Inspection, Load Rating, and Rehabilitation of the New River Gorge Bridge

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The New River Gorge Bridge

Fayetteville, West Virginia

- Owned by WVDOT
- Constructed June 1974 – October 1977
- Main Span Length: 1,700 ft
- Overall Length: 3,031 ft
- Height above the New River: 876 ft
- Longest Steel Arch Bridge in the Western Hemisphere
- Added to the National Register for Historic Structures in 2013
How High is the New River Gorge Bridge?

NEW RIVER GORGE BRIDGE
height comparison

Willis Tower
Chicago 1,730'

Empire State Building
New York City 1,250'

Eiffel Tower
Paris 1,063'

Washington Monument
DC 555'

Statue of Liberty
New York 305'

Space Needle
Seattle 605'

Pyramid of Giza
Egypt 456'

Gateway Arch
St. Louis 630'

Si Du River Bridge (World’s Highest Bridge) China 1,550'
Royal Gorge Bridge Colorado 1,053'
Hoover Dam Bypass Bridge Nevada/Arizona 900'
Recent B&N Projects on the Gorge

- 2008-2014 Inspections
- Assistance with 2012 Rehab
- 2014 Load Rating
- 2014 Rehabilitation Plans
- Selected for 2015-2020
- Six-Year Inspection Contract
- Services During Construction
Bridge Configuration

Bents

Approach Bents

Spandrel Bents
Bridge Configuration
Arch Truss

- Top & Bottom Lateral Bracing
- Chord Members
- Diagonals
- Posts
- Sway Bracing at Bent Connections
How Did Inspectors Access the Bridge?

- Snooper Truck
- Climbing
- Deck Truss
- Floorbeams
- Stringers
Bent Access

- Rappelling and Ascending
- Confined Space Entry
- Connected to the Arch
Power Ascending in 2011

- Inspector Controlled
- Standard Rappelling Set Up
- No Crane Required
- 1000’s of Feet on One Tank
- Work from the Deck
- Reliable
- Fast Ascent

B&N Using Power Ascender at New River Gorge in 2011
Arch Access

- Crane Basket
- Climbing
- Confined Space Entry
Long Term Issues

- Weathering Steel
- Prolonged Wetting
- Poor Bolt Sealing

Nut Loss

Pack Rust

Section Loss

Pigeon Nesting
Understanding the 2012 Rehab

- Vacuum Clean
- Pigeon Waste
- Water Blast
- Caulk Seams
- Apply Penetrant Sealer
  - Inside handholes
  - Areas of corrosion
- Bolt Replacements
2015 Bridge Rehabilitation
Plans are Currently out to Bid

Scope of Work

- Clearing and Grubbing
- Concrete Sealing and Patching
- Clean and Paint Selected Areas
- Replace Deteriorated Bolts
- Solve Debris Issue in the Arch Members
- Replace Abutment and Stringer Relief Joints
- Strengthen Deck Truss Diagonals
- Retrofit and Reset Bearings at Bents 19 and 5
- Miscellaneous Repairs and Maintenance, etc.
Primary Issue = Section and Nut Loss Inside

- **Deck Truss**
  - Sealed in 2012
  - Additional Locations

- **Bent Bases**
- **Arch Post, Diagonals, & Bracing**
  - Open End Boxes

- **Cleaning and Sealing**
Solving Debris Issues in Arch Members

- **Problem:** Water Flowing Under Arch Rib
- **Solution:** Divert Water with Magnetic Drip Bar
Solving Debris Issues in Arch Members

- **Problem:** Water/Birds Entering Top of Arch Members
- **Solution:** Install HDPE Cap Plates
Solving Debris Issues in Arch Members

- **Problem:** Members Not Draining, Weep Holes to High

![TYPICAL UPPER ARCH WEEPHOLE](image1)

![TYPICAL UPPER ARCH WEEPHOLE](image2)
Problem: Members Not Draining, Weep Holes to High
Solution: Extend Weep Holes
“Danielson! Show me Wax On… Wax Off…”

- Pressure Wash
- Penetrant Sealer
- Wax Coating – sets up like a candle wax
Expanding Polyurethane Foam Joints

