

Big Bearings = Big Problems



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Introduction

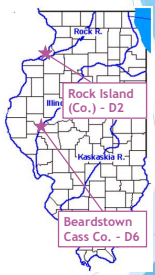
- ▶ Project Description
- ▶ Jacking System & Load Paths
- ▶ Deterioration
- ▶ Strengthening & Retrofitting
- ▶ Field Issues





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Structure Descriptions

- ▶ Centennial - 1940
 - ❖ US 67 w/ 4 traffic lanes over Mississippi River
 - ❖ 3 = 400 ft tied-arch spans
 - ❖ 2 = 540 ft tied-arch spans
- ▶ Beardstown - 1955
 - ❖ IL 100/US 67 w/ 2 traffic lanes over IL River
 - ❖ 2 span through-truss = 720 ft long
 - ❖ 3 span through-truss = 1,380 ft long



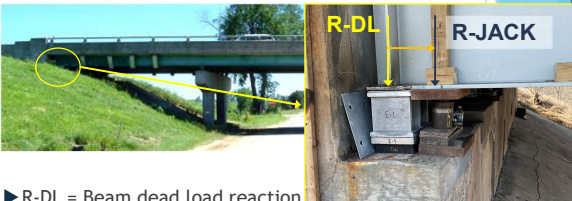

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Typical Structure & Bearing Replacement





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Typical Structure & Bearing Replacement




- ▶ R-DL = Beam dead load reaction
- ▶ R-DL → R-Jack: Minimal change in superstructure beam load path


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Typical Structure & Bearing Replacement



- ▶ Minimal change in load path for superstructure beams


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Typical Structure & Bearing Replacement

Expansion Length

Exp. Exp. Fixed

- ▶ Expansion issues are minimal when bearings can be replaced in short timeframe

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Typical Structure & Bearing Replacement

Expansion Length

Exp. Exp. Fixed

- ▶ Expansion Length
- ▶ As Exp. Length \uparrow = \uparrow chance of structure moving on jack

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Typical Structure & Bearing Replacement

Expansion Length

Exp. Exp. Fixed

R-DL

- ▶ R-DL \leq 100 kips
- ▶ Exp. Length \leq 200 ft

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Centennial Bridge

IL 400' 540' 540' 400' 400' IA

E F E F E F E F E

- ▶ DL Bearing Reaction for 540' Span:
 - ❖ 1,700 kips

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Beardstown Bridge

420' 360' 360'

E F E E F E

- ▶ DL Bearing Reaction at Truss Ends:
 - ❖ 275 kips (2 span unit)
 - ❖ 310 kips (3 span unit)

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Beardstown - Existing Condition

- ▶ Pins for rocker bearings appear to be seized
- ▶ Bearings are rotated in expanded state in middle of winter
- ▶ Anchor bolts are pried over

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Beardstown - Existing Condition

Constraint inducing multiple cracks

Long cracks in horizontal gusset plate

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Beardstown - Existing Condition

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Beardstown - Replacement Bearings

Replacement Bearing Assembly: Steel bolster on top of High Load Multi-Rotational Bearings

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Beardstown Jacking System

Miscellaneous Notes:

- Existing Plans: Load table for End Floorbeam Full D.L. Jacking ← Initially designed for jacking?
- Jacked in 1985 to refurbish bearings: no deck & new Grade 50 floor system
- Original deck: Lightweight open steel grid
- Current deck: 7" slab = ↑ DL

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Beardstown Jacking System

Initial jacking procedure: Jack 1 side at a time - maintain 1 lane of traffic

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Beardstown Jacking System - Load Path

R-Jack $\approx 1.1 \cdot R\text{-DL}$ (100% Left + 10% Right)

Potential "propped cantilever" behavior

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Beardstown Jacking System - Load Path

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Beardstown Jacking System - Load Path

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Beardstown Jacking System - Load Path

Items of Interest:
❖ WF diaphragm between gussets

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Beardstown Jacking System - Load Path

Items of Interest:
❖ Bolted floorbeam connection

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Beardstown Jacking System - Load Path

Items of Interest:
❖ Floorbeam

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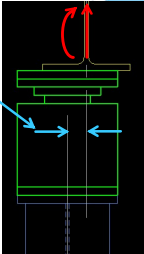
Beardstown Jacking System - Load Path

