Mississinewa Dam
Foundation Rehabilitation

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Louisville District
MISSISSINEWA DAM

Louisville District

Constructed – Mid to Late 1960’s

- Total length 8100 feet
- Total height 140 feet
- Crest elevation 797
- Spillway elevation 779
- Summer Pool 737 *
- Winter Pool 712
Geology

Glacial Deposits: 10-70 feet Silty clay overlying sands and gravels

Liston Creek Fm: 0-70 feet Thinly bedded, cherty, crystalline limestone prone to solutioning.

Mississinewa Fm: > 30 feet Thinly bedded argillaceous limestone
Typical geologic cross-section along the dam centerline.
Figure 3.--Block diagram showing the structure of lapies and grikes.

Adapted From Indiana Geological Survey, *Caves of Indiana* by Richard L. Powell
Solution feature on left abutment side of conduit excavation
View of solution channel, located at dam station 51+00, on left abutment side of conduit excavation.
MISSISSINEWA DAM
Louisville District
Features of Interest for the Mississinewa Dam Project
1988

Operations Personnel Identify Guardrail Deflections
SI-1 (station 40+25), approximately elevation 758

View in May 1995

View in June 1999
June 1999 view of SI-2 (station 40+25) at approximately elevation 758
Settlement Mechanism
Foundation Piping

Water
Settlement
Sand & Gravel
Rock

Not To Scale
Cut-off Wall

A cut-off wall was selected as the only practical and certain method of repairing the foundation for the dam. The cutoff wall would extend to depths of 180 feet and up to 80’ into rock.
Typical geologic cross-section along the dam centerline.
Construction Contract

RFP Performance Specification

Requirements Specified & Methods Restricted

Methods Selected by Contractor

Technical Factors More Important Than Price
Contract Award

All 3 Proposed Clamshell/ Hydrofraise Backup Method – Chisel Supplement

Award to Bencor/Petrifond JV for $29,800,000 September 2000
Site Map Showing Major Areas of Interest
Geotechnical and Dam Safety Section
MISSISSINEWA DAM

SECTION 1

NOTES:
1. RETAINING WALL TO BE DESIGNED BY CONTRACTOR. THE TYPICAL SECTION IS A DEPICTION OF A GENERAL RETAINING STRUCTURE.

2. SEE SHEET GB100 AND BORING LOGS FOR SOIL AND ROCK INFORMATION.

3. T.B.D. = TO BE DETERMINED. ACTUAL EMBEDMENT DEPTH SHALL BE DETERMINED BY THE CONTRACTOR.

4. EMBEDMENT DEPTHS FOR WORK PLATFORM WINGS SHALL BE SUFFICIENT TO RETAIN STONE BACKFILL. IN NO CASE SHALL EMBEDMENT BE LESS THAN 5'-0".
Cable-Clam Bucket

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Louisville District
Geotechnical and Dam Safety Section

MISSISSINEWA DAM

2003-10-07 16:08
Typical geologic cross-section along the dam centerline.
Test Section

Attempts to Excavate Rock in Test Section Resulted in Sudden Complete Slurry Loss
Test Section

Change To Construction Approach

Pregrouting Required to Enable Cutoff Wall Construction

RFP type selection of the Grouting Subcontractor (ACT)

Grouting ITR by Dr. Donald Bruce
Rotosonic Drill Rig
Sample Extrusion
Rotosonic Samples
Geotechnical and Dam Safety Section

MISSISSINEWA DAM

Rock Drill
Two High Speed/High Volume Grout Plants
Grout Header Controls
IntelliGrout Operator’s Station
Typical Void Refusal, Refined “D Mix”
Test Section
B Line Master Drawing
Grout Line Layout

B-Line

Cutoff Wall Alignment

A-Line

Downstream

Upstream
Tremie Concrete Placement
Test Section

Test section is complete.

Pregrouting was successful. NO SLURRY LOSSES

An optimum program for production was developed.

Drilling for grouting will provide a preview to problems.

Cost growth due to grouting is unknown.

