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Laboratory Determination of Hydraulic Conductivity and Diffusion Coefficient of Bentonite-Enhanced Sand Mixtures

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Abstract

Bentonite-enhanced sand (BES) mixtures are usually used in contaminant barrier systems in solid and radioactive waste disposal sites. In these types of barriers permeability is the most important property and the contaminant migration by molecular diffusion must be low. In this study the hydraulic conductivity and pure diffusion tests were performed on compacted BES mixtures with 10, 20, 30 and 40% bentonite contents. Experimental results illustrated that with increasing bentonite content, the hydraulic conductivity of BES mixtures decreased substantially and chloride effective diffusion coefficient decreased. Except for BES mixture with 10% bentonite content, the hydraulic conductivities of remaining BES mixtures meet the minimum recommended standard for hydraulic conductivity of contaminant barrier systems. The pure diffusion tests on BES mixtures resulted in the chloride effective diffusion coefficients ranging from 3.1×10^{-10} m^2/s to 1.7×10^{-10} m^2/s for 10% to 40% bentonite contents, respectively.

Keywords: Bentonite-enhanced sand (BES) mixtures, contaminant barrier, hydraulic conductivity, diffusion Coefficient

1. INTRODUCTION

In the absence of clayey soils, compacted bentonite-enhanced sand (BES) mixtures are attracting greater attention as suitable material for buffers, slurry walls, and contaminant barrier systems. Other benefits are that BES mixtures are fairly resistant to the effects of desiccation and the bentonite in BES has a high chemical buffering capacity [1,2]. In landfills, as the main function of the liner is to minimize the movement of water out of the waste disposal facility, BES should satisfy three performance criteria if it is to perform satisfactorily as a barrier material. It should have low hydraulic conductivity (typically less than 1×10^{-9} m/s), should have sufficient strength in order to be stable during construction and operation, and it should not be susceptible to excessive shrinkage cracking due to water content changes that usually occur during the lifetime of the landfill [1]. In this study, four BES mixtures with 10, 20, 30 and 40% bentonite content were selected and the hydraulic conductivity tests, pure diffusion tests were performed on the BES samples to examine their suitability as contaminant barrier material.

2. MATERIALS

The bentonite sample was obtained from Iran Barite Falat Company in Tehran, Iran. The sand used in this study was obtained from Tamin Mase Rikhteghari Company in Firoozkoh, Iran. Particle-size distribution curves of these two materials are shown in Figure 1. The sand used is poorly-graded silica sand with optimum water content of 12.6 %, maximum dry unit weight of 16.0 kN/m^3, and the hydraulic conductivity of 5×10^{-5} m/s at its maximum compacted density. Other properties of sand and bentonite used in this study are given in Table 1. The specific gravity of the solids and Atterberg limits reported in Table 1 were determined according to the standard practices [3,4].