RECLAMATION
Managing Water in the West

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Bottom Line

Canal embankments, levees, and dams are all susceptible to erosion and failure with potential for catastrophic damage and loss of project benefits. To address erosion issues, reliable methods for measuring soil erodibility are needed. Most embankments contain silt and clay, but many also include significant amounts of gravel, which makes erosion testing more difficult. This research project tested a new procedure for applying the submerged jet erosion test to these difficult soil types and confirmed the new method's effectiveness and accuracy for measuring soil erodibility.

Better, Faster, Cheaper

This research gives us confidence to use the jet erosion test to measure the erodibility of a broader array of embankment soils and this, in turn, enables better modeling of erosion processes that can lead to embankment failure.

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Measuring Erodibility of Embankment Soils Containing Gravel

Procedure extends submerged jet erosion test to a wider range of soils

Problem

Reclamation is responsible for the safety of more than 8,000 miles of canals and 250 embankment dams in the Western United States. Risks of structure failure must be accurately assessed, potential affected areas identified, and mitigation measures put into place to protect downstream populations and property. Failure of embankments almost always involves soil erosion, so it is crucial that Reclamation has the ability to measure and rate the erodibility of embankment soils.

For several years, Reclamation has measured soil erodibility using a submerged jet erosion test device developed by the U.S. Department of Agriculture, Agricultural Research Service. This method was used in Reclamation's Science and Technology Program research project, "Physical Hydraulic Modeling of Canal Breaches" (Project ID 8442, 2010 through 2012) to rate soil erodibility, estimate length of time for failure to occur, and determine the magnitude of resulting floodflows. The jet device can be used in the laboratory or in the field and is designed specifically for the fine-grained silt and clay soils that are common in most embankments. However, some embankments also include significant amounts of gravel mixed with the silt and clay, and these soils are difficult to test with the submerged jet device.

The jet test erodes a soil specimen using a small, ¼-inch-diameter hydraulic jet. Rates of erosion are observed to categorize the erodibility of the soil. Unfortunately, with gravelly soils, the small-diameter jet is unable to completely erode the larger gravel particles, and the test scour hole becomes armored in a way that does not represent an actual large-scale erosion event.

Solution

This Reclamation Science and Technology Program research project tested a proposed method for applying the jet test to fine-grained soils that also contain gravel. It was hypothesized that removing the coarse material that interferes with the jet test could allow an accurate test to be performed on just the remaining soil. The research tested different size thresholds for the removal of gravel (No. 4 versus No. 40 sieve) and evaluated methods for adjusting the compaction of the soil specimens to account for the removal of the gravel particles.

Canal breach test underway in the Hydraulic Investigations and Laboratory Services Group in Reclamation's Technical Service Center.

Aerial view of the 2012 Central Arizona Project canal breach near Bouse, Arizona. About 50 miles downstream, on this same canal, the embankments contain gravelly soils similar to those considered in this research.

Testing and Results

To carry out the research, a quantity of soil was first prepared to represent the gravelly fine grained soils that are difficult to test. Erosion tests on this "parent" soil were accomplished using a unique, horizontal jet orientation that prevented armoring the scour hole. The second stage of the research involved screening the parent soil to remove gravel particles and then performing jet erosion tests on specimens of the remaining finer-grained soil. These tests could be performed in the traditional way because gravel was no longer present to interfere with the tests. The preparation and compaction of the finer-grained soil specimens were adjusted to ensure that they matched the compaction state of the finer-soil fraction in the original parent soil.

The results of the testing validated the hypothesis that erodibility could be determined by testing only the finer-grained fraction of the soil. Erodibility is always variable, so significant scatter existed in the individual test results. However, averages of multiple tests of the parent and finer soils were in reasonable agreement. Results were inconclusive in determining whether the soils should be separated using the No. 4 or No. 40 sieve, but it appears that screening at either size threshold would yield reasonable results. Screening at the No. 4 sieve would be easier in most cases.

Future Plans

It is recommended that additional testing be performed on a wider range of soils to confirm the initial test results obtained by this research project. In addition, this research could benefit other Reclamation activities; for example, the Seismology, Geomorphology, and Geophysics Group in Reclamation's Technical Service Center is using this test to determine the erodibility of soils in alluvial flood plains where gravel is often encountered.

"This research increases our confidence in measurements of soil erodibility for many soils that we previously could not test."

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More information

http://www.usbr.gov/research/projects/detail.cfm?id=4104

http://www.usbr.gov/research/projects/detail.cfm?id=8442

Wahl, T.L. 2014. *Measuring Erodibility of Gravelly Fine-Grained Soils.* Research and Development Office Science and Technology Program Final Report 2014-4104. Hydraulic Laboratory Report HL-2014-05.

For printable version see: www.usbr.gov/research/docs/updates/2015-08-soil-erodibility.pdf