Project Summary

Texas Department of Transportation

0-5540: Mitigating the Effects of Organics in Stabilized Soils

Background

The Texas Department of Transportation (TxDOT) has reported difficulty stabilizing with lime those soils bearing high and low concentrations of organic matter. Problems include the stabilizer disappearing over time, difficulty measuring organic matter (ignition oven technique), and rough pavement due to poor subgrade support. Before a remediation technique can be developed, researchers have to understand exactly how the organic matter interferes with lime stabilization. Toward this goal, this research project had three objectives:

- to identify a good test to measure organic matter in soils and identify the fraction of organic matter that causes problems with lime stabilization,
- to determine what mechanism or mechanisms were responsible for organic matter interfering with lime stabilization, and
- to evaluate how organic matter affects the engineering properties of soils from real TxDOT projects.

What the Researchers Did

Researchers from the Texas Transportation Institute (TTI) focused on developing a quick field test to measure organic matter, and on determining how and under what circumstances the organic matter interferes with lime stabilization. The University of Texas at Arlington (UTA) researchers focused on addressing the engineering properties of organic-rich soils stabilized with lime.

To address these topics, TTI researchers collected 146 soils from the Soil and Crop Sciences soil library at Texas A&M University. These soils represent all major soils in the state of Texas. Researchers developed a new test using organic matter extracts from these soils. They used a UV-Vis instrument to measure the amount of deleterious organic matter in the soil. They also manufactured soils using two types of smectite (calcium saturated and sodium saturated), quartz sand, hydrated lime, and a reference humic acid (humic acid concentrations were 0, 0.5, 1.0, 2.0, and 5.0 percent by weight).

Strength measurements were taken on cores of the soils, and the broken cores were then characterized with X-ray diffraction (XRD), scanning electron microscopy (SEM), and differential scanning calorimetry (DSC) to elucidate chemical reactions responsible for the observed engineering changes.

Research Performed by:

Texas Transportation Institute (TTI),
The Texas A&M University System

The University of Texas at Arlington (UTA)

Research Supervisor:
Pat Harris, TTI

Researchers:
Omar Harvey, TTI
Stephen Sebesta, TTI
Srujan Rao Chikyala, UTA
Anand Puppala, UTA
Sireesh Saride, UTA

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The UTA researchers measured engineering properties on 12 organic-bearing soils from TxDOT projects. They measured optimum moisture content, plasticity, shrink/swell, unconfined compressive strength (UCS), and optimum lime and cement content for each soil.

What They Found

Laboratory test results of the 146 soils tested with the UV-Vis spectrophotometer yielded an r^2 value of 0.89 for the organic content. This simple procedure can be used in the field to estimate the amount of deleterious organic matter in about 15 minutes. Using the manufactured soils, the researchers found that humic acid (a major component of organic matter) prevents the lime from reacting with clay minerals in the soil to form pozzolanic reaction products (i.e., calcium silicate hydrate) if the humic acid is present in the soil at concentrations above 1 percent by weight. The DSC can also be used to measure the effectiveness of lime stabilization in organic-rich soils: it detects a crystallization product at 850-900°C, which has been directly correlated with UCS.

Researchers experimented with both calcium-saturated and sodium-saturated smectites to see how important cation saturation (i.e., calcareous soils) is with respect to lime stabilization. There was a profound impact on the strength and ability of the lime to form pozzolanic reaction products with cation saturation. The calcium-saturated clays provided UCS values over 400 psi, and the sodium-saturated samples barely exceeded 100 psi.

The natural soils exhibit properties similar to the manufactured soils. As the percent of organic matter increased in the soil, dry density decreased, optimum water contents increased, and the effectiveness of lime and cement in altering the engineering properties decreased. For example, the lime and cement significantly reduce the plasticity of a highly plastic soil. However, in these natural soils, as the organic content increases, the lime and cement become less effective in reducing the plasticity index of the soil. More importantly, after 56 days of curing there was a decrease in the UCS of lime- and cement-treated samples bearing high concentrations of organic matter. The shrink/swell characteristics of the soils increase with increasing organic matter, which shows that the lime and cement are not effectively stabilizing the soil.

What This Means

The results from this project indicate the following:

- The UV-Vis method for measuring organic matter is a good field technique that measures actual deleterious constituents.
- Humic acid, in concentrations greater than 1 percent, interferes with lime stabilization of soil by not allowing the lime to form the pozzolanic reaction products that generate long-term strength gain.
- Calcareous soils with high concentrations of organic matter (more than 1 percent) respond more favorably to lime treatment than acid soils.
- The natural soils show an increase in shrink/swell with increasing organic matter.
- With increasing organic matter, the natural soils stabilized with lime or cement exhibit a decrease in UCS after 56 days of curing.

For More Information:
0-5540-1 Mitigating The Effects of Organics in Stabilized Soils: Technical Report

Research Engineer - German Claros, TxDOT, 512-465-7403
Project Director - Darlene Goehl, TxDOT, 979-778-9650
Research Supervisor - Pat Harris, TTI, 979-845-5845

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keyword: research

Texas Department of Transportation
Research and Technology Implementation Office
P.O. Box 5080
Austin, Texas 78763-5080
512-465-7403