Improved Test Methods for Determining Sulfate Content in Soils

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ABSTRACT

Clay soils that have a high shrink/swell potential are often stabilized with lime, fly ash, cement kiln dust, or Portland cement. These chemical additives reduce the potential for shrinkage or swelling and improve other soil properties such as workability and strength. However, when clay soil containing sulfate is stabilized with lime, the sulfate can combine with the calcium in lime, and water to form the expansive mineral ettringite. Instead of improving the soil, the lime enables the ettringite reaction to occur, and heaving and buckling of the stabilized soil follows. Sulfate-induced heave in lime-stabilized soils is a serious problem costing millions of dollars in infrastructure damage each year. Thus it is important to know whether or not soil contains sulfate and if so, in what quantities. It is also important to know how the sulfate content and other mineralogical properties affect the swelling potential when ettringite forms.

Part of this research focused on finding alternative sulfate detection and quantification methods. Currently the most reliable method used in practice is colorimetry, but many studies have shown that colorimetry under-predicts the sulfate content for sulfate concentrations above about 5,000 ppm. A Na_2CO_3 wash method was investigated, which initially showed improved sulfate detection on manufactured soils. However, when this test was performed on natural soils, the resulting sulfate content was only higher than colorimetry results for one soil. Thus, there must be other factors affecting sulfate dissolution, such as mineralogical properties.

In addition, free swell oedometer tests were performed on manufactured samples of Hickory Clay kaolinite with varying percentages of sulfate and sulfate with 5% lime to see if a swelling trend based on sulfate content could be found. As the sulfate content increased, in the Hickory Clay with lime samples, the swelling increased. It appears that sulfate content is not the only factor affecting swelling though, because free swell tests on natural soils did not necessarily show higher swelling in the samples with higher sulfate contents. Thus, other soil properties besides sulfate content must affect the swelling potential in these soils. These other mineralogical, chemical, and physical properties were analyzed with SPSS software to determine whether or not swelling in stabilized samples was correlated to these parameters. The results showed low correlations for all parameters, necessitating additional testing.

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