AUBURN UNIVERSITY
Highway Research Center

Evaluation of Rock Check Dam Performance using Large-Scale Testing Techniques

Tech Transfer Summary

This projected evaluated the performance of the Iowa DOT standard rock check dam installation and efficient and cost-effective modifications through controlled, large-scale testing at the Auburn University – Research Facility. Modifications to the standard included the removal of an excavation beneath the installation, a smaller rock gradation, and a geotextile overlay with dewatering holes. Performance parameters for erosion prevention included impoundment formation, flow velocity reduction, and dewatering times; sediment-laden testing evaluated sediment deposition and water quality treatment.

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RESEARCH PROJECT TITLE
Evaluation Rock Check Dam Performance using Large-Scale Testing Techniques

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Objectives

- Evaluate the existing Iowa DOT rock check dam standard in impoundment formation, impoundment formation, flow velocity reduction, and sediment deposition
- Develop and evaluate efficient and cost-effective rock check dam installation enhancements for implementation by the Iowa DOT

Most Feasible and Effective Installation (MFE-I)

Findings at a Glance

- The Most Feasible and Effective – Installation was determined to be a rock check dam with no excavation, the Iowa DOT erosion stone, a geotextile overlay with dewatering holes, and a reduced width due to outperforming other installations in impoundment formation and reducing the cost of material and installation.
- Adding a geotextile overlay and reducing the size of rock used were found to significantly increase impoundment length and erosion protection compared to the standard installation.

Background

Conveyance channels are commonly used on construction projects, especially highway construction, to collect and guide stormwater runoff to downstream practices or discharge points. However, these channels can be prone to erosion due to high flow velocities and shear stress before stabilization. To protect channels from erosion, ditch checks such as rock check dams are installed in channels to impound runoff and slow flow velocities to non-erosive conditions. Spacing guidance dictates that rock check dams are installed so that the elevation of the toe of the upstream dam is the same as the lowest point of the top of the downstream installation, to ensure that the entire channel is projected; however, if rock check dams do not impound runoff to the top of the installation, areas of the channel are subject to high-velocity erosive flows.

Problem Statement

Erosive flows in unstabilized conveyance channels can be a source of sediment-laden runoff for construction projects, which can overload downstream sediment basins or contribute to sediment-laden discharge off-site. Rock check dams are commonly used on construction projects to slow flow velocities and protect channels from erosion; however, past field monitoring studies have indicated that many standard installations do not properly protect channels from erosion and can be improved. Despite this, very few studies on providing performance enhancements for rock check dam installations have been completed. In this project, large-scale testing techniques were employed at the AU-SRF to evaluate the Iowa DOT standard rock check dam installation and enhanced configurations to improve protection from erosive flows and, as a secondary benefit, capture sediment and treat water quality.

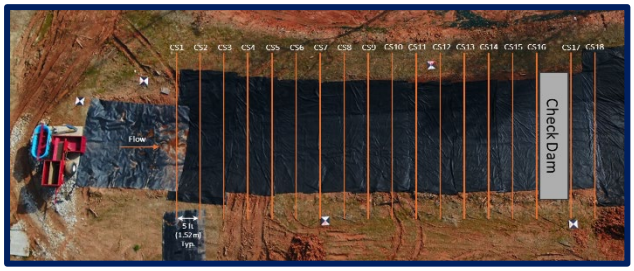
About the AU-SRF

The AU-SRF is a 10-acre outdoor research laboratory aimed to improve and develop stormwater technologies and strategies. The facility is situated adjacent to the National Center for Asphalt Technology Pavement Test Track in Opelika, AL. Since its inception, the AU-SRF has aimed its mission to developing improved erosion and sediment control stormwater technologies and practices; advancing the body of knowledge through research and development, product evaluation, and training.

Materials and Methods

A total of 8 rock check dam installations were evaluated through 3 tests each, each using a low and high flow rate to determine performance under varying conditions representative of those found on Iowa DOT construction projects., for a total of 24 clean-water performance evaluations. After competition of clean water tests, the Iowa DOT standard rock check dam and the highest-performing modified installation were evaluated under sediment-laden conditions to determine the improvements in sediment capture and stormwater treatment, a secondary benefit of rock check dams.

An existing 200 ft long channel, representative of those found on Iowa DOT highway construction projects was used for all tests. 16 upstream and two downstream cross-sections were demarcated with stringlines for testing measurements.



