“Drilled Shafts for Bridge Foundation
Stability Improvement
Ohio 833 Bridge over the Ohio River”
An Update

Meigs County, Ohio
Mason County, West Virginia

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Agenda

I. Introduction/Background
   A. General
   B. Initial Slope Movement
   C. Remediation Scheme
   D. Instrumentation Plan

II. Instrumentation Results/Recent Slope Movement

III. New Instrumentation on Existing Bridge

IV. Lessons Learned

V. Question/Answer
I. Introduction/Background
Project Location

Pomeroy, Ohio
Project Team

- **Owner:** ODOT/WVDOH
- **Designer:** URS Corporation
- **Contractor:** Mahan/National Joint Venture
- **Geotechnical Consultant:** FMSM
Existing Structure
Proposed Structure

WEST VIRGINIA

OHIO
Project Timeline

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
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<tbody>
<tr>
<td>2000</td>
<td>FMSM Geotechnical Exploration</td>
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<td>Bridge Design</td>
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<tr>
<td>2001</td>
<td>Bridge Construction</td>
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<tr>
<td></td>
<td>Slope Movement Detected</td>
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<tr>
<td></td>
<td>Slope Monitoring</td>
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<td>2002</td>
<td>Monitoring of Existing Bridge</td>
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<tr>
<td>2003</td>
<td>Construction of Protective Measures</td>
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<tr>
<td>2004</td>
<td>Monitoring of Protective Measures</td>
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<tr>
<td>2005</td>
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<tr>
<td>2006</td>
<td></td>
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<td>2007</td>
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Current State of Construction
Stability Issues/Slope Movement/Reaction

- New Main Street Embankment
- Short-Term Stability Concerns
- Controlled Rate-of-Fill
  - Slope Inclinometers
  - Piezometers
- Initial Detection of Movement
- Additional Instrumentation
Original Extents of Slope Movement

Approximate Limits of Slope Movement
Probable Causes of Slope Movement

- Weak slickensided clay shale (mudstone)
- Possible ancient movement
- Construction activity/embankment
- Rapid drawdown cycles of Ohio River
Slope Geology/Geometry

- Shale/Clay Shale/Mudstone
- Bedrock
- Residual Clay
- New Fill
- Existing Fill
- Alluvial Silt and Clay
- Apparent Failure Surface
- Siltstone
- Ohio River
Ohio River
Potential Failure Surface
Siltstone

ODOT’s Preferred Option and Related Decisions

Realign Main Street to Reduce Fill Height

Abutment  Touch Down Pier

NEW BRIDGE

Change Abutment and Land Pier Foundations to Drilled Shafts

Potential Failure Surface

One Row of Nine Drilled Shafts Between the Land Pier and the Water Pier
Plan View of Stabilization Shafts

8' Diameter Drilled Shafts on 12' c/c Spacing
Instrumentation Plan

- **Site** – Slope Inclinometers, Piezometers
- **Existing Bridge** – Tiltmeters, Survey Targets
- **Touch Down Pier** – Strain Gauges, In-Place and Manually Read Inclinometer
- **Stabilization Shafts** – Tiltmeters, Strain Gauges, In-Place and Manually Read Inclinometers
Stabilization Shaft Instrumentation Plan

Figure A - Plan View of Stabilization Shafts
Scale: 1"=10'

Note: Instrumented Shafts Are Shown Cross-Hatched.
II. Recent Slope Movement/Instrumentation Results
Recent Movement (Oct ’06 - Feb ’07)

- **Detection**
  - Instrumentation Activity (late October)
  - Tension Cracks (early December)
  - Water Main Break (early December)

- **Causes**
  - Construction Activity
  - River Fluctuation
Tension Cracks – 12/11/06
Construction Activity – 11/30/06
Ohio River Fluctuations

River Elevation (feet)

Slope Movement
Tied Back Retaining Wall
Results of Instrumentation

- **Site**
  - 4 Years of Data
  - Numerous Inclinometers Sheared Due to Slope Movement

- **Existing Bridge**
  - 3 Years of Data
  - Abutment Tilt Due to Recent Movement

- **New Bridge Touch Down Pier**
  - 3 Years of Data
  - Top Deflection Due to Lateral Loading

- **Stabilization Shafts**
  - 2 Years of Data
  - Northernmost Shaft Being Loaded
Current Extents of Slope Movement

Limits of Movement
Existing Bridge Tiltmeter Results

Zeroed Y-Tilt Readings
Positive → Top Moving Downslope

Abutment
Land Pier Top
Land Pier Bottom
Water Pier Top

Instrument Malfunction

Time
Tilt (deg)
Existing Bridge Tiltmeter Results

**Land Pier Top Tiltmeters**

**Temperature Influence on X-Tilt Readings**

- Temperature (F)
- Tilt (deg)

**Temperature Influence on Y-Tilt Readings**

- Temperature (F)
- Tilt (deg)

First Track: Oct-2004 – Mar-2005


Fourth Track: Dec-2006 – Feb-2007


Looking Up-slope, Positive → Clockwise Tilt

Positive → Top Moving Down-slope
Stabilization Shaft Strain Gage Results

SS9: Moment Diagram
With Linear Regression

Positive Moment ⇒ Tension on Upslope Face

Moment (kip-ft)

Elevation (ft)

Bottom of Shaft

Top of Rock

Top of Shaft

Cracking Moment

LPILE 0.2"

- 21-Oct-2006
- 04-Nov-2006
- 18-Nov-2006
- 02-Dec-2006
- 16-Dec-2006
- 30-Dec-2006
- 14-Jan-2007
- 28-Jan-2007
- 11-Feb-2007
- 25-Feb-2007
- 11-Mar-2007
- 25-Mar-2007
- 08-Apr-2007
- 22-Apr-2007
- 06-May-2007
- 20-May-2007
- 03-Jun-2007
- 17-Jun-2007
- 01-Jul-2007
- 15-Jul-2007
Stabilization Shaft 9 – IPI Plot

Cumulative Displacements
Stabilization Shaft 9
Pomeroy-Mason Bridge Project
Meigs County, Ohio

Y-Axis (Up slope +)

X-Axis (Right +)

30-Dec-2006
14-Jan-2007
26-Jan-2007
11-Feb-2007
25-Feb-2007
11-Mar-2007
25-Mar-2007

Cumulative Displacement (in.)

Elevation (ft)

-1 -0.5 0 0.5 1

550 545 540 535 530 525 520 515 510 505 500 495 490 485 480 475 470 465

-1 -0.5 0 0.5 1

550 545 540 535 530 525 520 515 510 505 500 495 490 485 480 475 470 465
Touch Down Pier Strain Gage Results

DS-54: Bending Moment History

Cracking Moment (approx. 30% of Moment Capacity)

- El. 530 ft
- El. 534 ft
- El. 542 ft
- El. 566 ft
- El. 576 ft

Bending Moment History

Time

Bending Moment (kip-ft)

Cracking Moment (approx. 30% of Moment Capacity)
III. New Instrumentation on Existing Bridge

- Jointmeters (3 Joints on Ohio Side)
- Tiltmeters on Linkage Assemblies
- Strain Gages on Truss Members
IV. Lessons Learned

- Difficulty with Instrumentation Durability in Construction/River Environment
- Sole-Source Instrumentation Consultants
- Communication Between Contractor and Engineer Key
- Better Results from Tiltmeters/Strain Gages than IPI’s
- Look for Agreement Between Instruments
- Human Intervention with Instruments Necessary At Times
- Installation and Access Can Be Difficult
V. Questions/Answers