Investigating Effects of Phosphorus Ions on Geotechnical Properties of Bentonite

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Abstract

As pore fluid's chemical properties in cohesive soils may have decisive effects on geotechnical characteristics of barriers, an investigation carried out to study bentonite-contaminant interactions at various phosphorus ion concentrations. Bentonite specimens were artificially contaminated by mixing the soil with di-ammonium phosphate (DAP) in concentrations ranging from 0.01 to 0.1mole/l. The conventional geotechnical experiments such as compaction, unconfined compressive strength, and direct shear box were performed. Findings on phosphorus ion impact on the water content (ω) change, dry density, unconfined compressive strength, internal friction angle, and cohesion indicate that: Increasing phosphate ion concentration in soil-electrolyte may lead to an increase in cohesion, and unconfined compressive strength of contaminated bentonite. The obtained results showed that 57% and 29% improvement in cohesion and unconfined compressive strength, respectively may be achieved by maintaining a high DAP concentration of about (0.1 mol/l). Our observations showed that a given value of 23% optimum water content with deionized water increased to 25% at the highest phosphorus ion concentration.

Keywords: Bentonite; Phosphorus ion; mechanical properties; Di-ammonium phosphate

1. Introduction:

Bentonite is commercially available clay which is widely used in the construction of barriers for waste containment due to its low hydraulic conductivity and high cation exchange capacity. As a barrier to contaminants, the bentonite is exposed to mechanical and chemical stresses. Results of many experimental studies showed that mechanical behaviour of montmorillonite clays such as compressibility, consolidation, and shear strength properties may be strongly affected by changes in pore fluid characteristics. For example, Ouhadi et al. investigated the influence of zinc nitrate and lead nitrate on compressibility and consolidation behaviour of bentonite and deduced that the chemical properties of pore fluid govern soil performance mainly at low applied loading [1]. In addition, Engelhardt and Gaida compressed pure montmorillonite with solutions of NaCl and $CaCl_2$ and suggested that the influence of electrolyte concentration on equilibrium porosity is significant under low to moderate overburden stress only [2].
Di Maio and Fenelli studied the effects of NaCl solutions on the residual shear strength of sodium bentonite. They concluded that the enhanced residual shear strength was due to both an increase in effective interparticle stresses which vary with the concentration of salts in pore water, and to the nature of the clay minerals [3]. In other study, Di Maio undertook residual shear strength testing of the dominantly sodium-montmorillonitic Ponza bentonite, exposed to saturated solutions of NaCl, KCl and $CaCl_2$. The results showed an increase in the residual shear strength of the bentonite when exposed to the saturated solutions [4].
Anson and Hawkins investigated the effect of Ca^{2+} ions on residual shear strength of kaolinite and sodium montmorillonite. According to their results, with higher concentrations of Ca^{2+}, the residual shear strength of the sodium montmorilinite increased more gradually [5].
In this paper, due to lack of attention given to the effect of anions on the shear strength, an investigation to study bentonite-contaminant interactions at various phosphorus ion concentrations has been carried out. The main objective of this paper is to investigate the influence of phosphorus ions on the geotechnical properties of bentonite.