2 - PL 3/4" x 8" (1 NS & 1 FS)

- Type 1 Crack
- Type 2 Crack
- Type 3 Crack
- Type 4 Crack
- Type 5 Crack

**SECTION THRU FLOORBEAM**

- Floorbeam Connection Stiffeners: 4 - PL 3/4" x 6" x 3'-0" (2 NS & 2 FS)
- Top Longitudinal Stiffener
- Type 1 Crack
- Type 2 Crack
- Type 3 Crack

**AS-BUILT FLOORBEAM-GIRDER CONNECTION**
Previously Repaired Connection

PREVIOUSLY REPAIRED FLOORBEAM-GIRDER CONNECTION
Floorbeam Stiffener Cracks

SECTION THRU GIRDER

PREVIOUSLY REPAIRED FLOORBEAM-GIRDER CONNECTION

SECTION THRU FLOORBEAM
Type 7 Crack
(30 locations, 27 at columns)
Type 8 Crack
(1 location only)
Type 9 Crack
(5 locations, 4 at unsymmetric columns)
Type 3 & 10 Crack
(37 & 5 locations, mostly at columns)
Web Gap Gages
Retrofit Stiffener Gages
Bottom Flange Gages
Controlled live load test
- 2 dump trucks
- 5 mph speed
- 10 sec stop at testing FB
- 6 test runs, 4 truck positions

Rainflow counting
- 1 week data collection
<table>
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<tr>
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<th>F14N FB2</th>
<th>F17S FB16</th>
<th>F17S FB18</th>
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<tbody>
<tr>
<td>Top Flange Web Gap Gauge (C)</td>
<td>4.51 ksi</td>
<td>—</td>
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<tr>
<td></td>
<td>2 yr</td>
<td>—</td>
<td>—</td>
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<tr>
<td>Retrofit Stiffener Gauge (C’)</td>
<td>—</td>
<td>2.03 ksi</td>
<td>1.83 ksi</td>
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<td>—</td>
<td>284 yr</td>
<td>579 yr</td>
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<tr>
<td>FB Bottom Flange Gauge (E’)</td>
<td>1.56 ksi</td>
<td>1.89 ksi</td>
<td>2.46 ksi</td>
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<td>73 yr</td>
<td>29 yr</td>
<td>9 yr</td>
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Finite Element Modeling
Finite Element Modeling
Repair Challenges

- Limited access at column connections
- Detail geometry varies at every single connections
- Field welding quality (overhead position, night time work, preheating and cooling, etc.)
- Traffic control – 8 hr closure 9pm-5am weekdays only, including 3 hr barricade setup and removal
Repair Detail Development

- Closing the web gaps
  - Stiffening angles for top flange web gaps
  - Corbel plates for bearing stiffener web gaps

- Limiting field welds
  - Stud welding at top flange
  - High-strength bolting at bearing stiffener
Top Flange Web Gap Repair

- Welded Threaded Studs with F2437 DTIs
- A325 Bolts With F959 DTIs
Top Flange Web Gap Repair

SECTION THRU GIRDER

REPAIR TYPE A1

FOR 24" GIRDER FLANGE WIDTH
AT SECTIONS BETWEEN THE BEARINGS

SECTION B-B

NEED NO GIRDERS(SHOR OR FLOPPING)
Stud Welding

Advantage

- Used in 2005 on a KSDOT bridge repair
- Automated, instantaneous arc welding (compared to stick welding)
- Hole drilling not needed (compared to bolting)

AWS D1.5 – Bend, Torque, Tension Tests

- Lab test during the design stage
- Contractor qualification test at the beginning of construction
- Production test at the beginning of each shift (only bend test required)
Bend Test

Torque Test

Tension Test

Acid Etching

TxDOT Steel Lab
Lab Test

Tension-Displacement Curve
Qualification Test
Qualification Test
Qualification Test

Failed

Passed

Lack of Fusion
Makeup Qualification Test

Bend Test

Tension Test

Torque Test
Finished Repair
Bearing Stiffener Web Gap Repair
Bearing Stiffener Web Gap Repair
Bearing Stiffener Web Gap Repair

**REPAIR TYPE B1**

1. Terminate all repair welds 1/6" short of plate ends or edges. Do not carry welds around the corners. Do not carry welds from one side of the plate to the other side.
2. Increase by dimension "B" on the opposite angle side if girder is skewed or flared out. See Section A-A for detail.
3. Burr, threads or tack weld other installation.

**FIELD VERIFICATION**

- $\beta_1$, $\beta_2$ - Floorbeam Flange slope angle
- $\alpha$ - Floorbeam Flange level angle
- $\theta$ - Girder Flange slope angle

*Texas Department of Transportation*

*Sheets 1 of 6*

**GIRDER CRACK REPAIR TYPE B1, B2, B3 & B4**

IH 345 ELEVATED SB & NB MAIN LANES SB & NB COLLECTOR RAMPS
Bearing Stiffener Web Gap Repair

SECTION A-A

LONGITUDINAL STIFFENER CLIP DETAIL
Cut short the end of longitudinal stiffeners as shown. Whenever in conflict with the new cable plates, grind smooth the cut edges, clean and paint after the repair.

ANGLE BRACKET DETAIL
Heat treat the repair angle if the floorbeam flange slope angle is not 90°. Heat only the outside corner or inside fillet areas to reshape the angle. Keep the legs straight. Do not bend or kink the legs.

FIELD VERIFY ALL DIMENSIONS PRIOR TO FABRICATION.

T = Girder skew or flaring angle

γ

11°-10° = γ° (Obtuse Angle Side)
where: \( γ° = 11\frac{1}{2}° + \sin (\frac{T}{2}) \)
Finished Repair
Crack Stop Holes
Crack Gouging & Rewelding
Summary

**Current repair**
- Local repair, at cracked locations only
- 381 repairs at 166 locations
- Contract amount $855,200
- Finished by June 2010

**Future repair**
- Making superstructure composite with deck (TxDOT Research Projects 0-4124, 5-4124, 0-6719)
- Adding columns to provide symmetric support
- Local repair at every connection
Will the repair work out right?
How long will the repair last?

Time will tell!
Acknowledgement

TxDOT Bridge Division
Inspection & Field Operation

TxDOT Dallas District
& Central Area Office

TxDOT Construction Division
Material & Pavements

UT-Austin Ferguson Structural
Engineering Laboratory
Acknowledgement

- Contractor – SCR Construction Co., Inc.
- Steel Erector – Erwin Steel Works, LLC
Thank you!
Any Questions?