Items of Interest:
X - WF diaphragm between gussets
X - Bolted floorbeam connection
X - Floorbeam

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Beardstown Jacking System - Load Path

- ▶ Bearing Replacement - Est.'d to take days
- ❖ Thermal movement $\approx 2''$
- ❖ Need to keep jack centered under floorbeam to prevent torsion/twisting

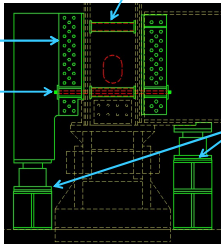


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Beardstown Alternate Jacking System

▶ 2-Jack Concept:

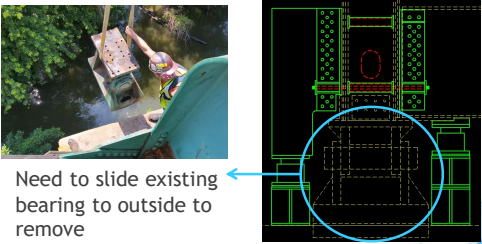
- Tube Stiffeners (top tube may need located above W30's)
- L's bolted to outside gusset
- P-T Bars (Relieves prying action in gusset plate bolts)
- Sliding surfaces under jacks



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Beardstown Alternate Jacking System

▶ 2-Jack Concept




Need to slide existing bearing to outside to remove

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Beardstown Alternate Jacking System

▶ 2-Jack Concept:



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Beardstown Deterioration

▶ Possible extent of concrete repairs?



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Beardstown Deterioration

▶ Diaphragm corrosion



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Beardstown Deterioration

- ▶ Floorbeam Corrosion

Span 9 FB - West

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Beardstown Strengthening & Retrofitting

- ▶ Bolted diaphragm repair
- ▶ Plates and L's on each side of diaphragm
- ▶ Field drilled to match gusset holes
- ▶ Detailed procedure required to protect gusset connection integrity

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Beardstown Strengthening & Retrofitting

- ▶ Floorbeam strengthening:
 - ❖ Top / bot. flange cover plates
 - ❖ Flange to web L's
 - ❖ Brg. stiffener
 - ❖ Web plate
 - ❖ P-T rods

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Beardstown Strengthening & Retrofitting

- ▶ P-T rods: transfer tension at top of FB & limit prying action on FB/gusset conn.
- ▶ 1" dia. - 150 ksi by Williams Form Eng. Corp in oversize hole to prevent shear loading
- ▶ Tensioned to 75 kips w/ impact wrench/Direct Tension Indicating washer

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Beardstown Strengthening & Retrofitting

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Beardstown Miscellaneous Design Issues

- ▶ $R_{DL} = 310$ kips (Unit 1), 275 kips (Unit 2)
 - ❖ From AASHTO bridge rating software
 - ❖ Agrees with exist. plan loading diagram
 - ❖ *But how much does it really weigh?!?*
 - ❖ Increased R_{DL} 10% to account for misc. weight (utilities, rust, etc.)
 - ❖ $Jack_{DL} \approx 1.2 * R_{DL}$ (including propped cantilever behavior)

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Beardstown Field Issues

- ▶ 1st Jacking Attempt = *Unsuccessful*
 - ❖ Max. Span 9 Plan Jack DL = 329 kips
 - ❖ Span 9 Jack Load Req'd = 360 kips
 - ❖ "Popped up" when bearing released
 - ❖ Existing bearings appeared "stuck down"
- ▶ 2nd Jacking Attempt = *Success*
 - ❖ Span 10 Jack DL = Max. Plan Jack DL = 311 kips
- ▶ Remaining Jacking Attempts = *Mixed Results*
 - ❖ Generally had to allow nom. higher jacking loads
 - ❖ Allowing structure to sit overnight on jacks helped "break bearings loose"

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Centennial Bridge - Short Span Exp. Bearings

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Centennial Bridge - Long Span Exp. Bearings

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Centennial Bridge

- ▶ Replace span 2 expansion bearings
- ▶ Monitor the other expansion bearings
- ▶ Design and detail jacking system

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Centennial Bridge - Replacement Bearing

Exist. 2" Chrome Pl.'s → Good Cond.!!!

