RECLAMATION
Managing Water in the West
U.S. Department of the Interior
Bureau of Reclamation

Technical Service Center, Denver, Colorado **Sedimentation and River Hydraulics Group**

Qualitative Results from Physical Modeling of Scour Pools Downstream of Rock Weir Structures

Design Guidelines for River Spanning Rock Structures

What Is The Problem?

Field investigations identified growth of the downstream scour hole and the resulting geotechnical slump as a primary failure mechanism for loose rock weir structures. Existing methods do not accurately predict scour or capture the hydraulic processes controlling growth of scour holes and undermining in rock weir structures.

What Is The Solution?

Physical modeling facilities at Colorado State University are being used to test a range of weir configurations and bed material sizes. Testing includes live bed scour simulations of single and double drop style weirs. Initial test results identified several design considerations including:

- Scour depths significantly exceeded estimates using techniques for culverts and other processes.
- To minimize scour, the rocks comprising the weir should consist of blocky shapes spaced tightly together and carefully placed to form a smooth continuous crest.
- The intersection of the arm with the bank creates a weak point and requires a key-in to prevent flanking.
- Structures are highly sensitive to drop height. Lower heights result in more robust structures.
- A stair step approach to the header and footer rocks reduces the size of the scour hole.
- Placing the crest at or above the upstream bed elevation did not impact the hydraulics or scour.

Physical model testing confirmed field observations and provided guidance for future observations.

What Are The Benefits Of This Solution?

Laboratory results confirmed the geotechnical failure mechanism hypothesized from field investigations. Intact structures appeared to successfully modify flow patterns and bed characteristics and warrant use of weirs in the future. An understanding of scour processes and quantities allows design of sustainable structures requiring fewer repairs, rarer disruption of service, and lower maintenance costs. Understanding processes governing success and failure allow designers to construct more robust river structures to better fit project constraints and minimize design, construction, and maintenance costs.

Future Development Plans

The testing matrix for the physical model includes a total of 27 cases; 3 grain sizes (coarse gravel, very coarse gravel, and small cobble), 3 discharges, and 3 structure types (U, A, and W crest configurations).

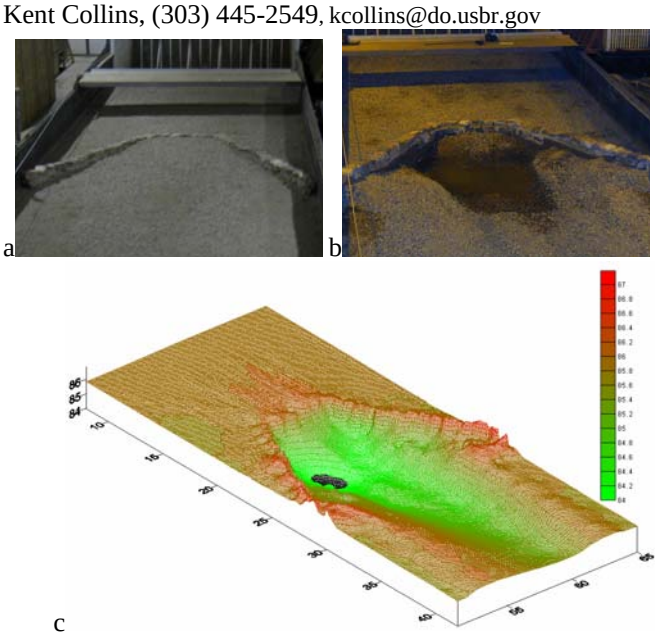
Structure	Bed Material	Discharge
U-weir	CG, VCG, SC	1/3, 2/3, Bankfull
A-weir	CG, VCG, SC	1/3, 2/3, Bankfull
W-weir	CG, VCG, SC	1/3, 2/3, Bankfull

Results from the laboratory tests will assist in developing a scour prediction method for rock weir structures. The laboratory physical modeling forms part of a multifaceted approach incorporating a quantitative evaluation of field data to provide empirical validation, laboratory physical modeling for controlled testing of complicated processes, and numerical simulations to expand the range of applicability and analytic capability. The end product will develop tools and guidelines for more robust design or retrofits of rock weir structures based upon predictable engineering and hydraulic performance criteria.

Additional information on the River Restoration Structures Research is available on the Sedimentation and River Hydraulics Group web site:
http://www.usbr.gov/pmts/sediment/kb/spanstructs/index.html

Contact Information

Kent Collins, (303) 445-2549, kcollins@do.usbr.gov



Physical modeling results for a U-weir rock structure (a) initial bed (b) final bed (c) 3D grid of final bed elevations.