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Construction of Chemically and Mechanically Stabilized Test Sections to Reduce Freeze–Thaw Damage of Granular Roads

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Abstract

Granular-surfaced roads in seasonally cold regions regularly experience damage and degradation due to freeze–thaw cycles and steadily increasing traffic loads. Repair and maintenance of such roads can consume significant portions of budgets from counties and secondary roads departments.

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Construction of Chemically and Mechanically Stabilized Test Sections to Reduce Freeze–Thaw Damage of Granular Roads

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INTRODUCTION

Granular-surfaced roads in seasonally cold regions regularly experience damage and degradation due to freeze–thaw cycles and steadily increasing traffic loads. Repair and maintenance of such roads can consume significant portions of budgets from counties and secondary roads departments. Several approaches are used to combat these types of moisture-related damage, including

- Temporarily spreading rock on the affected areas;
- Lowering or improving drainage ditches;
- Tiling;
- Bridging the areas with stone and geosynthetics covered by a top course of aggregate or gravel;
- Coring boreholes and filling with calcium chloride to melt lenses and provide drainage; and
- Regrading the crown to a slope of 4% to 6% to maximize spring drainage.

However, most of these solutions are aimed at dealing with frost boils after they occur.

To help prevent or minimize the occurrence of freeze–thaw damage-related problems in the first place, the Iowa Highway Research Board (IHRB) has supported several previous and ongoing research projects. In the previous Phase II IHRB Project TR-664: Low-Cost Rural Surface Alternatives: Demonstration Project (*1*), several stabilization methods were implemented over 17 test sections in Hamilton County, Iowa. Data was collected on construction and maintenance costs, and extensive laboratory tests, field tests, and field photographic surveys were conducted. The most-effective and economical stabilization methods for the soil and climate conditions of Iowa were identified, with several of the methods greatly improving the longevity and performance of the roadway materials.

For the ongoing IHRB Project TR-721: Low-Cost Rural Surface Alternatives Phase III: Demonstration Project additional mechanical and chemical stabilization methods were used to construct a total of 33 additional test sections in four counties distributed geographically around the state of Iowa in August through October 2018. Through the upcoming winter and spring seasons, the test section performance will be documented using extensive field tests and surveys. The goal of the ongoing project is to assess the effectiveness and relative costs of the additional stabilization methods for improving performance and minimizing freeze–thaw damage, under a wider range of climate conditions, subgrade types, and aggregate sources. To aid other stakeholders interested in using the stabilization methods, this paper details some of the construction equipment and methods used to build the 33 test sections.

METHODOLOGY

The stabilization methods used in the current project include five chemical stabilization methods in Washington and Hamilton counties and six mechanical stabilization methods in Howard and Cherokee counties (Table 1). Additionally, two of the mechanical methods (optimized gradation with clay slurry and aggregate columns) were also used in Washington and Hamilton counties, as the Technical Advisory Committee was particularly interested in assessing the performance of these two economical methods in all counties.

To design the test sections, extensive laboratory tests were conducted including sieve and hydrometer, Atterberg limits, slaking, California bearing ratio, proctor compaction, and unconfined compressive strength tests on soil samples that were taken from the test sites and mixed with the stabilizers when appropriate. After construction of the test sections, field tests including dynamic cone penetrometer, falling weight deflectometer, light-

TABLE 1 Types and Locations of the 33 Field Test Sections Used in This Study

		Counties			
	Stabilization Method	**Howard**	**Cherokee**	**Washington**	**Hamilton**
None (control section)		X	X	X	X
Mechanical	Aggregate columns (*2*)	X	X	X	X
	Optimized gradation with clay slurry (*3*)	X	X	X	X
	Ground tire rubber (eliminated)	X			
	Recycled asphalt pavement mixed 50/50 with aggregate (*4*)	X	X		
	2-in. slag surface above 2-in. existing aggregate base (*5*) (two slag sources)	X+X	X+X		
	4-in. slag surface (*5*) (two slag sources)	X+X	X+X		
Chemical	12 in. Type I/II cement-treated subgrade			X	
	4 in. Type I/II cement-treated aggregate surface course (*6*)			X	X*
	Silicic acid, sodium salt concentrated liquid stabilizer (SASS-CLS)			X	X
	Non-ionic concentrated liquid stabilizer with neutral pH (NI-CLS)			X	X
	Ionic concentrated liquid stabilizer (I-CLS)			X	X

NOTE: X = Section constructed in this county. X* = Section will be constructed in this county.

weight deflectometer (LWD), nuclear density gauge, and Colorado State University dustometer tests were performed. Additionally, smoothness and friction measurements were made using the Roadroid cell phone app. The field test results will be compared to those after the spring thaw to track changes in the strength, stiffness, and general performance of the test sections. Visual surveys with photos will also be conducted after periods of thawing and precipitation to assess performance. Maintenance requirements will also be tracked using survey reports completed by grader operators and county engineers.

FINDINGS

Based on the laboratory tests, the optimum compaction moisture contents and dry densities were determined and used to design the test sections. Suggested construction methods were drafted and then modified as necessary according to the actual soil and weather conditions encountered, equipment available, county crew experience, and other challenges commonly encountered in the field. The research team communicated and worked with the liquid stabilizer manufacturers, slag providers, and clay slurry provider to ensure that their recommended construction procedures were followed as closely as possible. Representatives from the manufacturers of the SASS-CLS and I-CLS (see Table 1), as well as both slag providers and the clay slurry provider traveled to the site to oversee construction and provide guidance. Information on the final as-built construction procedures and equipment are proved below to aid other secondary roads departments who may wish to use the same or similar stabilization methods. More detailed lists of construction procedures will be presented in the project's final report.

