RECLAMATION Managing Water in the West

April 2013
Research and
Development Office
Bulletin 2013-14

The Knowledge Stream
Research Update

Improving the Range of Hydraulic Performance of Type III Stilling Basins

Determining how stepped chutes affect stilling basin performance

Bottom Line

Current design guidance for Reclamation's Type III stilling basins can be used for stepped spillway applications.

Better, Faster, Cheaper

Successfully applying existing stilling basin design guidance to stepped spillways improves the range of applicability of design standards.

Principal Investigator

Connie Svoboda
Hydraulic Engineer
303-445-2152
csvoboda@usbr.gov

Problem

Water passing over the spillway of a dam typically has a large amount of energy, resulting in high flow velocities at the downstream end of the spillway. Stilling basins at the end of spillways are commonly used to dissipate energy from the flow and slow the water velocity to protect the downstream river channel from erosion and damage.

Traditionally, spillway surfaces were constructed with concrete and made as smooth as possible. Standard stilling basin designs, such as Reclamation's Type III stilling basin, were developed to provide appropriate energy dissipation for these smooth spillways. Over the last 20 years, however, spillway construction techniques have evolved to include using spillways and chutes with a series of abrupt steps built into them, called "stepped spillways."

Flows passing over a stepped spillway exhibit different velocity and energy characteristics than flows passing over a smooth spillway. This has created concerns about the appropriateness and applicability of standard stilling basin designs when used in combination with stepped spillways.

Investigation

This Science and Technology Program research project used a physical hydraulic model to compare the performance of Reclamation's Type III stilling basin for smooth and stepped spillways.

— continued

Physical model of stepped spillway and stilling basin.

— continued

The model was constructed to represent two spillway and stilling basin configurations:

1. Smooth spillway with stilling basin featuring chute blocks, baffle blocks, and endsill.

2. Stepped spillway with stilling basin featuring baffle blocks and endsill.

Each configuration was tested using three different spillway slopes: 4 horizontal (H) to 1 vertical (V), 2H:1V, and 0.8H:1V. Two types of baffle blocks were tested in the model to identify the effects of block shape on stilling basin performance. Standard baffle blocks and a new type of baffle block, called a "supercavitating baffle block," were examined. This supercavitating baffle block was designed to minimize damage to the blocks and the stilling basin floor at high incoming velocities.

Parameters measured in the model for each test configuration included discharge, flow depth entering the stilling basin, flow depth exiting the stilling basin, and the air concentration in the flow at the bottom of the spillway. These parameters and visual observations of the energy dissipation within the stilling basin were used to evaluate the performance of the stilling basin under the various test conditions. The data collected from the model were compared to data from previous studies and design parameters documented in Reclamation's Engineering Monograph No. 25, *Hydraulic Design of Stilling Basins and Energy Dissipators.*

Conclusions

Results of this study indicate that using Reclamation's Type III stilling basin design with a stepped spillway is acceptable. The required downstream water depth (tailwater) guidelines outlined in Monograph No. 25 for Type III stilling basins are conservative. For both smooth and stepped chutes, this study showed that acceptable performance can be attained with 20 to 25 percent less tailwater than recommended in design guidelines. For the aerated spillway flows typically encountered on steep slopes and stepped spillways, using clear water parameters allow Reclamation to consistently apply the design principles detailed in Monograph No. 25. For low energy inflows, significantly less tailwater is required to prevent basin sweep-out with a stepped chute. Under certain conditions, only the basin appurtenant structures are needed to maintain basin performance, regardless of tailwater. When supercavitating baffle blocks are used instead of standard baffle blocks, 6 to 12 percent less tailwater is required for acceptable basin performance.

"Understanding how features such as stepped spillways and modified baffle blocks affect stilling basin performance is an important step in extending the operational range of Type III stilling basins."

Connie Svoboda
Hydraulic Engineer, Reclamation

More Information

"Performance of Type III Stilling Basins - Stepped Spillway Studies."
Hydraulic Laboratory Report HL-2012-02:
www.usbr.gov/pmts/hydraulics_lab/pubs/HL/HL-2012-02.pdf

Science and Technology Program Research Project:
www.usbr.gov/research/projects/detail.cfm?id=4925

Stilling basin model with a smooth chute at a slope of 53.1 degrees.