Grouting and Anchoring an 1880’s Masonry Dam

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Presentation Overview

- History
- Design
- Construction
- Challenges and Takeaways
Background

- **Deficiencies**
  - Spillway Capacity
  - Stability

- **Alternatives**
  - Anchor
  - Buttress
Background

- Exploration
  - Traditional coring
  - Piezometers
Design

Stabilize for PMF Overtopping

Grout rubble masonry
Dowel masonry units together
Anchor dam
Design

- Pressure grout rubble fill
  - MMG and HMG
  - Balanced / stable grouts
  - Real time monitoring
  - Primarily ascending stage
Design

- Grout rubble fill
- Dowel masonry
Design

- Grout rubble fill
- Dowel masonry
- PT anchor dam
Parapet Dowels
Grouting
Grouting Evaluation

Grout Take Comparison

- **Upstream**: Primary - 3.2, Secondary - 1.0
- **Tertiary**: Primary - 0.4
- **Downstream**: Primary - 2.5, Secondary - 1.2

Legend:
- **Primary**
- **Secondary**
Grouting Evaluation
Masonry Dowels
PT Anchors
Drilling Challenges
Drilling Challenges

Uphole Velocity

\[ UHV = \text{Uphole Velocity of Flush Water} \]

\[ D^2 = \text{Hole Dia.} \]

\[ d^2 = \text{Drill Steel Dia.} \]

\[ \text{Drill Bit} \]
Drilling Challenges

Cuttings Removal

**Uphole Velocity**

\[ UHV \, (m/\text{min}) = 1274 \times \text{Flush Rate (liters/min)} \, \frac{D^2 - d^2 \,(\text{mm})}{\text{D}^2} \]

Ref 1

**Slip Velocity**

Stokes law w/ drag force, stagnant fluid

\[ v_{sl} = d_s^2 g (\rho_s - \rho_f) / (18 \mu) \]

Ref 2

**Turbulent slip velocity**

\[ v_{sl} = \frac{2}{3} \sqrt[3]{\frac{3gd_s (\rho_s - \rho_f)}{fp_f}} \]

Ref 2

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Drilling Challenges
Drilling Challenges

RETURN WATER/ CUTTINGS
FLOW DIRECTION

DRILL BIT

CUTTINGS

DRILL ROD

DEBRIS/ CUTTINGS

DRILL BIT
Drilling / Grouting Challenges

- **Exploration**
  - Coring ≠ Drilling
  - Test drilling methods

- **Drilling**
  - Water Loss
  - Caving
  - Cutting removal
  - Dam disturbance

- **Grouting**
  - MMG/HMG
  - Pressure
Thank You