Ph.D. DEFENSE ANNOUNCEMENT

ENGINEERING BEHAVIOR OF FINE-GRAINED SOILS MODIFIED WITH A CONTROLLED ORGANIC PHASE

Bate

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ABSTRACT

Organic materials are ubiquitous in the geologic environment, and can exert significant influence over the interfacial properties of minerals; however, due to the complexity of their structure and interaction with soil solids, their impact has remained relatively unquantified. This study investigated the engineering behavior of organoclays, which were synthesized in the laboratory using naturally occurring clay minerals and quaternary ammonium compounds of controlled structure and density of loading. The tested organic cations were chosen to study the effect of functional group structure and size.

The laboratory investigation demonstrated that the presence of the organic cations on the mineral surface resulted in increased hydrophobicity of all clays tested. Conduction studies on the electrical, hydraulic, and thermal properties of the organoclay composites demonstrated that increasing the total organic carbon content resulted in decreased electrical and thermal conductivity, but increased hydraulic conductivity, due to the reduced swelling of the base clay mineral phase. Electrokinetic properties of the organoclays demonstrated that compared to the clay’s naturally occurring inorganic cations, exchanged quaternary ammonium cations were more likely bound within a particle's shear plane, resulting in a less negative zeta potential for organoclays when compared to unmodified bentonite. Increasing the length of one carbon tail was more effective at binding organic cations within the shear plane than increasing the size of the cation, when compared on the basis of total organic carbon content.

In terms of large strain strength, the modified organic clays demonstrated increased shear strength, in part due to the reduction in water content due to the presence of the hydrophobic organic layering. Increases in shear strength resulted from increased cation size, although the effect reached a plateau as the cation tail length was increased. In terms of small strain behavior, the shear modulus was shown to be a function of the total organic carbon content, with stiffness increasing as either the size of the cation or the total organic carbon content was increased, due to an increased number of particle contacts. Damping also increased as the organic loading was increased, with the organic phase acting as an energy dissipation mechanism.