Montana Department of Transportation April 2020
RESEARCH PROGRAMS

Project Summary Report: FHWA/MT-20-002/9389-522

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Guidelines for Chemically Stabilizing Problematic Soils

https://www.mdt.mt.gov/research/projects/geotech/chemical_stablize.shtml

Introduction

The Montana Department of Transportation (MDT) initiated this project to research and develop guidelines for chemical stabilization of problematic subgrade soils in the state of Montana. The research was conducted through the Sustainable and Resilient Geotechnical Engineering (SuRGE) lab at Boise State University (BSU) in coordination with technical panel from MDT.

The goal of this project was to develop a comprehensive guideline to effectively evaluate the suitability and concentration of chemical additives to improve problematic subgrade soils. The following research objectives were laid out to achieve the goal of the project.

1. Determine the efficiency of common soil stabilizing agents for mitigating problematic Montana soils.
2. Develop protocols for selection of additive type and dosage.
3. Understand sulfate heaving issues and shed light on factors such as additive types along with reactive alumina and silica.
4. Examine scope and impact of using stabilizing agents to mitigate problematic soils against current MDT practice.

What We Did

In the process of developing the guidelines, several tasks were performed. Task 1 (Practices Survey) included a literature review of current chemical stabilization guidelines of several state and federal agencies along with the stabilization practices of Department of Transportation (DOTs) of the states neighboring Montana. It was evident from the study in Task 1 that many states surrounding Montana didn't have much experience with chemical stabilization of subgrade soils. Thus, the stabilization guideline developed through this study will not only help MDT but provide a reference to the nearby states as well.

Task 2 (Material Selection) of this project involved the sample collection from various problematic areas, encountered by MDT, within the State of Montana. Based on the interactions with MDT personnel, six different locations were chosen from different regions of Montana. The goal was to obtain different problematic soil types from various geological conditions to ensure that the stabilization guideline at the end of this project will address diverse problematic soils.

Task 3 (Evaluate Chemical Stabilizer) of the project primarily focused on establishing the baseline data and determining the type and amount of additive needed for stabilization – based on existing guidelines. In Task 4 of this project, chemical and mineralogical changes between treated and untreated soil samples was studied. It was decided that the strength target for treated subgrade soil will be 50 psi for both lime and cement treatments.

Task 5 in the research project was to establish curing and moisture conditioning protocols that can help minimize the time required for curing. Conventional methods for curing require 7 days but a faster protocol was developed for curing stabilized samples as a part of this task. The new protocol, named Humidity Controlled Accelerated Curing (HCAC), was used to cure soil samples at elevated temperatures of 65.5°C (150°F) while maintaining 95% ± 5% humidity for 24 hours.

In task 6, the durability of stabilization effects against freezing/thawing and wetting/drying was studied. Durability studies were conducted primarily to simulate the seasonal moisture fluctuations that might transpire during summer and winter seasons.

Task 7 (Life-Cycle Cost Analysis) was conducted with a goal to help engineering managers make informed decisions on adopting appropriate methods (as applicable) to counter problematic soils. As a part of this task, life cycle cost analyses were performed for pavement sections on untreated subgrade, chemically treated subgrade and the currently preferred practice of using special borrow.

What We Found

Some of the important observations/findings from above mentioned tasks are as follows:

1. Out of the six soils collected, there were two high plasticity clays, two low plasticity clays, one low plasticity silt, and, one silty sand. Two out of six soils contained soluble sulfates in excess of 10,000 ppm and, all but one soil contained organic content greater than 1%. Such soils require special attention in selecting stabilization method and durability.

2. It was noted that only 2% lime was sufficient to increase strength above 50 psi for all soils tested in this research. One soil required 7% cement to increase the strength above 50 psi whereas 2% lime was enough. However, some of these samples have high sulfate contents which can cause issues with durability.

3. Of the three different accelerated curing protocols studied in this research, Humidity Controlled Accelerated Curing (HCAC) is the most practical and reliable. This protocol is recommended when time is of the essence, otherwise, the ASTM standard 7-day curing protocol should be used.

4. Based on the Freeze -Thaw and Wetting – Drying durability studies, the results generally show that cement treatment is most compatible in terms of durability at 7-9% cement. It should be noted here that two soils would be suitable to be treated with cement but did not fare as well as the others.

5. The durability of chemical treatment on four of the soils was poor compared to other Montana soils. This could be due to the high amounts of sulfates present in these soils.

6. The general cost increase in construction is higher for special borrow than chemical stabilization. The percentage increase in initial construction cost due to the use of a chemically treated subgrade soil varied from 6.9% to 8.4%. The increase in construction cost for pavements on special borrow varied from 12.6% to 15.3%.

