92nd Street Bascule Bridge Repairs

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Introduction

Location Map of Bridge Structure (from Google Earth Pro)
Structure Description and Project Background

Plan view of existing south drivetrain for the West Leaf taken from the original design drawings.

Typical rack segment layout and naming convention taken from the original design drawings (S = Segment).
2010 Investigation and Repair Project
Initial Field Measurements and Observations

As-designed rack tooth taken from the original mechanical design drawings.

Rack tooth wear shown on Tooth 5 of the north rack. Top land tooth measurements ranged from 1 1/4” to 2 1/8”.
2010 Investigation and Repair Project
Initial Field Measurements and Observations

As-designed pinion tooth and rack tooth mesh detail taken from original drawings.

Pinion tooth wear shown on a representative north pinion tooth.

Root-to-tip measurement for the north pinion with the leaf seated. Design value = 1”.
2010 Investigation and Repair Project
Initial Field Measurements and Observations

As-designed pinion shaft bearing Journal Block F, also known as the B1 bearing. Detail taken from the original bridge design drawings. Loose 3” diameter base bolts.

Painter’s tool inserted between the pinion shaft journal and bearing bushing.
Precision Survey

- **Static Measurements**
  - Trunnion position and alignment
  - Rack radii and center location with respect to trunnions
  - North pinion center location with respect to trunnions

- **Dynamic Measurements**
  - Alignment of north and south racks and north pinion shaft
Rack and Pinion Refurbishment

Original Pinion Geometry:
- Risk of...
  - tooth tip interference
  - pinion tooth breakage
  - rack tooth accelerated wear
- Large difference in actual (operating) versus design pressure angle

Engagement of the original pinion tooth geometry with the worst case existing radial misalignment at the south rack.

Goal: Do not move existing pinions or racks.
Rack and Pinion Refurbishment

Engagement of the proposed special pinion tooth geometry with the worst case existing radial misalignment at the south rack.

Special pinion tooth profile used for the new south pinion.
2017 Investigation and Repair Project

Overall view of south pinion in June 2017.

Up-close view of worn pinion tooth.
## Rack Run-Out Measurements 6/29/2017

<table>
<thead>
<tr>
<th>Segment</th>
<th>North Rack</th>
<th>Ideal Location (in.)</th>
<th>South Rack</th>
<th>Change Run-Out Over Length (in.)</th>
<th>Ideal Location (in.)</th>
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<tbody>
<tr>
<td>5</td>
<td>0</td>
<td>0.75</td>
<td>5</td>
<td>0</td>
<td>1.2</td>
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<td>0.75</td>
<td>4</td>
<td>0</td>
<td>1.2</td>
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<tr>
<td>4</td>
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<td>4</td>
<td>0</td>
<td>1.2</td>
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<tr>
<td>3</td>
<td>0.125</td>
<td>0.875</td>
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<tr>
<td>3</td>
<td>0.625</td>
<td>1.375</td>
<td>3</td>
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<tr>
<td>2</td>
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<td>1.375</td>
<td>2</td>
<td>0.625</td>
<td>1.825</td>
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<tr>
<td>2</td>
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<td>1.625</td>
<td>2</td>
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<tr>
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<td>1.125</td>
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<td>1.25</td>
<td>2</td>
<td>1</td>
<td>1.25</td>
<td>2.45</td>
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</table>
Vessel Allision
Vessel Allision
Repair Recommendations

- **Option 1**: Restore south pinion special tooth profile; Minor modifications to north tooth profile; No rack modifications.

- **Option 2**: Restore south pinion special tooth profile; Remove, relocate, and reinstall bottom 2 south rack and bottom 1 north rack segments.

- **Option 3**: Restore original south pinion tooth profile; Remove, relocate, and reinstall all 5 south rack and bottom 2 north rack segments.

- **Option 4**: Restore original south and north pinion tooth profile; Remove, relocate, and reinstall all 5 south and north rack segments.
Goals:

- Design rack side plates to allow segment relocation
  - Existing conditions
  - Interferences
- Design structural repairs for miscellaneous problems
  - Cracks in critical truss members
  - Deterioration / corrosion problems
Structural Design and Implementation
Structural Design and Implementation
Structural Design and Implementation
Structural Design and Implementation
Structural Design and Implementation

Grind to Remove Existing Rivet Heads, Rivet Body to Remain in Existing Hole

Replace Existing Rivet with 
7/8" A325 Bolt, Typ.

1/2" Plate, Typ.

