IOWA STATE UNIVERSITY
Institute for Transportation

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RESEARCH PROJECT TITLE
Low-Cost Rural Surface Alternatives: Demonstration Project

SPONSORS
Iowa Highway Research Board (IHRB Project TR-664)
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The mission of the Institute for Transportation (InTrans) at Iowa State University is to develop and implement innovative methods, materials, and technologies for improving transportation efficiency, safety, reliability, and sustainability while improving the learning environment of students, faculty, and staff in transportation-related fields.

Low-Cost Rural Surface Alternatives: Demonstration Project

tech transfer summary

A field demonstration project was conducted in Hamilton County, Iowa to compare the relative performance, durability, and costs of several stabilization methods for preventing or mitigating freeze-thaw damage to granular surfaced roads.

Objectives

- Identify the most effective and economical methods for preventing or mitigating freeze-thaw damage to granular surfaced roads in seasonally cold regions

- Construct demonstration test sections using several stabilization methods recommended in Iowa Highway Research Board (IHRB) Project TR-632 *Low-Cost Rural Surface Alternatives: Literature Review and Recommendations*

- Conduct field and laboratory tests to compare the relative performance of the demonstration sections before, during, and after seasonal freeze-thaw cycles, under the same set of geological, climate, and traffic conditions

- Compare construction, maintenance, and projected long-term life-cycle costs to identify the most effective and economical stabilization methods for minimizing or eliminating freeze-thaw issues before they occur

Post-thawing conditions of selected road before stabilization

Background

Granular surfaced roads in seasonally cold regions are frequently subjected to freeze-thaw cycles, which lead to damage such as frost heave, frost boils, thaw weakening, rutting, and potholes. The damage significantly increases maintenance costs, adversely affects public safety, and inconveniences both agricultural traffic and the traveling public.

Current maintenance practice typically involves covering the entire damaged road surface with virgin aggregate and then blading without compaction, which focuses on repairing freeze-thaw damage rather than minimizing or preventing its occurrence.

Problem Statement

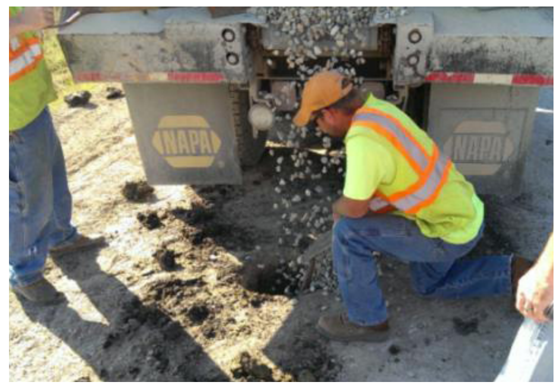
Many studies have evaluated various methods to improve the freeze-thaw performance of granular surfaced roads, but most of these studies focused on only one or two technologies, and without comprehensive long-term performance monitoring and economic analysis.

Materials, Construction, and Research Description

A two-mile stretch of heavily used granular surfaced road in Hamilton County, Iowa (Vail Avenue between 310th and 330th Streets) was selected for constructing the demonstration test sections.

- Three types of macadam (dirty, clean, and recycled Portland cement concrete/RPCC) were used as base materials in Sections 1 through 8 to improve stability and drainage. Nonwoven (NW) geotextile was embedded in some sections to provide separation and drainage. Chloride and bentonite surface treatment were also applied for dust control and stabilization.
- Aggregate columns were used as drainage basins in Sections 12 and 13 to prevent frost boils within the subgrade.
- Three chemical stabilizers (bentonite, class C fly ash, and cement) were used in Sections 15 through 17 to improve strength and stiffness of the surface course.
- Different geosynthetics were used in Sections 18 through 19B to improve subsurface drainage or strength of surface course.

An aggregate spreader was used to place the macadam base and surface course materials



Aggregate columns (8 in. diameter by 6 ft deep) in Sections 12 and 13 were filled with 1 in. clean aggregate

A geocomposite drainage layer was placed at the aggregate-subgrade interface in Section 18

Left to right: Dirty, clean, and recycled Portland cement concrete macadam materials

During construction, all of the demonstration sections except for the chemically stabilized ones remained opened to traffic.

Laboratory and field tests were performed to monitor performance prior to construction, as well as before and after two seasonal freeze-thaw periods.

An economic analysis was performed using the documented construction and maintenance costs. The estimated cumulative costs per square yard were projected over a 20-year timeframe to determine break-even periods relative to the cost of continuing current maintenance practices.

Key Findings

- Most of the stabilization methods examined can minimize rutting, potholes, and frost boils and improve surface conditions of granular surfaced roads to varying degrees

- The macadam base materials and biaxial geogrid provided high stiffness and the best observed freeze-thaw performance

- Aggregate columns can be used as drainage basins to effectively prevent subgrade frost boils

- The bentonite treatment provided a much drier and tighter roadway surface and slightly higher stiffness than the control sections during thawing periods

- Class C fly ash and cement significantly increased stiffness of the surface course after construction, but the stiffness of the fly ash section decreased significantly after the first seasonal freeze-thaw cycle

- The geocomposite drainage layer increased the permeability of the surface material by two orders of magnitude, but some spots suffered significant rutting during thawing periods, which may require further study

- Construction speed and costs for the dirty and clean macadam-based sections depended highly on the distance between the quarry and construction site and availability of trucks for hauling materials.

