3D Block Erodibility: Experimental Results & Application





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The Issue...

- Infrastructure operation / safety (dams, tunnels, bridges)
- Excessive erosion -> high remediation costs, loss of life







Rock spillway /channel

Unlined tunnel



Rock Scour Mechanisms – Hydraulic Controls

- Inertial force mass of water hitting rock, magnitude ~ u_m
- Fluctuations turbulent eddies, **u**'



Rock Scour Mechanisms

• Block removal along existing and newly formed fractures







Current scour technology

- Erodibility Index Method
 - Semi empirical
 - Failure mechanism not considered



- Comprehensive Scour Model
 - Physics based
 - Simplified rock structure







Data Collection for 3D Block Erodibility

- Hydraulics: Physical hydraulic model
- Hydraulics: Instrumented field blocks
- Rock Mass: LiDAR



Point Cloud at Spaulding Dam



Instrumented field blocks





- 2D channel flow
- Froude scale model
- Length scale ~ 10













Flume at UC-Berkeley Richmond Field Station

- Instrumentation
 - pressure (12)
 - displacement (3)
 - 3D flow velocity (1)
 - flow depth (2)



Rotatable Block Mold

- Modeled scenarios:
 - 9 discharges (Q1-Q9)
 - high/low turbulence
 - 3 block protrusions
 - 13 block rotation angles
- Goal:
 - Comprehensive, high-resolution data set (> 1,000 runs)





• Real-time video (165 deg rotation, low Tu)





Side View

Top View



• Slow motion 1FPS (165 deg rotation, low Tu)





Side View

Top View

























Block Erodibility Threshold

• Block protrusion effects





Block Erodibility Threshold

• Turbulence effects





Framework for prediction





Variability in Scour Process

Erosive Capacity



Rock Resistance



Variability = $f(\mathbf{x},t)$



Summary

- Block erodibility threshold highly influenced by 3D geologic structure
- Turbulence can lower block erodibility threshold (NEED to CONSIDER FLUCTUATIONS, not just mean velocity).
- Reliability based block theory approach provides a way to incorporate 3D site specific rock structure and variability into scour assessment
- Critical areas & key variables can be targeted leading to more efficient field investigations / remediation designs



Questions?