Actual quantities required to treat features will govern.
$10 - 15 Million (Likely)
$25 Million (Worst Case)
Holes were drilled on both sides of the cutoff wall
Crane Mod For Deep Section
Crane Boom Failure
Crane Fire

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Geotechnical and Dam Safety Section
Mill Recovery

MISSISSINEWA DAM

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Louisville District

Mill Retrieval With Dywidag Bars
September, 2004
Dam Foundation Remediation
Contract No. DACW27-01-C-0018

Bencor-Petrifond, J.V.

U.S. Army Corps of Engineers
Mill Recovery

Bencor-Petrifond, J.V.
Mill Retrieval Hydraulic Jacks
September, 2004
Dam Foundation Remediation
Contract No. DACW27-01-C-0018

U.S. Army Corps of Engineers
Mill Recovery
Mill Recovery
Additional Mills Mobilized
Soil Cutting Wheels
Mill Fest

Bencor-Petrifond, J.V.  
Hydromills On Platform  
December, 2004  
Dam Foundation Remediation  
Contract No. DACW27-01-C-0018

U.S. Army Corps of Engineers
Final Wall Profile
Quality Control

- Bentonite Testing
- Panel Embedment & Continuity
- Panel Verticality
- Concrete Testing
- Verification Drilling
- Dam Instrumentation
Bentonite Testing Equipment

Mud Balance and Marsh Funnel Cone

Pressure Filtration Machine
Marsh Funnel Test
Density Test
Pressure Filtration Testing
Sand Content Testing
Cuttings Observations for Panel Embedment
Verticality Checks

- Hydromill Inclinometer
- Jean Lutz® Inclinometer/Gyroscope
- Plumb Bob
- Koden® 682/684
Jean Lutz® Plot

MISSISSINEWA DAM

Geotechnical and Dam Safety Section
MISSISSINEWA DAM
Koden® Verticality Machine
Koden® Plot

Geotechnical and Dam Safety Section
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Plumb Bob Reading

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Geotechnical and Dam Safety Section
MISSISSINEWA DAM
## Plumb Bob Results

### Panel P-11 - Bore #1 - Verticality - Plumb Bob

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<th>Depth (ft) Below Guide Wall</th>
<th>Readings at Guide Wall (Inches)</th>
<th>Panel Deviation (Inches)</th>
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**Note:** () Upstream, (*) Downstream

### Panel P-11 - Bore #2 - Verticality - Plumb Bob

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**Note:** () Upstream, (*) Downstream
Concrete Quality Checks

- **Batch Plant**
  - Scale Calibration quarterly
  - Electronic Moisture meter calibration
  - Sieve Analysis on aggregates
  - Gradation analysis on aggregates
  - Moisture on sand and aggregate
  - Fly-ash grain size analysis
Tremie Procedures

- Go-Devil utilized
- Tremie Pipe Embedment
- Chart tremie progress and quantities
  - (in real time)
- Count tremie pipe lengths
Concrete Quality Testing

During Placement--
- Slump
- Air Content
- Temperature
Verification Drilling

• Purposes:
  – Concrete Quality
  – Panel Contact/Joint Quality
  – Cutoff-Wall---Rock Bottom Contact

• Techniques:
  – 4 inch core for Panels
  – 6 inch core for Panel Joints
Verification Drilling

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Geotechnical and Dam Safety Section
Panel-Rock Contact
What we don’t want!
Borehole Pressure Testing

- Verifies wall water-tightness
- Verifies Wall-Rock Interface
Dam Instrumentation

• Purposes
  – Verify dam integrity
  – Check effectiveness of grouting
  – Check effectiveness of concrete cutoff wall
  – Historical record for future use
Paired Piezometers

Geotechnical and Dam Safety Section
MISSISSINEWA DAM

Downstream Piezometers

Cutoff Wall Position

Upstream Piezometers

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What have we learned?

• Solution Features are worse than expected.
• Clearly we were in a failure mode, reinforcing the need for remediation.
• Need for Pool restriction reinforced.
• Pregrouting is required to control slurry loss.
• Need to adjust design to field conditions.
• Cost and Schedule Growth will be governed by Geology.
• Large Contingencies are required for foundation repair projects.
Final Price Approx. $50 Million.

Most of the cost growth due to pretreatment grouting.

No milling production issues related to rock strength.