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RESEARCH PROJECT TITLE

Field Monitoring of Erosion and Sediment Control Practices and Development of Additional Iowa DOT Design Manual Guidance

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tech transfer summary

This project assessed the performance of the Iowa Department of Transportation's current erosion and sediment control standard practices and provided guidance to make modifications to its construction stormwater management program by adopting state-of-the-art practices.

Problem Statement

The Iowa Department of Transportation (DOT) has specifications, standard drawings, and guidance for the design of erosion and sediment control (E&SC) practices, but many of these practices had not been formally evaluated for field performance of erosion reduction or sedimentation potential.

Objectives

- Compile and catalog E&SC practices applicable for Iowa DOT construction projects
- Install and field-evaluate selected practices on active Iowa DOT construction sites to determine their effectiveness in reducing erosion and capturing sediment
- Develop implementable modifications for E&SC design guidance

Background

Roadway construction often involves heavy earthwork activities (clearing, grading, soil compaction, etc.) that disturb large land areas and can increase sediment yield by up to 10,000 times that of stabilized land. These activities leave sites susceptible to rainfall- and runoff-induced soil erosion and significantly increase the risk of degrading the quality of downstream receiving waterbodies. Poorly managed construction activities are a major contributor to nonpoint source pollutants that lead to water quality degradation.



Observed site erosion on Iowa US 30 highway expansion project

To mitigate the downstream effects from construction, the National Pollutant Discharge Elimination System General Permit No. 2 (NPDES permit) requires construction operators with a site disturbance of more than one acre to develop a stormwater pollution prevention plan (SWPPP) for all construction activities that are covered by the permit. The SWPPP must include E&SC practices and a plan for implementation throughout construction phases.

Project Description

E&SC practices evaluated included standard and modified silt fence ditch checks, wattle ditch protections, rock check dams, silt fence perimeter control, and temporary sediment control basins. The installation setup and modified design components were as follows:

- **Silt fence ditch checks:** 12 silt fence ditch check installations were monitored during this study. One standard and three modified designs were evaluated. The modifications included decreased T-post spacing, wire reinforcement backing, de-watering weir, V-shaped installation, and manufactured silt fence geotextile. Sliced and trenched methods were also evaluated.
- **Wattle ditch protection:** 30 wattle ditch protection installations were monitored in this study. One standard and one modified design with four different wattle fill materials were evaluated. The modifications included special ditch protection underlay, non-destructive teepee staking, and pinning wattle to channel. Various wattle fills were also field-evaluated and laboratory-tested for impoundment properties.
- **Silt fence perimeter control:** 21 silt fence perimeter control segments were monitored in this study. One standard and six modified designs were evaluated. The modifications included decreased T-post spacing, wire reinforcement backing, geotextile offset, manufactured silt fence geotextile.

Two additional practices—a rock check dam and a temporary sediment control basin—were initially planned for this project; however, due to site contractor and/or material availability, neither the standard nor planned modifications were installed on-site for field evaluation, although the researchers did receive a lot of monitoring data on how existing sediment control basins on-site performed in the field.

Practices were installed during active construction on US 30 in Tama County, Iowa, by the site contractor. Installation and field monitoring were coordinated around the normal grading and work operations of the site contractor.

Performance data collection included rainfall data, water samples, surveying, visual forensic inspections (weekly regimen of photographs at same views), and unmanned aerial system (UAS) analysis. A cost analysis was also completed for each installation technique.

Key Findings

- **Silt fence ditch checks:** The silt fence installation technique with the highest sediment retention had 4.0 times the sediment accumulation of the standard and included a V-shaped installation, wire reinforcement, dewatering weir, and geotextile trenched into the ground. A second modification had 2.5 times the sediment accumulation of the standard and included the V-shaped installation, wire reinforcement, and dewatering weir, but the geotextile was sliced into the ground.



Observed T-post deflection and undercutting on standard silt fence ditch check installation, top, and impoundment on modified silt fence installation, bottom

- **Wattle ditch protection:** The best performing wattle installation included a wood chip fill, special ditch protection mat underlay pinned to the channel bottom, and nondestructive teepee staking. The installation captured 13.2 times the sediment of the standard method.



Observed undercutting on standard wattle ditch protection, top, and sedimentation upstream of a modified wood chip wattle installation, bottom

- **Silt fence perimeter control:** The primary observed deficiency in the standard installation was T-post deflection leading to overtopping failure. The researchers recommend adopting either a wire reinforcement at 8 ft spacing or decreasing spacing to 5 ft to aid in the structural integrity and offset the silt fence material from structural T-posts.
- **Temporary sediment control basin:** Three temporary sediment control basins were monitored (one standalone basin and two basins in series). The monitored sediment basins did not provide significant water quality improvements to stormwater runoff.

Recommendations and Limitations

Recommendations for E&SC Practice Design and Implementation

- Silt fence ditch check details should include the addition of wire reinforcement backing and a dewatering weir to prevent T-post deflection, as well as a splash pad at the weir to prevent downstream scour.
- Wattle ditch protection details should include a pinned underlay and non-destructive teepee staking to prevent undercutting and promote intimate ground contact between the channel and wattle.



Observed T-post deflection and overtopping on standard silt fence perimeter control practice, top, and sediment retention on modified silt fence perimeter control with 5 ft T-post spacing, middle, and 8 ft T-post spacing, bottom

- Inspectors should ensure the geotextile underlay is present on all rock check dam installations. In addition, it is suggested to add a geotextile overlay on the rock check dam detail to aid in impoundment, particularly in low flow conditions.
- Silt fence perimeter controls should have decreased segment lengths, and either C- or J-hook installations should be required to decrease the pressure on low points along the fence. Also, T-post spacing should be decreased or the perimeter control should include wire reinforcement backing to decrease the frequency of T-post deflection. Silt fence geotextile should be offset from the T-posts.

- Further evaluation of sediment basins using floating surface skimmers and baffles should be conducted to potentially improve performance. Additional recommendations include lining the channel with a geotextile, creating an upstream forebay with a rock check dam, and installing flow baffles at every quarter-length of the basin.

Limitations

- Although field-evaluated practices were installed in their own proximities for comparison, each practice was subjected to different drainage areas, and thus encountered varying flow patterns and sediment loads. In addition to drainage conditions, channels had different slopes and geometries, which did not allow for cross-comparison of ditch check practices.
- Installation of ditch checks and perimeter controls were planned for May 2019, but due to contractor schedule practices were not installed until July 2019. This shortened the monitoring window, and the season allowed for vegetation to quickly establish. While the vegetation aided in ground stabilization, it impeded data collection for erosion and sedimentation.

Recommendations for Future Research

Practices that exhibited improved performance should be tested in a full-scale laboratory setting to evaluate and

adjust new components for maximum performance and repeatability. Full-scale testing would allow practices to be subjected to known rainfalls, flows, drainage areas, slopes, sediment loads, and vegetative conditions. This also would allow major components or groups of components contributing to practice success to be isolated and adopted.

Laboratory-based research would eliminate several assumptions made during in-field testing. Full-scale testing also provides opportunities for longevity evaluation and determination of necessary maintenance procedures.

Implementation Readiness and Benefits

The updated E&SC design guidance allows Iowa DOT designers to incorporate the latest technology into its SWPPP. The developed guidance is geared toward ease-of-implementation with proposed specifications, design guidance language, and/or details.

The enhanced practices will protect water quality downstream of construction activities, reduce regulatory compliance issues, and improve overall public perception.