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Systematic Studies on Defining Interaction Process of Clay Minerals for Achieving Synthetic Mixtures as Composite Materials Applied in Stabilization Works

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Abstract

By considering the worldwide use of composite materials in stabilization works, according to sustainable and ecological principles, the present paper is focused on the analysis of changes of several geotechnical properties depending on components of bi-mineral mixtures and interaction existing among various mineral types. Correlations of soil geotechnical indices as plasticity limits, particle size distributions, linear swelling and chemical-mineralogical composition have been determined for two clay bi-mineral mixtures (montmorillonite-illite and kaolinite-illite). Dependency of plasticity limits with mineralogical compositions and ion nature in absorption complex and linear relations between activity factor and liquid limit – plasticity index have been carried out. Effect of moisture content on soil properties, which influenced the aggregation or dispersion processes, has been investigated through a parallel preparation of samples resulting from the mixing of the component material in dry and wet state. Analysis of swelling characteristics has indicated various behaviors of clay soils depending on type and amount of mineral components. The influence of adsorbed ions on physical and mechanical soil characteristics on clay mineral mixtures, as well as long-term structural variations have been studied. The results will lead to improvement of material performances used in stabilization according to internal soil changes mixture behavior.

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1. Introduction

Nowadays, there is a tendency of increase of stabilization works volume due to poor quality of soils and induced economic losses during execution and construction life cycle. Severe damages of built structures reported worldwide due to inappropriate soil conditions can be avoided by setting and implementing proper and reliable treatments [1, 2]. Present practice consists in modifying the engineering characteristics of the natural difficult soils in order to gather the design specifications. However on several construction sites, there is a deficit of proper soil materials and it leads to transportation expenses increase and geotechnical project value growth. For this purpose, adoption of various stabilization solutions using different natural components is widely used to achieve construction significant cost reduction and environmental benefits. In this regard, geotechnical soil properties have to be determined in order to establish correct measures for assuring the stability and safety of constructions. It is widely recognized that an important issue regarding the durability of earthworks is related to a realistic selection of soil nature. A correlation between the conventional classification indexes of soils and their chemical-mineralogical composition is of particular interest, leading to a more adequate use of the factors characterizing geotechnical properties of soils. Based on literature published in the field of soil stabilization [3, 4, 5], various links between basic soil properties and shear and compression strengths, swelling – shrinkage potential and chemical-mineralogical composition of some typical soils have been developed. In the studies performed by [6, 7, 8], mixtures with different mineralogical composition have been tested in order to establish correlation between plasticity limits, grain size composition, swelling pressure and various percentages of clay minerals. Due to large use of materials with complex structure during stabilization process, the study of geotechnical indices variation depending on mineralogical composition of multi-mineral mixtures is considered necessary in the selection of optimum recipe and sustainable design specifications. The aim of present paper is to obtain the dependency of geotechnical indexes both on mineralogical composition and ion nature in adsorption complex for achieving synthetic mixtures of clay minerals as composite materials applied in stabilization and ground improvement works.

2. Experimental tests for determining plasticity and activity of clay mineral mixtures

The materials used for laboratory testing consist in three clay types, composed essentially of sodium (Na) and calcium (Ca) bentonite with a high content of Na-montmorillonite, kaolinite and illite. Preparation of clay mixtures, with different mechanical properties, consisted in homogenization of compositions in dry state and mixing components in various dosages (10%, 20%, 40%, 60% and 80%). Basic geotechnical characteristics of clay bi-mineral mixtures (bentonite clay with montmorillonite - illite clay and kaolinite-illite clay), summarized in Table 1, have been determined in previous studies.

Table 1. Geotechnical properties of clay mineral mixtures.

Sample	Grain size distribution				Plasticity limits			Activity index
	Colloidal clay (<0,002 mm)	Clay (<0,005 mm)	Silt (0,005-0,05 mm)	Sand (>0,05 mm)	Plastic limit (PL, %)	Liquid limit (LL, %)	Plasticity index (PI, %)	(A, %)
Illite clay	58	65	30	5	18.9	77.7	58.8	0.91
Ca-bentonite clay	52	60	21	19	31.0	391.0	360.0	1.57
Na-bentonite clay	63	71	19	10	27.5	122.5	95.0	5.08
Kaolinite	56	78	20	2	31.8	78.0	46.2	0.59

The soil plasticity and activity index of clay soils are strongly influenced by the type and amount of minerals. Plasticity limits depends on several factors such as size and shape of mineral particles, surface activity and adsorption complex. For different mono-mineral types there are delimitated interval values for plasticity limits and

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