Aging of Physical Properties of MX80 Buffer Layer Material Under High-Temperature and Strong Alkaline Conditions (Postprint)

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Abstract

During the operation of deep geological repositories, groundwater erodes the concrete used as a construction material, causing aging and degradation. The bentonite employed as a buffer material will be exposed to high-temperature, strong alkaline environments for extended periods, resulting in time-dependent deterioration of its physical properties. To investigate the time-dependent behavior of bentonite physical properties under high-temperature, strong alkaline conditions, MX80 bentonite powder was reacted for varying durations (t = 0, 15, 30, 45, 60, 90 d) in an environment at 90°C with an alkaline solution concentration of 0.5 mol/L. A series of tests including specific gravity, specific surface area, free swelling ratio, and Atterberg limits were conducted to study the variation patterns of physical property indices with reaction time t. Additionally, selected representative specimens were subjected to X-ray diffraction (XRD) and thermogravimetric analysis (TGA) tests to explain the aforementioned changes from a microscopic perspective. The test results indicate that after exposure to high-temperature, strong alkaline conditions for different durations, the specific gravity, specific surface area, free swelling ratio, liquid limit, plastic limit, and plasticity index of MX80 bentonite decreased sharply within 0–45 d and stabilized thereafter. The reduction amplitudes after 45 d were 13.18%, 17.94%, 64.05%, 3.24%, 6.69%, and 2.89%, respectively. The fundamental cause for the time-dependent deterioration of bentonite physical properties under high-temperature, strong alkaline conditions lies in the dissolution of montmorillonite, the primary mineral constituent of bentonite. The decrease in montmorillonite content directly leads to changes in its physical properties.

Full Text

Preamble

Title: Effect of Reaction Time on the Physical Properties of MX80 Bentonite Buffer Material Under High-Temperature and Strongly Alkaline Conditions

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Abstract

During the operation of deep geological repositories, groundwater erosion degrades the concrete construction materials, subjecting bentonite buffer materials to prolonged exposure in high-temperature, strongly alkaline environments. This leads to time-dependent deterioration of their physical properties. To investigate the temporal effects, MX80 bentonite powder was exposed to a temperature of 90°C and a 0.5 mol/L alkaline solution for varying durations (t = 0, 15, 30, 45, 60, 90 days). Following the reaction period, comprehensive testing was conducted to determine specific gravity, specific surface area, free swelling ratio, and Atterberg limits, thereby examining the evolution of these physical property indices with reaction time. Selected representative specimens were further analyzed using X-ray diffraction (XRD) and thermogravimetric analysis (TGA) to provide microscale interpretation of the observed changes.

The experimental results demonstrate that the specific gravity, specific surface area, free swelling ratio, liquid limit, plastic limit, and plasticity index of MX80 bentonite under high-temperature alkaline conditions decrease sharply within the first 45 days, after which they stabilize. After 45 days, the respective reductions are 13.18%, 17.94%, 64.05%, 3.24%, 6.69%, and 2.89%. The fundamental cause of this time-dependent degradation of bentonite physical properties under high-temperature alkaline conditions is the dissolution of montmorillonite, the primary mineral constituent. The reduction in montmorillonite content directly leads to the observed changes in physical performance.

Keywords: Bentonite; High-temperature and strongly alkaline; Physical properties; Time-dependent behavior; Montmorillonite

Note: Figure translations are in progress. See original paper for figures.