7. Special borrow is more favorable than chemical stabilization in the long term when compared to soils that failed in the durability tests. When considering soils that performed well in the durability test, chemical stabilization is the more favorable alternative than special borrow.

8. Based on the results of the lifecycle cost analysis (LCCA), it can be concluded that using chemical stabilization on problematic soils is more advantageous than special borrow, if the durability of the treatment is high. When durability results are poor for chemical treatments, special borrow is more cost advantageous in the long term. It should be noted that the life cycle costs and analyses for this research project are based purely upon construction costs. Additional incurred costs and/or time that would be included during project design and development to implement chemical stabilization have not been included in this analysis.

What the Researchers Recommend

The following chart is recommended to determine the type of chemical additive for preliminary design of chemical stabilization for Montana soils.

The information from the chart applies to most, but not all cases and validation testing must be performed to verify whether the selected additive accomplishes the goals and requirements for the treated soil. To determine the optimal additive content recommended step-by-step procedures for both lime and cement stabilization are included in the final report.

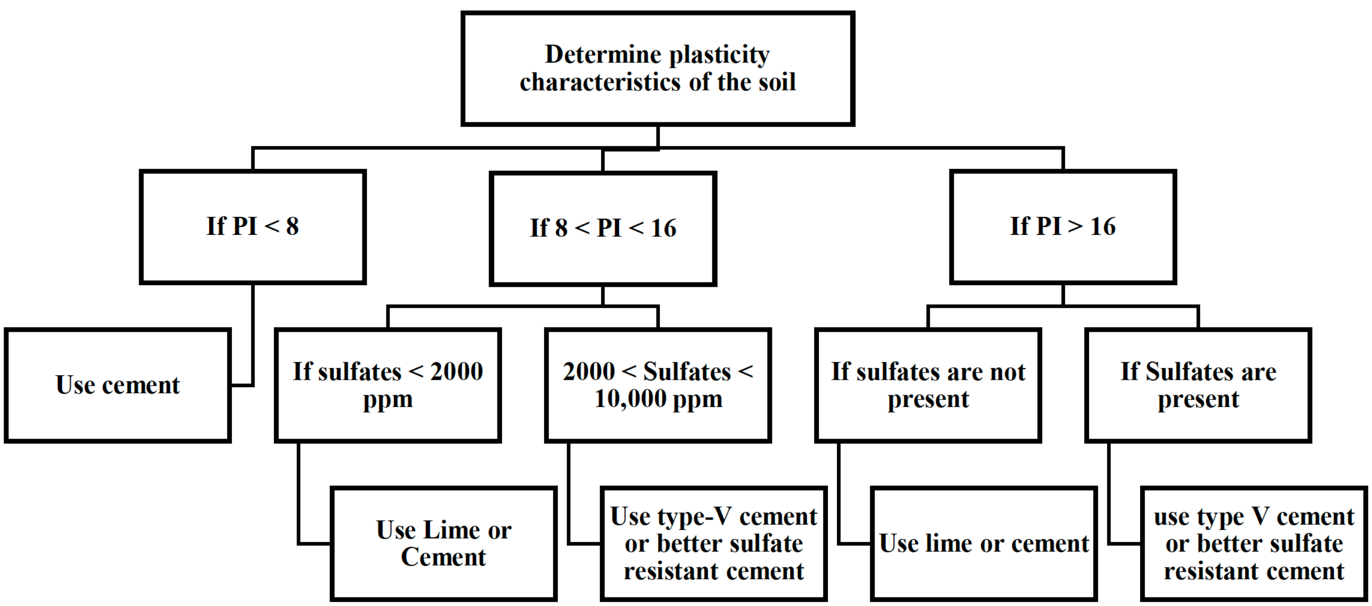

Figure 1: Flowchart to select optimal additive type for chemical in Montana.

For More Details . . .

The research is documented in Report FHWA/MT-20-002/9389-522, https://www.mdt.mt.gov/research/projects/geotech/chemical_stablize.shtml.

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MDT Implementation Status:

Two types of implementation studies could be taken up: 1) short-term improvements for constructability and 2) long-term improvements where the stabilization is used to strengthen the subgrade and becomes part of the pavement structure. MDT will utilize the information and procedures gained from this research project to help assess the feasibility of using chemical stabilization for problematic soils on our projects. This feasibility analysis will consist of using processes and procedures recommended in the research project, evaluating available MDT resources and project schedules, contractor availability, and economics which may include life cycle cost analyses as applicable for both short- and long-term conditions.