Thermal Aging Time Effects on Thermal Conductivity of Bentonite Buffer Materials at High Temperatures: Postprint

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Abstract

To investigate the thermal aging time effect on the thermal conductivity performance of bentonite buffer materials under high temperature conditions, MX80 bentonite powder was subjected to thermal aging pretreatment for 0, 15, 30, 60, 90, and 120 days at 100℃ and 200℃, respectively. The thermal conductivity of the pretreated compacted bentonite specimens was measured using the thermal probe method, and their thermal aging time-dependent behavior was analyzed. Microstructural tests including particle size analysis, X-ray diffraction, and thermogravimetric analysis were employed to reveal the underlying mechanism of the thermal aging time effect on the thermal conductivity performance of MX80 bentonite specimens under high temperature conditions. The experimental results indicate that: (1) The thermal conductivity coefficient λ of bentonite specimens after high-temperature (100 and 200℃) thermal aging pretreatment decreases with increasing thermal aging time t, exhibiting a pronounced thermal aging time effect: a sharp decrease during 0-15 days, followed by stabilization after 30 days. Compared with 100℃, the thermal aging time effect on bentonite specimens is more significant under 200℃ conditions. (2) High temperature (100 and 200℃) exposure causes gradual desorption of water in various states, thinning of bound water films, and reduction of solid soil particle size in bentonite specimens. Additionally, under 200℃ conditions, partial montmorillonite minerals in the specimens transform into paragonite. The evolution of these microstructural characteristics exhibits thermal aging time-dependent behavior consistent with the thermal conductivity coefficient λ of the specimens. (3) The fundamental reason for the thermal aging time effect on the thermal conductivity performance of bentonite materials lies in: Under 100℃ conditions, as thermal aging time t increases, temperature action leads to gradual desorption of water in various states, thinning of bound water films, reduction of particle size, decrease in solid phase volume, and increase in gas phase volume, but the mineral composition remains unchanged. Under 200℃

conditions, as thermal aging time t increases, the aforementioned temperature effects are further intensified, and the high temperature induces transformation of partial montmorillonite minerals into paragonite with lower thermal conductivity.

Full Text

Preamble

Temporal Influence of Thermal Ageing on the Thermal Conductivity of Bentonite Buffer Layer Materials Under High Temperature Conditions

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Abstract

To investigate the temporal influence of thermal ageing on the thermal conductivity of bentonite buffer materials under high temperature conditions, MX80 bentonite powder was subjected to thermal ageing pretreatment at 100°C and 200°C for durations of 0, 15, 30, 60, 90, and 120 days. The thermal conductivity of compacted bentonite specimens after pretreatment was measured using the thermal probe method to analyze its thermal ageing temporal characteristics. Microscopic tests including particle size analysis, X-ray diffraction, and thermogravimetric analysis were conducted to reveal the underlying mechanisms governing the thermal ageing temporal effect on thermal conductivity.

The experimental results demonstrate that: (1) The thermal conductivity λ of bentonite specimens after high-temperature (100°C and 200°C) thermal ageing pretreatment decreases with increasing thermal ageing time t, exhibiting a pronounced thermal ageing temporal effect characterized by a sharp reduction during 0–15 days followed by stabilization after 30 days. This effect is more significant at 200°C than at 100°C. (2) High temperature (100°C and 200°C) induces gradual desorption of various forms of water in bentonite specimens, thinning of bound water films, and reduction in solid particle size. Additionally, at 200°C, partial transformation of montmorillonite into paragonite occurs. These microstructural evolutions exhibit temporal characteristics consistent with the thermal conductivity λ. (3) The fundamental mechanism underlying the thermal ageing temporal effect differs between temperatures. At 100°C, increasing thermal ageing time t causes temperature-induced desorption of various water forms, thinning of bound water films, reduced particle size, decreased solid phase volume, and increased gas phase volume, without mineralogical changes. At 200°C, these temperature effects are exacerbated, and high temperature further triggers transformation of some montmorillonite into lower-conductivity paragonite.

Keywords: bentonite buffer layer; thermal conductivity; thermal ageing temporal effect; high temperature conditions; microscopic mechanism

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