ABSTRACT

This work encompasses an experimental investigation to examine the effect of the presence of laponite - a synthetic nanoclay with plasticity index exceeding 1000% - on the mechanical response of loose sand. The research is motivated by the interest in utilizing laponite to treat soils susceptible to earthquake-induced liquefaction.

The experimental program includes cyclic triaxial and resonant column tests performed on specimens prepared pluviating sand and laponite under dry conditions and then permeated with deionized water. Optical microscopy and SEM observations complement the mechanical tests, offering insight into the fabric of the specimens and the sand-laponite interactions and providing supportive evidence for the micro-mechanisms that are hypothesized to be responsible for the behavior observed during testing.

The small percentages (1-5% by dry mass of the sand) of laponite do not impact significantly the flow or consolidation properties of the soil but markedly affect the stress-strain-strength behavior. Cyclic triaxial test results show that the addition of 1% laponite impacts all stages of the cyclic behavior, from the response during the first loading cycle to the development of large strains, and to liquefaction. With 1% laponite, there is an increase of over one order of magnitude in the number of cycles that can be sustained at a given cyclic stress ratio. Longer pre-shear aging periods or higher dosages (3-5%) of laponite lead to higher cyclic resistance and have a consistent impact on the parameters used to describe the excess pore pressure generation behavior.

Measurements conducted in the resonant column apparatus show that the small strain shear stiffness (G_{max}) of the sand increases by over 20% in the presence of 1% laponite, with additional laponite causing a slight decrease in G_{max} relative to clean sand. For all dosages, the presence of laponite extends the linear threshold of the soil, reduces stiffness degradation and delays excess pore pressure generation.
Analysis of the cyclic and resonant column results and observations of the microstructure suggest that the mobility of the sand particles is reduced, when laponite is present. This effect may be ascribed to two mechanisms: (1) bonding/bridging at the particle contacts due to the charged laponite fines present on the sand grains; and (2) formation of a pore fluid with solid-like properties. The first appears to control the behavior with 1% Laponite while the second would be responsible for the behavior observed with higher dosages of laponite.

The results obtained with laponite are compared to those from a previous study of sand-bentonite specimens, defining a framework for evaluating the effect that highly plastic fines have on the behavior of sands.