Existing 3/8" x 21" Rivet, Typ.

Cut and Remove Existing Rivet Heads, Rivet Body to Remain in Existing Hole

SECTION A-A
Structural Design and Implementation
Side Plates – Stage 1
Structural Design and Implementation
Structural Design and Implementation

Yellow paint stick layout marks shown on the existing structure during development of final shop drawings for the new rack side plates.
Goals:

- Determine proper location to reset the rack segments
- Cut new pinion tooth profile inside extents of existing forgings
- Rehabilitate B1 bearing assemblies
- Design turned bolts for racks
- Develop alignment procedures
Design drawing excerpt showing new pinion tooth profile inside extents of existing pinion forgings.
Mechanical Design and Implementation

Typical rack assembly laid out on the floor plate during the templating process.

Template clamped to the rack during the templating process.
Verification of segment joint gaps during the templating process.
Access for rack installation work.
Mechanical Design and Implementation

IPM Personnel utilizing laser tracker to verify template alignment.
Mechanical Design and Implementation

Template removed for temporary installation of rack segment.
Using template to drill rack mounting holes in truss.
Mechanical Design and Implementation

Rack segments installed with alignment pins, ready for final drilling and reaming.
Mechanical Design and Implementation

Final turned bolts installed between rack and truss.
B1 Bearing Assembly Rehabilitation

Existing condition of the machinery girder faying surface for the B1 bearing housing.

The machinery girder was field machined to restore a flat faying surface.
B1 Bearing Assembly Rehabilitation

The B1 bearing assemblies were refurbished in the shop.

B1 bearing reinstalled in the field ready for installation of refurbished pinion shaft.
Pinion Shaft Rehabilitation

The pinion shaft assembly, which had been refurbished in the shop, shown during reinstallation.
Pinion Shaft Rehabilitation
B1 Bearing Assembly Rehabilitation

Field machining setup for reaming B1 bearing base stud holes.
B1 Bearing Assembly Rehabilitation

Detail of fixture for reaming B1 bearing base stud holes.
Final Alignment

Completed repair with proper radial alignment. South assembly shown.
# Bridge Balance Testing

**Test Date: June 29, 2017**

<table>
<thead>
<tr>
<th>Run</th>
<th>WR (ft-lb)</th>
<th>Phi (deg)</th>
<th>Imbalance Seated (ft-lb)</th>
<th>Toe Reaction (lb)</th>
<th>Average Friction</th>
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<tbody>
<tr>
<td>1</td>
<td>+683,171</td>
<td>-70.1</td>
<td>+232,652</td>
<td>2,041</td>
<td>+164,221</td>
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<td>+267,570</td>
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<td>+2,232</td>
<td>+180,306</td>
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</table>

**Notes:**

1. Positive (+) imbalance indicates span heavy balance condition.
2. Positive (+) Phi is measured from horizontal on the channel side of the trunnion in the opening direction of leaf rotation.
3. Toe reactions are based on a perpendicular distance of 114 feet centerline of rotation to toe of the leaf.
Ballast Design and Installation
Commissioning of Repaired Bascule Leaf

G2 Gear Contact Pattern.  
View of completed north truss.
Commissioning of Repaired Bascule Leaf

![Diagram of Repaired Bascule Leaf]

**West Leaf Pinion Engagement**

<table>
<thead>
<tr>
<th>Approx. Angle</th>
<th>Location</th>
<th>south shoulder</th>
<th>tip clr.</th>
<th>north shoulder</th>
<th>tip clr.</th>
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<tbody>
<tr>
<td>70°</td>
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<td>5.75&quot;</td>
<td>0.97&quot;</td>
<td>5.75&quot;</td>
<td>0.97&quot;</td>
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<tr>
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<td>1.03&quot;</td>
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<td>5.81&quot;</td>
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<tr>
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<tr>
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<td>5.97&quot;</td>
<td>1.19&quot;</td>
<td>5.78&quot;</td>
<td>1.00&quot;</td>
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**Measurements:**

- min 0.97" 0.85"
- max 1.22" 1.06"
- south north
Summary and Conclusions

- Operational issues were the result of wear and misalignment
- A robust repair scheme was implemented to refurbish and realign the racks and pinions
- Precision measuring devices allowed machinery installations using custom procedures and templates
- All work performed with bridge raised
- Commissioning process confirmed positive results
- Performance since repair indicates that the rate of wear has been mitigated
Acknowledgements

- Chicago Department of Transportation
- DB Sterlin Consultants
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