

Executive Summary, Research Readiness Level Assessment, and Technology Transfer

Erosion Resistant Rock Shoulder

Research Objectives

The study aims to determine erosion coefficients for different gradations and binding agents using the UNLETB and JET tests. It will then use Flow3D software to predict erosion performance and derive a simplified field erosion equation. Finally, an optimized design chart will be created to assist engineers in selecting the best crushed rock surface course.

Research Benefits

Allowing flexibility in selecting crushed rock surface courses, with multiple available gradations and from various rock quarries, will mitigate supply chain issues. This approach contributes to safer highways by minimizing drop-offs and consequent lane departure crashes. Additionally, it leads to reduced maintenance work and cost savings by offering more resilient highway shoulders. Furthermore, by decreasing the amount of dislodged rocks, it alleviates stress on District Maintenance Operations.

Principal Investigator

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NDOT Lead TAC Member

Bruce Barrett, PE

Background

With the advent of climate change, weather patterns are becoming more unpredictable, and consequently, severe drought and flooding are unavoidable. For highway structures, this new weather pattern created new problems in the pavement system. Techniques to evaluate erosion resistance of these materials are not well developed so far. Consequently, the improved design of erosion resistant aggregate and combinations of soil and aggregate are needed. NDOT currently utilizes the gradation of crushed rock surface course and soils, however, materials with this gradation are not always readily available or perform as intended. This study combines dedicated testing methods and hydrodynamics analysis technique to test, evaluate and obtain the erosion resistant shouldering materials which outperform the current design recommendation.

Conclusion

Highway shoulder rocks are exposed to continuous erosion force due to unexpected floodings caused by climate change. The evaluation methods of the erosion resistance of highway shoulder rocks are not currently well-developed. This study developed a new large-scale testing device, the University of Nebraska-Lincoln Erosion Testing Bed (UNLETB), which has the capability of testing the shoulder gravels. Different gradations were tested using UNLETB, and the results distinguished a high-resistant group and a low-resistant group. The low resistant group was treated with different binding agents: Ammonium Lignosulfonate (LIGNO10), Soybean Soap Stock, and DirtGlue. The treated samples showed better erosion resistance based on the binding agent and the sample type. Then, a hydrodynamics-based analysis was conducted using CFD software. UNLETB was modeled using FLOW3D-Hydro, and a comprehensive parametric study was conducted to obtain the hydrodynamics-input parameters for the tested samples. In addition, this study trained ANN (Artificial Neural Network) with test results to conveniently discern the erosion resistance of different gradations. The ANN quickly predicted the acceptable/non-acceptable erosion characteristics of shoulder rocks with close to 99% accuracy based on three simple parameters related to gradation (D10, D30, and D60 are the particle sizes corresponding to 10%, 30%, and 60% finer materials on the cumulative particle size distribution curve, respectively).

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Interested in finding out more?
Final report is available:
[HERE](#)

NDOT Recommendations Based Off Research Project

Having completed the research on Erosion Resistant Rock Shoulder, this is the first step in a series of steps to erosion resistant rock shoulders durable in Nebraska. The Department has selected two projects to be let in the summer of 2024. 1.5" Crusher Run on the Skyline Drive Project in Omaha, Ne and the Combined Package Class A (with fines) on the Harrison to Dodge Project. Both were let for 2025 construction. Harrison to Dodge will be this late summer or early fall. The department will follow up with the performance.

- As provided by Bruce Barret, Lead TAC Member

Research Readiness Level (RRL) Assessment Level: Implementation with Follow-up for 5 Years

RRL 4

Technology Transfer

Webinars/Presentations

- Chung R. Song (2024), "Erosion Resistant Rock Shoulder," Annual Meeting of National Road Research Alliance (NRRRA), Jan. 3rd, 2024
- Basil Abualshar, Chung R. Song and Bashar Al-Nimri (2024), "Investigating Hydrodynamics Input Parameters for a Non-Conventional Flow Scenario in Sediment Transport Modeling," EMI-ASCE 2024, Chicago, IL
- Basil Abualshar and Chung R. Song (2023), "Parametric Study to Determine Hydrodynamics Input Parameters in Flow-3D-Hydro for Gravels in Nebraska," June 6 – 9, EMI 2023, Georgia Tech., Atlanta, GA
- Bashar Al-Nimri and Chung R. Song (2023), "ANN-Based Evaluation System for Erosion Resistant Highway Shoulder Rocks," June 6 – 9, EMI 2023, Georgia Tech., Atlanta, GA
- B. Abualshar and C.R. Song (2022), "Evaluation of the Equivalent D50 to Predict the Erodibility of Fine Riverbed Soils in Nebraska," EMI 2022, Columbia University, NY, NY

Journal Papers Submitted for Review and In Progress Journal Papers and Theses

- Aiman Tariq, Basil Abu-Alshar, Babur Deliktas, Bashar, Al-Nimri, and Chung R. Song (2024), "AI-Based Evaluation of Erosion Resistant Gradation of Highway Shoulder Gravels," International Journal of Geoenvironment, under review

**This brief summarizes Project FY22 (004)
"Erosion Resistant Rock Shoulder"
Nebraska Department of Transportation Research Program**