Effectiveness and Guidance of Aggressive Rehabilitation of Gravel Roads

tech transfer summary

Aggressive rehabilitation to restore the proper width, cross-sectional profile, and drainage capacity of granular-surfaced roads that have been lowered, widened, and flattened by traffic can improve their performance, while incorporating enzymatic soil stabilizer into the surface can further improve strength and stiffness.

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RESEARCH PROJECT TITLE
Effectiveness and Guidance of Aggressive Rehabilitation of Gravel Roads

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Objective

This research aimed to evaluate the effectiveness of the aggressive rehabilitation of granular-surfaced roads and the practical applicability and potential use of enzymatic chemical stabilizers to improve performance over two freeze-thaw cycles.

Background

Over the service life of a granular-surfaced roadway, the cumulative effects of traffic loads, aggregate deterioration, weathering, erosion, and maintenance operations progressively displace surface and subgrade materials laterally and vertically. These displacements can widen the roadway, flatten the crown, and cause sediment to accumulate in the drainage ditches, leading to further degradation, moisture-related damage, and higher annual maintenance costs.

Common maintenance operations, including blading and the spreading of new aggregates, are often insufficient to address these issues. Frequent blading can also contribute to a loss of the fine particles that help maintain surface stability and durability.

A more robust option is rehabilitation, which typically involves loosening a large amount of surface and subgrade material to rebuild a roadway's foreslopes, drainage ditches, and crown. Aggressive rehabilitation refers to a complete rebuilding of a roadway's cross-section profile by using material excavated from the ditches to raise the roadway's central elevation and restore its proper width, crown, and drainage capacity.

Aggressively rehabilitated and chemically stabilized gravel road

Beyond conventional maintenance and rehabilitation, chemical stabilization has been shown to improve the performance and longevity of roadway surfaces and subgrades and reduce maintenance frequency.

Problem Statement

Although many studies have examined strategies to extend the service lives of granular roads, few have investigated aggressive rehabilitation or a combination of aggressive rehabilitation and chemical stabilization.

Research Description

The Camp Dodge Iowa Army National Guard base in Johnston, Iowa, offered a unique opportunity to study the effectiveness of aggressive rehabilitation and chemical stabilization. The site features heavily loaded granular-surfaced roads exhibiting distresses such as frost boils, rutting, washboarding, loss of crown, filling of drainage ditches, excessive widening, and flooding in low-lying areas.

Four road segments ranging from 660 to 1,500 ft in length were selected for test section construction. The segments' cross-sectional profiles were rebuilt by recovering material from the ditches to restore the proper widths, elevations, slopes, and drainage ditch profiles. An unmodified 1,320 ft control section was also studied to represent surrounding roads in the area.

Two of the test sections were constructed with an enzymatic chemical soil stabilizer, while the other two were not. For each pair of test sections, one was constructed using smooth-tired compaction, while the other was constructed using sheepsfoot compaction.

Performance was assessed through in situ stiffness and strength measurements of the surface and subgrade layers; laboratory tests of soil properties and aggregate breakage behavior, including gyratory compaction and image analysis; intelligent compaction mapping; and visual condition surveys. Testing was performed before construction in summer 2023 and over two freeze-thaw seasons in fall 2023, spring 2024, fall 2024, and spring 2025.

Excavation of ditch material

Smooth-tired compactor

Tow-behind sheepsfoot compactor

Stabilizer being sprayed onto subgrade

Key Findings

- Among the four test sections, the two enzyme-stabilized sections exhibited the highest strength and stiffness in the first year.
- The differences in strength and stiffness among all sections decreased by the end of the second year, but the California Bearing Ratio (CBR) values of the enzyme-stabilized sections remained 2.5 times higher (with smooth-tired compaction) and 4.5 times higher (with sheepsfoot compaction) than the CBR values of their untreated counterparts.
- The stabilizer provided a significant strength increase in the surface course that lasted through heavy vehicle loading and at least two winter-spring freeze-thaw seasons. The enzyme-stabilized sections also generally maintained higher subgrade CBR values than the two sections without stabilizer.
- Sheepsfoot compaction generally produced better results for the enzyme-stabilized sections, while smooth-tired compaction produced better results for the untreated sections.
- The relative breakage measured via gyratory compaction testing showed strong linear correlations to the initial gravel contents and field-measured average CBR values of the test sections. This laboratory test could therefore be used to efficiently predict which materials or blends will perform best under actual traffic loading.
- The particle size distribution (PSD) curves of samples collected over time from the test section surfaces showed that most of the particle breakage occurred in the first several months following construction, after which the breakage rate greatly decreased.
- Overall, no consistent difference was found between the breakage values of the enzyme-treated and untreated test sections throughout the project.
- According to the visual condition surveys, the enzyme-stabilized sections experienced the least surface deterioration, with only minor rutting or corrugation. The unstabilized test sections showed the most visible deterioration, including rutting and depressions along the wheel paths and migration of material to the shoulders. The control section also exhibited minor rutting and showed noticeable migration of material to the shoulders.
- Particle size distributions determined by image analysis using the Iowa DOT's Camsizer device (but limited to material coarser than the No. 10 sieve) were found to produce results consistent with traditional sieve analysis.
- Intelligent compaction mapping indicated that the four test sections experienced an initial decrease in stiffness and modulus after construction in 2023 but then recovered in 2024, with the enzyme-stabilized sections exceeding the stiffness and modulus of the control section by spring 2024. By spring 2025, the stiffness and modulus values for all sections decreased and converged to similar ranges.

Recommendations for Future Research

- The strong correlation between field-measured CBR values and relative breakage measured by gyratory compaction should be studied further to develop stronger predictive capabilities of field performance.
- Camsizer testing with smaller particle sizes should be pursued to track changes in PSD curves from which particle breakage can be determined more efficiently than traditional sieve analysis.
- Additional field testing and sampling at the project site is recommended to quantify the longer-term benefits of both the aggressive rehabilitation methods and the enzymatic stabilizer.
- The benefits of enzymatic stabilization should be studied in other Iowa counties, as the extremely strong and stiff subgrade soils encountered at the Camp Dodge site are not representative of typical Iowa gravel roads.

Implementation Readiness and Benefits

This study demonstrated the effectiveness of aggressive rehabilitation in restoring the proper width and cross-sectional profile of granular-surfaced roads that had been lowered, widened, and flattened by decades of heavy traffic. Ensuring proper drainage and long-term performance can help reduce a significant financial and safety burden on local agencies and the traveling public.

The enzymatic soil stabilizer used in this study showed measurable benefits in terms of strength and stiffness, though the benefits decreased somewhat by the end of the second year. Further field testing and observation can help determine whether the stabilization will produce continued benefits over time.

Because the test sections in this study were constructed without specialized equipment, county engineer offices can employ similar methods using equipment that they have on hand or can easily rent.