Thermal Conductivity Testing and Theoretical Prediction Model for Guangxi Red Clay (Post-print)

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Abstract

The thermal conductivity of four types of red clay in Guangxi was measured in the laboratory using the probe method to obtain the variation law of red clay thermal conductivity with its water content. Combined with composite medium theory, simulation analysis was conducted on commonly used thermal conductivity calculation models, attempting to find a suitable calculation model for effective prediction of Guangxi red clay thermal conductivity. On this basis, combined with mineral composition analysis, the issue of calculating and determining the solid-phase thermal conductivity of red clay in theoretical prediction models was discussed. The research results show that: (1) Under the same dry density conditions, the thermal conductivity of the four types of Guangxi red clay all take their respective critical water content as the boundary point, showing a piecewise increasing trend with the increase of volumetric water content, with different growth rates in each segment. (2) The thermal conductivity of Guangxi red clay can be calculated piecewise using the Effective Medium Theory model (EMT model) and the parallel model: when the water content is below the critical value, the EMT model is used for calculation; when the water content is above the critical value, the parallel model is used for calculation. (3) The method of determining the solid-phase thermal conductivity of Guangxi red clay using the differential effective medium theory comprehensively considers the influence of mineral composition in red clay on the solid-phase thermal conductivity of soil particles, and the calculation results are closer to engineering practice.

Full Text

Preamble

Experimental Research on Thermal Conductivity of Red Clay in Guangxi and Its Theoretical Prediction Models

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Abstract

This study employs the probe method to conduct laboratory measurements of the thermal conductivity of four types of red clay from Guangxi, establishing the relationship between thermal conductivity and water content. Based on composite medium theory, commonly used thermal conductivity calculation models are simulated and analyzed to identify an appropriate model for effectively predicting the thermal conductivity of Guangxi red clay. Furthermore, the calculation and determination of solid-phase thermal conductivity in theoretical prediction models are discussed through mineral composition analysis. The research results indicate: (1) Under identical dry density conditions, the thermal conductivity of the four Guangxi red clays exhibits a piecewise increasing trend with volumetric water content, with each segment bounded by its respective critical water content and characterized by different growth rates. (2) The Effective Medium Theory (EMT) model and parallel model can be applied for piecewise calculation of Guangxi red clay thermal conductivity: the EMT model is used when water content is below the critical value, while the parallel model is employed when water content exceeds the critical value. (3) The method of determining solid-phase thermal conductivity using differential effective medium theory comprehensively accounts for the influence of mineral composition on the solid-phase thermal conductivity of soil particles, yielding calculated results that more closely approximate actual engineering values.

Keywords: soil mechanics; red clay; thermal conductivity; composite medium theory; calculation model; mineral composition

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