Test Channel

Three water depth and velocity measurements were taken at each cross-section to generate a flow profile for each installation. Additionally, the length of impoundment and dewatering times were monitored for each installation. For sediment-laden testing, water quality samples were taken upstream of the theoretical impoundment length, immediately upstream of the check dam, and the discharge downstream of the installation. Additionally, sediment deposited upstream was removed and measured for total sediment retention.

The results of testing for the Iowa DOT standard installation and subsequent modifications were used to develop additional modifications and work towards the selection of a Most Feasible and Effective Installation (MFE-I).

Modified Rock Check Dams

Standard Installation

The Iowa DOT standard rock check dam installation, consisting of Class D Revetment with a 6 in. excavation and a geotextile underlay, was evaluated. The standard installation impounded approximately 6 feet on average, indicating that only 9% of the channel was protected from erosive flow conditions.

Iowa DOT Standard rock check dam

Removal of Excavation

The first modified component aimed to determine if the excavation beneath the installation played a role in

impoundment formation and velocity reduction. No adverse impacts on impoundment length compared to the standard were found after removing the excavation and installing the rock check dam on grade, while also saving cost of material and installation.

Smaller Rock Gradation

In testing of rock check dams constructed of Class D Revetment, large voids were present, leading to high flow-through-rates during testing. An alternative rock gradation used by the Iowa DOT, a smaller erosion stone, was used to construct modified installations. The smaller rock increased impoundment to 33 ft on average, representing over 50% of the channel being protected. Additionally, the smaller rock led to more consistent installation heights that allowed overtopping to occur at the design height of 2 ft, rather than between gaps in larger rocks.

Geotextile Overlay

The addition of a geotextile overlay facilitated addition impoundment as the geotextile became bound with sediment, leading to overtopping. Despite overtopping, the theoretical impoundment was not reached due to flow finding the lowest points to overtop on the installation. An average of 49 ft of impoundment was facilitated, with impoundment increasing for each additional test due to the geotextile losing flow-through capabilities. Geotextile binding with sediment also led to excessive dewatering times, which can be detrimental to the establishment of vegetation in channels and lower storage capacity for subsequent storm events.

Dewatering Holes

To reduce excessive dewatering times facilitated by installations with a geotextile overlay, nine x-shaped, razor blade sized dewatering holes were cut in the geotextile. These dewatering holes did not negatively impact performance in the formation of impoundment while reducing dewatering time from 60 hours to 26 hours on average compared to installations with a geotextile overlay. Despite this improvement, dewatering time increased after each subsequent storm event to a maximum of 60 hours, indicating maintenance is required to ensure dewatering holes remain effective.

Reduced Profile w/ All Modified Components (MFE-I)

The MFE-I consisted of a combination of modified components (no excavation, smaller rock gradation, and a geotextile overlay with dewatering holes), with a reduced width to further reduce cost of material. This installation had the highest impoundment facilitated, with an average of 58 ft. Additionally, the approximate material cost was reduced by 55% compared to the Iowa DOT standard rock check dam installation. Due to performance improvements in all areas and the reduced cost, this installation was selected as the MFE-I.