Features

- Silicone Impregnated
- Traffic durable
- Pre-compressed
- Non-invasive anchoring
- Staged installation
- 2 lanes in 2 hours

https://www.youtube.com/watch?v=mbsIhnATnUQ
Load Rating Scope

- Rate all primary bridge members
- Rate all primary member connections, including gusset plates
- Include wind and temperature effects in the rating
- Ratings for 10 different live load vehicles
- Include all member losses and deficiencies

- 4500+ members
- 871 gusset plates
- 1034 non-gusset connections
Structural Model

- Modeled using Midas Civil Software.
- Truss Elements were used for the arch truss and deck trusses.
- Beam Elements were used for the bent legs and floor system.
Structure Configuration

- 3 Units, with expansion joints at bent 5 and bent 19
- Longitudinally fixed at the abutments
- Unit 1 and 3 bents fixed at the base
- Unit 2 bents treated as pin-pin
Typical bearing condition at top of bent
Typical Bent Bearings:

- Bent bearings were modeled using elastic links. Links were released for rotation at the top node.
Bearing Configuration at Bent 5 and Bent 19
Bents 5 & 19 (Expansion bearing locations):
- A series of 4 links is used to connect the truss bearings to the bent cap.
Geometric nonlinear analysis was conducted for 12 wind combinations + dead load.
Data Management

Database
(Excel Spreadsheet)
- Node Coordinates
- Member Data
- Section Properties
- Dead Loads
- Live Load Cases
- Section Loss

Write Midas input file using VBA macro

Model
(Midas Civil)

Output Data
(Export to Excel)

Member Capacity
Calculations

Rating Factor
Calculation
- A total of 871 gusset plates were rated.
- Many of the connections are very large and very complex.
- A standardized data collection and rating system was used for efficiency and consistency.
Gusset Plate Geometry Data Collection

- Shop drawings were imported into Cadd and scaled.

- Critical dimensions (Whitmore section, block shear, global shear planes) were added and measured within the drawing.
Rating Results For Existing Bridge

- All rated members have HS20 operating ratings > 1.0
- 8 Deck truss diagonals have HS20 inventory ratings < 1.0. These members will be strengthened.
- All gusset plates and connections have HS20 inventory and operating ratings > 1.0
Bearing Repositioning

- The roller bearings at bents 5 and 19 have excessive tilt
- Upper and lower bearing plates are misaligned
- Roller has slipped relative to the sole plate and baseplate
- Retainer are not functioning properly
Retainer plates are intended to prevent slipping relative to baseplate and sole plate.

Retainer plates are connected to the roller only at the center.

This connection allows the plates to rotate relative to the roller, making the retainer plates ineffective.
Bearing Repositioning

- Vertical jacking would be very difficult due to height of the bent and the steel pier cap.
- The bearings will be repositioned without removing dead load by horizontally jacking the baseplate and roller.
Schematic layout of Bent 5 / Bent 19 bearings:

- Approach Spans
- Main Span
- Fixed Bearing
- Bent Cap (Bent 5 or Bent 19)
- Roller Bearing
Step 1: Install Jacking Assembly & Threadbars

- 2-1¾” Dia. Threadbars
- Jacking Assembly
- Bumper
- Pushing Beam
Step 2: Temporarily remove retainer plates from roller bearing

Remove retainer plates to allow free rotation of roller
Step 3: Jack threadbars, pull bearing base plate to final position

Jack threadbars until bearing baseplate hits the bumper
Step 4: Remove jacking assembly

Roller is still tilted
Step 5: Install roller jacking assembly and threadbars

- Roller Jacking Assembly
- Bumper
- Pushing Beam
- 2-1\(\frac{3}{4}\)" Dia. Threadbars
Step 6: Jack threadbars and pull roller base to final position

Jack threadbars until bearing baseplate hits the bumper

PULL!
Step 7: Remove roller jacking assembly

Still tilted
Step 8: Re-install roller jacking assembly

2-1\(\frac{3}{4}\)” Dia. Threadbars

Pushing Beam

Bumper

Roller Jacking Assembly
Step 9: Jack threadbars, pull top of rocker to final position
Step 10: Remove roller jacking assembly

Now roller is plumb
Step 11: Reinstall retainer plates

If roller is positioned properly, retainer plate alignment should match roller.
Step 12: Install retaining bars to lock retainer plates and roller together

1” x 3” bars connected to tabs welded to retainer plates
Summary

- Significant, Unique Structure
- Technical Challenges
- Successful Partnering
- Full-Service Project
- Practical Solutions
- Protecting the Public Investment
Thank You

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