Mitigation of Expansive Soils Damages

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This presentation will focus on four main sections:

1. Introduction and Background
2. Experimental Program
3. Results and Conclusion
4. Additional Work
Introduction and Background

Experimental Program

Results and Conclusion

Additional Work
Clay is the most common particle that makes soils expansive because of its ability to retain large amounts of water.

Very fine particles (less than 2 microns)

Large surface area (plates with negative charge)
How expansive clay is depends on the minerals in the clay

Montmorillonite is the most expansive mineral. One pound of it can have a surface area of 800 acres.
Expansive soil behaves like a sponge. It expands when it soaks up water and then shrinks back down when it loses water.

Water being attracted to the negatively charged clay plates.

3 plate shaped clay particles with no water between them

3 plate shaped clay particles with water molecules attached, pushing them apart.
The damage to infrastructure by expansive soils costs close to 9 billion dollars per year.
Austin, Texas is located in an area of highly expansive soil

USGS (1989)
The main objective of our research was to understand the concepts behind soil stabilization and determine the best percentage of lime to stabilize our soil.
1. Atterberg Limits Test
The Swelling Potential of Expansive soils can be determined indirectly from Atterberg Limits.

PI = LL - PL

Liquid Limit (LL)

Plastic Limit (PL)

Plastic index (PI)

(ASTM 4318)
2. Determination of Sulfate Content
Ettringite formation, Heave-inducing crystal, can be avoided by checking the sulfate content of Soil before lime stabilization.

Day 1: Sample Preparation

Day 2: Filtration and Precipitation

Day: Precipitate Filtration

Day 4: Final Weight of Soluble Sulfate

Modified UTA method (2000)
On the first day, Pulverization and Dilution of the soil are performed.
On the second day, Stirring, centrifugation and Filtration of the soil solution are the major tasks

Modified UTA method (2000)
On the Third day, The filtration of the precipitate solution is performed
On the Fourth Day, The final Weight of the dry precipitate is determined.

Removal Of Weighing Tin and precipitate from the oven

\[
\%SO_4 = \frac{\text{Molecular Weight } SO_4}{\text{Molecular Weight } BaSO_4}
\]

Modified UTA method (2000)
3. Additive Selection/ Mix Design
Samples with different % of lime are tested to determine the most effective amount of lime

Common % of Lime: 3%-8%

OMC of control soil is the starting point

Required mellowing time: at least 24 hrs

Nelson and Miller (1992)
4. One-Dimensional Swell Test
A Direct Indication of Swell Potential can be obtained through 1-D Swell Test.

(ASTM 4546)
5. Unconfined Compressive Strength Test
The UCS Test helps to estimate the strength of Treated and Non-Treated Soils.
1. Results and Discussion
Austin’s soil was found to be a high-plasticity clay

Moisture content vs. Number of blows

<table>
<thead>
<tr>
<th>Soil Property</th>
<th>Results</th>
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<tbody>
<tr>
<td>Liquid Limit (LL)</td>
<td>51.04%</td>
</tr>
<tr>
<td>Plastic Limit (PL)</td>
<td>19.76%</td>
</tr>
<tr>
<td>Plasticity Index (PI=LL-PL)</td>
<td>30.84%</td>
</tr>
<tr>
<td>USCS Classification</td>
<td>CH</td>
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</tbody>
</table>
The Sulfate content was within the Acceptable range

<table>
<thead>
<tr>
<th></th>
<th>Sample 1</th>
<th>Sample 2</th>
<th>Sample 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>*W₁ (grams)</td>
<td>1.2116</td>
<td>1.2198</td>
<td>1.2156</td>
</tr>
<tr>
<td>*W₂ (grams)</td>
<td>1.2182</td>
<td>1.2263</td>
<td>1.2216</td>
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<tr>
<td>Sulfate content (ppm)</td>
<td>271.63</td>
<td>267.514</td>
<td>246.936</td>
</tr>
<tr>
<td>Avg. Sulfate content (ppm)</td>
<td></td>
<td>261</td>
<td></td>
</tr>
</tbody>
</table>

Acceptable Range = 1000 to 2000 ppm¹

W₁ = Mass of weighing tin and filter paper
W₂ = Mass of weighing tin, filter paper, and precipitate

¹Puppala et al. (1999) and Viyanat (2000)
In the time-displacement curve, 6% was observed to have reduced swell the most.

All of the specimens with lime performed better than the control sample.
The 6% lime sample had the overall highest strength.

In general, all lime treated samples had a higher shear strength than the control.
2. Conclusions
Performance benefits from lime stabilization reduce maintenance costs
6% lime and 4% lime were found to be suitable to reduce swelling and increase bearing capacity

- 4% lime could be used in situations requiring reduced cost
- 6% lime could be used in situations requiring additional strength
For future research, additional additives could be tried in combination with lime (such as cement)
Introduction and Background
Experimental Program
Results and Conclusion
Additional Work
1. Field Stabilization
Reduction of Slope and Embankment Failure at Grape Vine and Joe Pool Lakes

Monitoring of Horizontal Movement by Inclinometer

Monitoring of Vertical Movement by surveying
2. Three-Dimensional Swell Test
The 3-D Swell Test can be Conducted Using Double Inundation
Lime Stabilization reduces the swelling potential considerably.
3. Hydrometer Test
The size Distribution of Silt and Clay can be Obtained through Hydrometer Test
References

Acknowledgements

We are very grateful to all the people who made this research possible, especially Dr. Anand Puppala, Dr. Nur Yazdani, Dr. Yvette Weatherton, Dr. Stephanie Daza, Mr. Aravind Pedarla, Mr. Justin Thomey, Mr. Minh Lee and Mr. Naga Talluritinnu.
Questions???????