0-6362: Rapid Field Detection of Sulfate and Organic Content in Soils

Background

Failures in chemical stabilization of subgrade soil due to sulfates or organics interfering with the intended stabilization mechanism can cause the Texas Department of Transportation (TxDOT) costly repairs, project delays, and poor riding pavements. Prevention of such failures by early detection of the presence of sulfates and organics prior to construction provides the best means to avoid problems.

There are test methods in place that measure sulfate minerals and organic matter in subgrade soil, but these methods are time consuming and spot tests that test only a small portion of the soil. Currently, TxDOT selects soil samples at intervals ranging from 500 to 2500 feet along a highway construction project to measure the sulfate content. Experience shows that sulfate minerals and organic matter are often concentrated in areas smaller than the 500 to 2500 foot interval. It is highly possible for TxDOT to miss detection of these harmful soil constituents under the current testing protocol, which may result in pavement failures at a later date.

What the Researchers Did

TxDOT established several criteria needed for choosing equipment and methods to identify sulfate minerals and organic matter in soils in the field. These criteria include: continuous coverage, measurements to a depth of 3 to 4 feet, ease of use, and low cost. After a comprehensive literature review and discussion with vendors, researchers identified several methods used to detect sulfates and organic matter in soils. Most of these techniques did not meet the coverage requirements or measurement depths proposed by TxDOT.

The researchers further screened two pieces of equipment that could execute tests that met all of the criteria for detecting sulfate minerals: the Veris 3150 and the EM38DDRT. These instruments are shown in Figures 1 and 2. Researchers did not identify any test method that would measure the organic matter to the depth requested by TxDOT.

To determine the utility of the two instruments, the researchers traveled to three regions of Texas that are known for bearing sulfate-rich soils: Eagle Pass, Fort Worth, and Sherman. They collected data tied to global positioning system coordinates and made maps of the soil conductivity. They used the conductivity maps to pick locations where soil samples could be collected. Soil properties tested in the laboratory correlated to conductivities measured with the instruments.

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Figure 1. Veris 3150 Conductivity Device Used to Measure Soil Conductivity.

Figure 2. EM38-DDRT Electromagnetic Device Used to Measure Soil Conductivity.

What They Found

The researchers identified several soil properties that correlate with the conductivity maps created with data obtained from the Veris 3150. These properties include: soil moisture content, clay mineral content, and soil salinity (dissolved salts including sulfate minerals). Provided the soil moisture is high enough (~10 vol %), researchers found that sulfate minerals were restricted to soil conductivities above 100 mS/m (milli Siemens per meter).

What This Means

TxDOT can generate soil conductivity maps using the Veris 3150 equipment which provides continuous coverage of a project and shows conductivity to a depth of approximately 4 feet. Maps can then be used to select locations where conductivities are above 100 mS/m to collect soil samples to measure sulfate minerals in the laboratory. This approach could eliminate problems associated with the current technique where sulfate-rich soils may go undetected.

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