All of the chemical stabilizers except for the 12-in. cement-stabilized subgrade section were mixed using a 60-in. wide RoadHog mounted on a Caterpillar 938M Wheel Loader and attached to a water truck by a hose system. The portland cement was first spread on the road surface using a spreader truck and the liquid stabilizers were added directly to the water tank before mixing. For all sections except the aggregate columns, tow-behind rubber tire rollers were used for compaction, along with a smooth drum vibratory roller for finishing most of the chemically stabilized sections. The smooth drum roller was also used for the slag sections in Howard County and for all the optimized-gradation-with-clay-slurry sections. Because the three concentrated liquid stabilizers can set up hard in cold weather, it is important to get a smooth finished surface by using the smooth drum roller and tight blading. The 12-in. cement-stabilized subgrade section was mixed using a Caterpillar RM300 Road Reclaimer, followed by compaction with an 86 in. wide pad-foot vibratory compactor.

The optimized gradation with clay slurry sections were based on research described in Li et al. (*3*, *7*). In this approach, the gradations of existing surface materials and up to three potential quarry materials can be entered into a spreadsheet that will determine the optimum mixture proportions to give the tightest particle packing and therefore greatest strength. The clay slurry is used to increase the plasticity to reduce material loss due to water and fugitive dust. The optimization spreadsheet can be downloaded from the Project TR-685 final report webpage given in the references. After blade mixing the optimized proportions of aggregates and forming a 6-in. high windrow on each side, the clay slurry was sprayed by a self-unloading tanker trailer with a custom-fabricated deflector plate, then blade mixed edge to edge with 10 to 15 grader passes. After blade mixing the slurry and aggregate, a light cover of fresh dry aggregate over the top (two truckloads spread over a 500-ft section) was determined to be effective to minimize sticking of the very wet mixture to the compaction equipment.

Both the steel slag and recycled asphalt pavement (RAP) sections were placed using conventional methods and blade mixed using graders. In Cherokee County, a disc plow harrow was also found effective for mixing the RAP and aggregate together. The slag from Source A had a finer gradation, while that from Source B had a larger and more uniform gradation. Both materials resulted in a good final surface, with the Source A slag packing to a tighter surface due to the higher fines content.

However, their performance through winter freeze–thaw cycles has not yet been compared. Figures 1 and 2 show the various equipment used to construct the test sections.

FIGURE 1 Equipment used for mechanically stabilized sections: (*a*) disk plow harrow; (*b*) motor grader; (*c*) power auger; (*d*) vibratory compactor; (*e*) water truck; (*f*) rubber tire roller; (*g*) self-unloading tanker trailer spraying clay slurry; and (*h*) dump truck.

FIGURE 2 Equipment used for chemically stabilized sections: (*a*) RoadHog reclaimer; (*b*) water truck with chemical stabilizer added to tank connected to RoadHog; (*c*) road reclaimer; (*d*) sheepsfoot vibratory compactor; and (*e*) powder spreader truck.

CONCLUSIONS

All of the stabilization methods except for ground tire rubber resulted in good quality surfaces immediately after construction. The ground tire rubber was incorporated at only 20% by volume in the bottom 2 in. of a 4-in. thick aggregate surface, but created a soft, unstable surface that had to be removed. The clay slurry results in a rather wet construction procedure, but the surface is passable by the end of construction. In all four counties, significant rainfall the same day or one day after construction did not make the sections impassable. Secondary roads crews from all four counties remarked that the optimized gradation with clay slurry sections looked very good (better than the control sections) after a few days of drying, and have continued to hold up well for several months.

In the remainder of the project, the performance of the demonstration sections will be assessed using extensive field tests performed after spring thaws along with photo surveys and condition rating reports completed by grader operators. The costs of constructing and maintaining the various stabilized sections will also be tabulated and compared, to provide insight into their relative effectiveness and economy.

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REFERENCES

1. Li, C., J. C. Ashlock, D. J. White, and P. Vennapusa. Low-Cost Rural Surface Alternatives: Demonstration Project. IHRB Project TR-664. InTrans Project 13-479, Ames, Iowa, 2018. https://intrans.iastate.edu/research/completed/low-cost-rural-surfacealternatives-demonstration-project-2/
2. Ashmawy, A., R. McDonald, D. Carreon, and F. Atalay. Stabilization of Marginal Soils Using Recycled Materials. Final Report No. BD-544-4. Florida Department of Transportation, 2006.
3. Li, C., J. Ashlock, B. Cetin, and C. Jahren. Feasibility of Granular Road and Shoulder Recycling. Final Report. IHRB Project TR-685, April 2018. https://intrans.iastate.edu/research/completed/feasibility-of-gravel-road-and-shoulder-recycling/.
4. Koch, S., K. Ksaibati, and G. Huntington. Performance of Recycled Asphalt Pavement in Gravel Roads. *Transportation Research Record: Journal of the Transportation Research Board*, *No. 2204*, 2011, pp. 221–229. https://doi.org/10.3141/2204-28.
5. Mathur, S., S. Soni, and A. Murty. Utilization of Industrial Wastes in Low-Volume Roads. *Transportation Research Record: Journal of the Transportation Research Board*, Vol. 1652, No. 1, 1999, pp. 246–256. https://doi.org/10.3141/1652-31.
6. Henry, K. S., J. P. Olson, and S. P. Farrington. Improved Performance of Unpaved Roads During Spring Thaw. ERDC/CRREL TR-05-1. Cold Regions Research, 2005.
7. Li, C., J. C. Ashlock, B. Cetin, C. T. Jahren, and V. Goetz. Performance-Based Design Method for Gradation and Plasticity of Granular Road Surface Materials. *Transportation Research Record: Journal of the Transportation Research Board*, *No. 2672*, pp. 216–225, 2018. https://doi.org/10.1177/0361198118787372.