GUIDELINES FOR CHEMICAL STABILIZATION OF PROBLEMATIC SOILS IN MONTANA

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INTRODUCTION

- Wide variety of problematic subgrade soils are present across the State of Montana.
- Subgrade stabilization as per Montana Department of Transportation's (MDT) geotechnical manual -
  - Geosynthetic reinforcement – currently inclined practice of MDT
  - Chemical stabilization – Focus of this project
- Literature review and current state of practice of neighboring states show limited experience and no established guidelines (except for Saskatchewan)
- MDT's interests -
  - Understanding of chemical methods for subgrade stabilization on Montana specific soils
  - Development of chemical stabilization guideline tailored to the needs of MDT

MONTANA SOILS

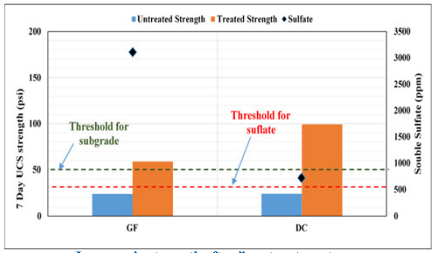
Out of the six soils collected, there were two high plasticity clays, two low plasticity clays one low plasticity silt, and one silty sand. Two out of six soils contained soluble sulfates in excess of 10,000 ppm and, all but one soil contained organic content greater than 1%. Such soils require special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

Soil	USCS	AASHTO	Plasticity Index (%)	Sulfate (ppm)	Organic Content (%)
GF	CH	A-7-5	62	3107	3.3
DC	CL	A-6	17	722	3.5
BR	CL	A-7-6	16	13635	1.2
CNK	SM	A-2-4	N/A	29	0.7
NTF LP	ML	A-5	8	2450	3.7
NTF HP	CH	A-7-6	32	14500	4.2

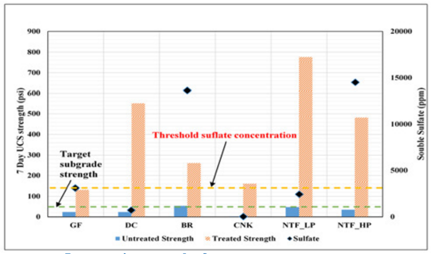
GF = Great Falls, DC = Dry Creek, BR = Bad Route, CNK = Chinook, NTF_LP = North Three Fork Low Plastic, NTF_HP = North Three Fork High Plastic

MAJOR FINDINGS

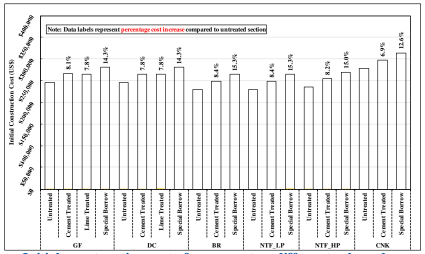
- It was noted that only 2% lime was sufficient to increase strength above 50 psi for all soils tested in this research. One soil required 7% cement to increase the strength above 50 psi whereas 2% lime was enough. However, some of these samples have high sulfate contents which can cause issues with durability.
- **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.
- The **durability of chemical treatment** on four of the soils was poor. This could be due to the high amounts of sulfates present in these soils.
- The **Life Cycle Cost Analysis** showed 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%. This special borrow increase does not include additional cost in design efforts for chemical stabilization
- If durability tests failed, special borrow is more favorable than chemical stabilization in the long term.
- When considering soils that performed well in the durability test, chemical stabilization is the more favorable alternative than special borrow.



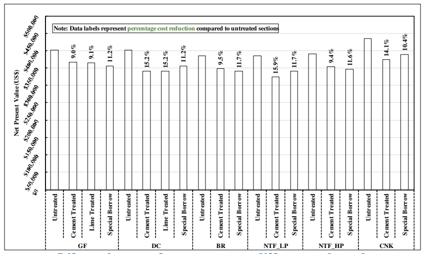
Increase in strength after lime treatment



Increase in strength after cement treatment



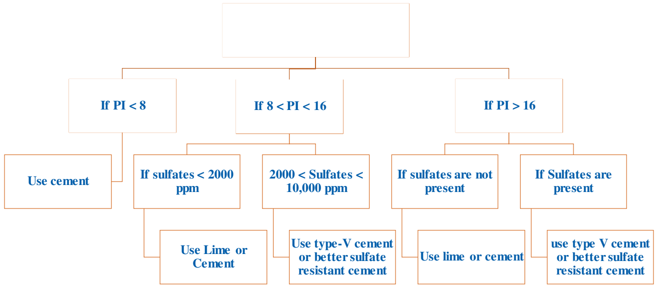
Initial construction cost of pavement on different subgrades



Life cycle cost of pavements on different subgrades

RECOMMENDATIONS FOR CHEMICAL STABILIZATION

DETERMINATION OF THE TYPE OF ADDITIVE



DETERMINATION OF THE AMOUNT OF ADDITIVE

LIME STABILIZATION

- Step 1: Verify that the sulfate and organic contents are within acceptable limits. Measure the sulfate and organics content prior to the addition of the additive. Sulfates should be less than 2000 ppm (if the PI of the soil is less than 16) and organics should be less than 1%. If the sulfates are more than 2000 ppm, do not use lime as additive. If organics are more than 1%, be cognizant that the soil may require higher dosages to counter the effect of cation exchange capacity.
- Step 2: pH test. The initial optimum lime content is established using a procedure developed by Eades and Grim (1966) which targets a pH of 12.4 or higher.
- Step 3: Moisture Density curve. Establish the moisture density curve using the lime content established in Step 2. This will be used to prepare soil samples for UCS testing.
- Step 4: Plasticity Index. Conduct a plasticity index test to evaluate shrink/swell characteristics of treated soil. Most soils turn non-plastic at optimum lime content.
- Step 5: Strength Testing. Conduct a UCS test at OMC and MDUW established in Step 3. Verify if the strength meets the governing specification.
- Step 6: Durability Testing. Perform durability tests if stabilization is targeting long-term performance.
- Step 7: Select the optimal content. Select the lowest modifier content necessary to satisfy the project requirements.

CEMENT STABILIZATION

- Step 1: Verify that the sulfate and organic contents are within acceptable limits. Measure the sulfates and organics content prior to the addition of the additive. If the sulfates are less than 2000 ppm use type I/II Ordinary Portland Cement. If sulfate content exceeds 2000 ppm, use type V or better sulfate resistant cement. If organics are more than 1%, be cognizant that the soil may require higher dosages to counter the effect of cation exchange capacity.
- Step 2: Moisture Density curve. Establish the moisture density curve using an initial cement content. This will depend on the soil type and the target performance requirements. Start with minimal percent typically 2%.
- Step 3: Strength Testing. Conduct a UCS test at OMC and MDUW established in Step 3. Verify if the strength meets the governing specification.
- Step 4: Durability Testing. Perform durability tests if stabilization is targeting long-term performance.
- Step 5: Select the optimal content. Select the lowest modifier content necessary to satisfy the project requirements.