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Effects of Acidic Contamination on the Geotechnical Properties of Marine Soils in Japan

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ABSTRACT

Laboratory investigation, including a series of consolidation tests, was conducted on three marine deposits in order to study the effects of acidic contamination on the geotechnical properties of soils from coastal areas in Japan. Solutions of sulfuric acid were used to leach the clays for defined time periods ranging from 3 to 6 months, thus simulating the process of long-term soil-acid interaction that occurs during municipal and industrial waste storage. The obtained results showed that acidic contamination could affect the compressibility of the clays, and the factors determining the degree of such changes were clay mineralogy, soil structure, and the duration of clay-acid interaction.

KEY WORDS: acid; contamination; clay; compressibility; buffer capacity; clay mineralogy; soil structure.

INTRODUCTION

In mountainous countries like Japan, municipal development has generally concentrated along the coastal line. As the land available for construction in such countries is limited, new development projects often face the problem of soil contamination caused by mismanagement of the land in previous years. At the present time, little is known regarding the effects of contamination on the physicochemical properties of marine deposits. Sridharan et al. (2002) and Imai et al. (2006) studied the influence of ions on the mechanical properties of clays from Osaka Bay and Ariake Bay and reported that changes in soil's plasticity, compressibility, and strength occurred during soil-water-contaminants interaction. It has been already recognized that such changes strongly depend on the mineral composition of clay. For example, the compressibility of kaolinitic soils typically increases due to soil-acid interaction (Sridharan et al. 1981; Gratchev and Towhata, 2008), while for bentonite the opposite effect may occur (Gajo and Maines 2007). Yet the majority of natural clays contain a variety of clay minerals, and thus the effect of contamination on the properties of such clays still remains unclear. Also, due to the low permeability of natural clays, it has become common practice to use remolded soils for testing, as it provides satisfactory results within a reasonable period of time. As a result, the influence of important factors such as soil microfabric and the duration of contamination has been neglected in a number of studies. Decidedly, additional research is necessary to clarify different aspects of contamination, and its effects on the geotechnical properties of soil.

To address these issues, a laboratory study was conducted at the University of Tokyo, Japan. The objective of this study was to investigate the effects of acidic liquid resulting from municipal waste on the compressibility of marine deposits. It is noted that the results of this research can be also applied to a variety of soils in mega cities, where the problem of acidic contamination of subsurface water and soil has become of national concern.

Soil samples were collected from different coastal areas in Japan; namely, Osaka, Tokyo, and Ariake, in order to obtain soils with different mineral composition, and thus different physicochemical properties. X-ray analysis, Atterberg limits tests and grain size distribution tests were carried out to determine the index properties of the soils. The buffer capacity was determined experimentally by measuring the pH change when a strong acid was added to a solution. To study the effects of long-term contamination, the soil samples were leached with acidic water for certain periods of time. A series of compression tests were performed in order to establish whether contamination could influence the compressibility of soil. This article presents the obtained results.

SOILS TESTED AND LIQUIDS USED

The clays used in this research were kindly provided by the Port and Airport Research Institute, Japan. Borehole samples of the Osaka Bay clay were obtained at the elevation of -44 m (the water depth was about 20 m) during the in-situ investigation for the second construction phase of the Kansai International Airport, Osaka, Japan (Watabe et al. 2002). The geotechnical properties of this clay have been extensively studied by Watabe et al. (2002), Tanaka and Locat (1999), and Imai et al. (2006), who pointed out that the liquid limit (LL) and plasticity index (PI) of the Osaka clay varied with the elevation: the liquid limit was estimated to be in the range of 75-90, and the plasticity index in the range of 50-55. Tanaka and Locat (1999) reported that the dominant