- RPCC macadam is an economical alternative to clean or dirty macadam

- The stiffness of RPCC macadam increased one year after construction, possibly due to further hydration of the cement

- Sections with chloride surface treatments suffered more ice lenses during freezing, and were more prone to potholes and washboarding during the thawing period

Post-thawing surface conditions of three demonstration sections (March 11, 2014)

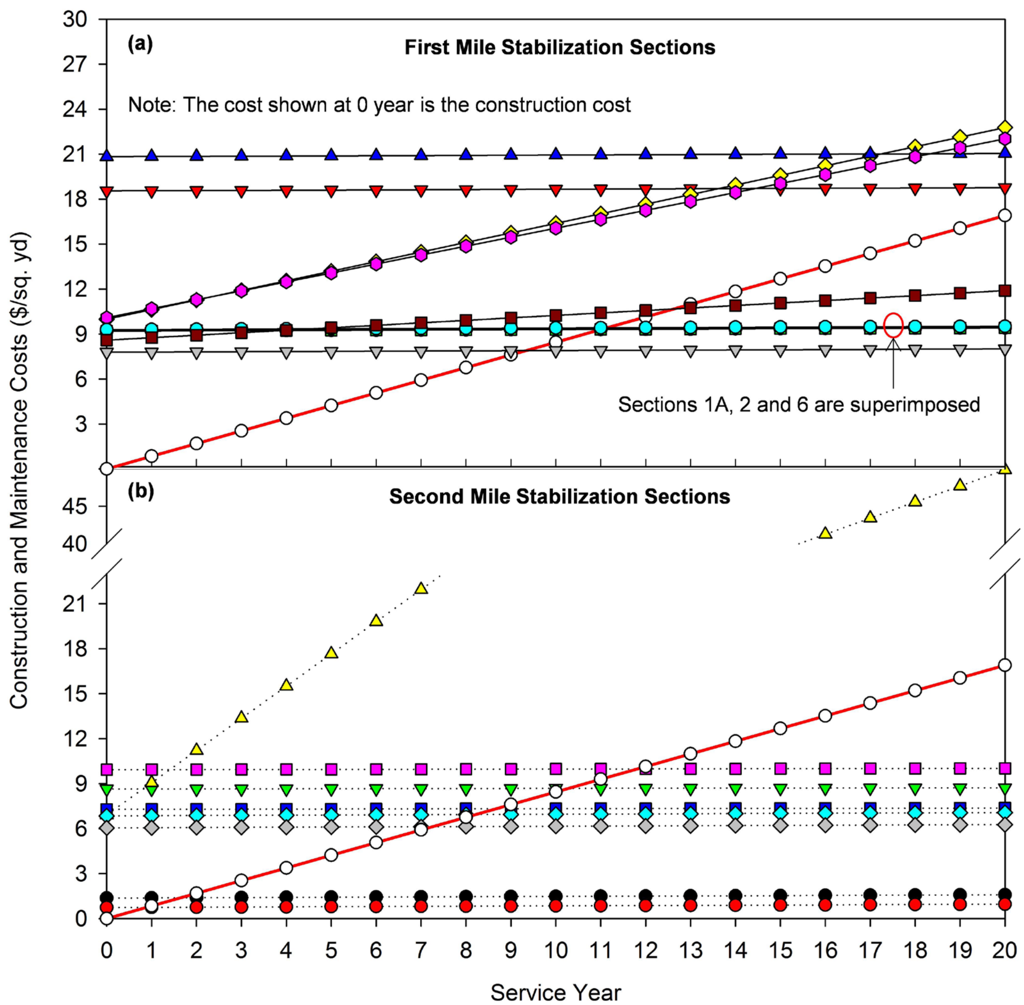
Implementation Readiness

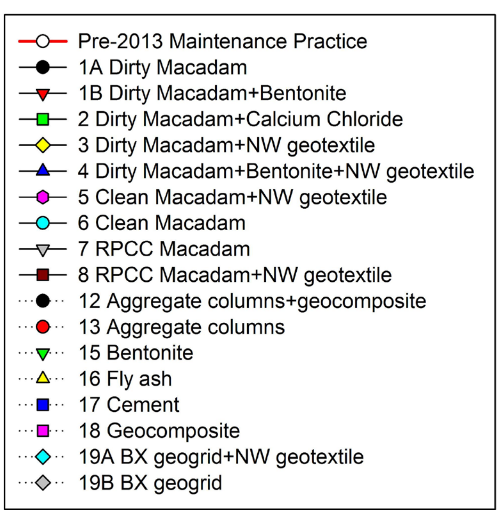
Most of the mechanical stabilization methods can be easily implemented by county secondary roads departments with existing crews and equipment. An aggregate spreader is needed for placing macadam stone.

Implementation Benefits

The aggregate columns had a break-even period of 1 year (2 years with geocomposite linings), after which the cumulative construction and estimated maintenance costs would be less than continuation of existing maintenance practices.

The macadam-based and BX-geogrid sections have greater initial costs and longer break-even periods, but counties should also weigh the benefits of improved ride quality and savings that these solutions can provide as excellent foundations for future paving or surface upgrades.





Section #	Break-Even Period
1A	11
1B	>20
2	12
3	>20
4	>20
5	>20
6	12
7	10
8	13
12	2
13	1
15	11
16	>20
17	9
18	12
19A	9
19B	8

Projected cumulative (construction + annual maintenance) costs for the different stabilization sections compared to current maintenance practices