Exist. Pin

Top Pl. 2" x 2'-10" x 4'-5 3/4"

SS/PTFE Surface

Bot. Pl. 5 7/16" x 2'-2" x 4'-4 7/8"

Exist. rollers: 7 15/16" φ x 4' - 5 3/4"

- ▶ Steel plates with stainless steel / PTFE sliding surface
- ▶ Existing pin at top of bearing → no need for Multi-Rotational bearing

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Centennial Bridge - Replacement Bearing

Exist. 2" Chrome Pl.'s → Good Cond.!!!

Exist. rollers: 7 15/16" φ x 4' - 5 3/4"

Lateral restraint & guide bar

Teeth to match exist. grooves

Field Fillet Weld

- ▶ Steel plates with stainless steel / PTFE sliding surface
- ▶ Existing pin at top of bearing → no need for HLMR bearing

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Centennial Bridge - Jacking System

- 1,700 kips DL
- Vertical Splice Plane for Jacking Bracket
- Existing Plans indicate Jacking Bracket
- Removeable Cover for Jacking Bracket

▶ Jacking bracket = structurally adequate load path

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Centennial Bridge - Jacking System

- 3 1/2"
- 2 1/2"
- Tension Tie
- Compression Struts

▶ Finite element analysis = satisfactory stresses

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Centennial Bridge - Jacking & Cribbing Sequence

- ▶ **Step 1:** Trim exist guide bar (2 1/4" thick) and roller teeth with chrome plates

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Centennial Bridge - Jacking & Cribbing Sequence

- ▶ **Step 1:** Trim exist guide bar (2 1/4" thick) and roller teeth with chrome plates
- ▶ **Step 2:** Remove the exterior rollers (method TBD by Contractor)

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Centennial Bridge - Jacking & Cribbing Sequence

- ▶ **Step 2:** Remove the exterior rollers (method TBD by Contractor)

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Centennial Bridge - Jacking & Cribbing Sequence

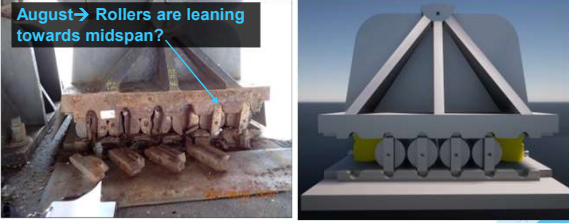
- 4 - 200 Ton jacks with locking collars (Each side)
- Stainless & PTFE Sliding surface under jacks

- ▶ **Step 3:** Install hydraulic jacks
- ▶ **Step 4:** Jack to 1,200 kips and hold for 24 hours

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Centennial Bridge - Jacking & Cribbing Sequence

August → Rollers are leaning towards midspan?



- ▶ Step 3: Install hydraulic jacks
- ▶ Step 4: Jack to 1,200 kips (=70%) and hold for 24 hours

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Centennial Bridge - Jacking & Cribbing Sequence



- ▶ Step 3: Install hydraulic jacks
- ▶ Step 4: Jack to 1,200 kips (=70%) and hold for 24 hours

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Centennial Bridge - Jacking & Cribbing Sequence



- ▶ Step 5: Jack ¼" and remove 4 interior rollers

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Centennial Bridge - Jacking & Cribbing Sequence



- ▶ Step 6: Install new bearing

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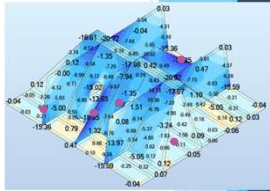
Centennial - Bearing Replacement



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Centennial - Bearing Replacement

- ▶ Staged traffic - replace one bearing at a time
- ▶ Strain gauges specified to monitor stress in existing cast steel section during jacking



Strain Gauge Summary				
Location	Units	Specification Limits	Field Measurement	Ratio
1	ksi	-22	-14.6	0.66
2	ksi	-9	-4.5	0.5
3	ksi	-22	-16.4	0.75
4	ksi	-13	-7.5	0.58
5	ksi	2	0.1	0.06

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Centennial - Bearing Replacement

- ▶ Estimated Reaction = 1,700 kips → 2,000 kips jacking allowed
- ▶ Actual Jacking Loading = 1,900 kips Stage I, 1,600 kips Stage II
- ▶ Center rollers required to be removed and new bearing placed w/in 8-hour period
- ▶ Complete new bearing connection w/in 48 hours of being set in place
- ▶ April 2022 Letting → Bearings were not available until January 2023
- ▶ Bearing replacement completed June 2023

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Questions?



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