McAlpine Lock Replacement Project
Foundation Characteristics and Excavation

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**Presentation Items:**

- Project History and Regional Geology
- Construction Activity and Interactions with Site Geology
- Corrective Measures Required due to Construction Activity Problems
- Disputed Issues and Lessons Learned
General Geologic Conditions at McAlpine
General Geology

New Albany Shale

Beechwood Limestone

Silver Creek Limestone

Jeffersonville Limestone
General McAlpine Layout

- Roller Compacted Concrete (RCC) Monoliths
- Conventional Concrete Monoliths
- Lock Floor Culverts
Mechanical Rock Excavation
Location of new lock extension
Explosive Rock Excavation
Excavations which penetrate into rock anywhere from 5-feet to 35 feet, requiring controlled blasting techniques.
Smooth-Wall Blasting Technique
Sinking and production shots made previous to perimeter shots
Trim Blast
Buffer Holes
Trim Holes
As a consequence of choosing a method with no perimeter control, a diligent quality control (QC) program needs to be implemented.
Without a diligent quality control (QC) program, you end up with...
Examples of back-break due to lack of perimeter control.
Effects of back-break on foundation integrity

SM-17
Effects of back-break on foundation integrity

SM-8 through SM-11
Offset boreholes observed in north face of north culvert
Sliding Resistance Results from Direct Shear Testing

![Graph showing sliding resistance results.]

- Normal Load (psi) vs. Sliding Resistance Strength (psi)
- Data points for Post Shear Sliding, Sawn Surface, and Natural Fracture
- Design Trendline: \( \phi = 35^\circ \), \( c = 5 \) psi

Geotechnical and Dam Safety Section
Louisville District
What kind of strength do you give to a seam which has been damaged and shifted?
Sliding Resistance Strength

Reduced from
\[ \phi = 35^\circ \]
\[ c = 5 \text{ psi} \]

SM-8
\[ \phi = 22^\circ \]
\[ c = 0 \text{ psi} \]

SM-9
\[ \phi = 25^\circ \]
\[ c = 0 \text{ psi} \]

SM-10
\[ \phi = 27^\circ \]
\[ c = 0 \text{ psi} \]

SM-11
\[ \phi = 29^\circ \]
\[ c = 0 \text{ psi} \]
Allowable Bearing Capacity

- Reduced from 62 ksf

SM-8: 29 ksf
SM-9: 46 ksf
SM-10: 46 ksf
SM-11: 62 ksf
Pre-stressed tendon anchors placed in SM-8 & 9
Interpretation of what caused the damage
In-Situ Stress

“Prove that it is there” … vs … “Prove that it is not there”
SM8N: Downstream Movement

As presented by Dr. Matthew Mauldon
Horizontal Stress Ratio vs Depth

**Horizontal Stress Ratio vs Depth**

\[ \frac{\sigma_h}{\sigma_v} \]

Depth (m)

- 115 Measured stress ratio data points (from other sites)

**McAlpine SM8-N (estimated)**

- 116 Measured stress ratio data points (from other sites)

As presented by Dr. Matthew Mauldon
Horizontal Stress vs Depth

Horizontal stress (ksi)

0 2 4 6 8 10 12

1 10 100 1000 10000

Depth (m)

McAlpine: stress required to produce observed offset

Hoek-Brown Data

As presented by Dr. Matthew Mauldon
The right interpretation...
As depicted by Dr. Calvin Konya
As depicted by Dr. Calvin Konya
As depicted by Dr. Calvin Konya
Besides....
North Culvert Shots Adjacent to SM-8
North Culvert Shots Adjacent to SM-8

Gas coming out of fracture in adjacent SM-8 foundation
North Culvert Shots Adjacent to SM-8
North Culvert Shots Adjacent to SM-8

Fly-rock…
North Culvert Shots Adjacent to SM-8

A lot of fly-rock…
North Culvert Shots Adjacent to SM-8
North Culvert Shots Adjacent to SM-8

More fly-rock…
North Culvert Shots Adjacent to SM-8
North Culvert Shots Adjacent to SM-8

Fly-rock...still...
Lessons Learned
When blasting, always use a proven method which promotes perimeter control, helping to protect the final rock surfaces.
Document every possible observation in detail, no matter how insignificant it appears to be at the time!
In order to make said observations, specify what is expected of the Contractor to maintain as clean a work site as possible.
QC procedures must be implemented and adhered to. Post-blast conditions must be observed so future blast designs are modified to prevent perpetuating problems.
Questions?