Performance of Installation On Grade

Smaller Rock Gradation

Large Rock Overtopping at Low Points

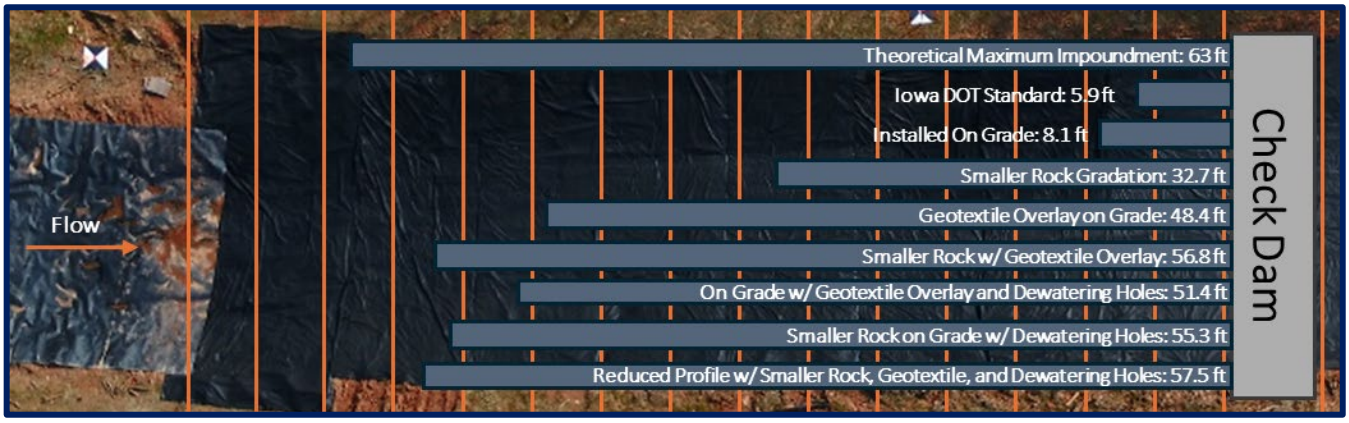
Dewatering Holes

Most Feasible and Effective Installation (MFE-I) overtopping

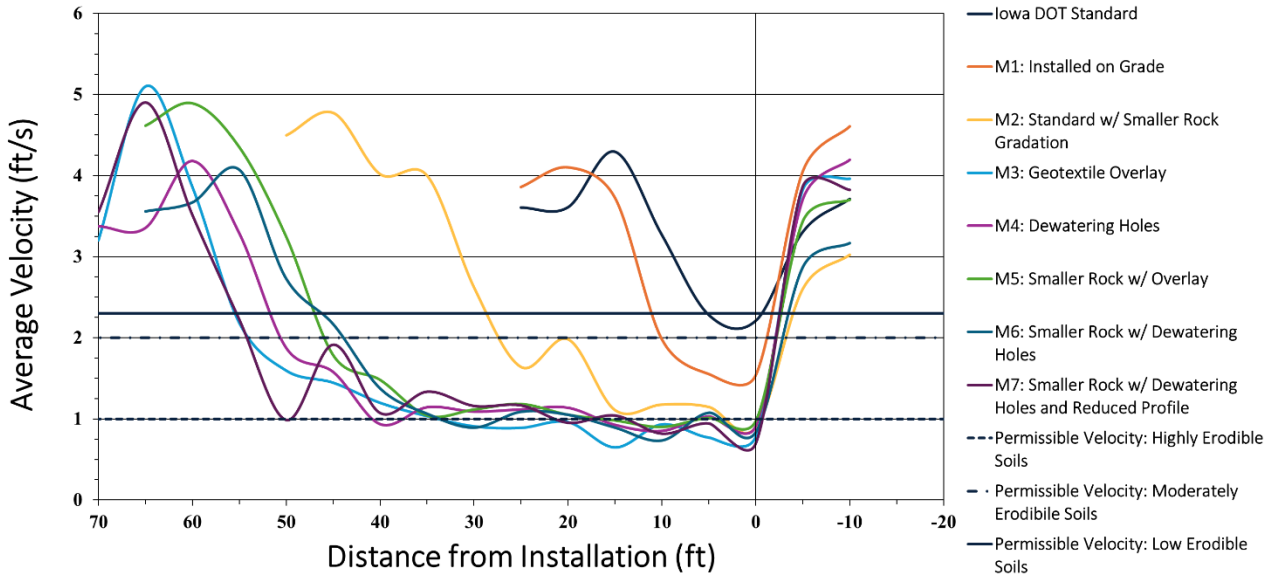
Results

Installations with similar components, such as the geotextile overlay, performed similarly in impoundment formation. Despite the improvements made by modifications, no installation impounded to the theoretical impoundment, indicating that spacing guidance may need to be adjusted or the geotextile underlay may need to be extended. Flow velocities increased immediately downstream of all installations and were still above permissible limits for highly erosive soils in the impoundment formed by highly performing installations.

Sediment-laden performance testing indicated that the additional impoundment facilitated by the MFE-I compared to the standard increased sediment capture from 9.3 to 72.3%. Additionally, the turbidity of the discharge from the MFE-I was significantly lower than that of the standard installation due to the increased impoundment formed and the extended detention time. However, turbidity was not treated effectively by the installations, indicating rock check dams are primarily an erosion control practice.



Performance of Evaluated Rock Check Dam Installations



Velocity Profile for Evaluated Rock Check Dam Installations

Recommendations & Implementation

The following recommendations should be considered based on results:

- Remove the excavation beneath installations and reduce the width to reduce material and installation costs while not losing performance;
- Adopt the smaller Iowa DOT erosion stone due to increased performance without geotextile overlays and more consistent height of installations;
- Employ a geotextile overlay with properly maintained dewatering holes to increase impoundment without excessive dewatering times;
- Use additional erosion control practices in channels with highly erosive soils;
- Extend the geotextile underlay downstream to protect downstream areas from erosive flows after overtopping;
- Employ downstream sediment control practices to ensure sediment is captured and runoff is treated.