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Thermal conductivity of compacted fill with mine tailings and recycled tire particles

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Abstract

With the advantages of a light weight and improved thermal insulation, recycled tire particles have been utilized as engineered fills either alone or mixed with other geomaterials. To better utilize recycled tire particles, the thermal conductivity of their mixtures with mine tailings is studied as affected by the water content, mixing ratio of tailings and tire crumbs, compactive effort, and size of tire crumbs. The results show a clear correlation between the thermal conductivity and bulk density of the mixtures. Furthermore, the horizontal thermal conductivity is slightly higher than the vertical thermal conductivity and the anisotropic effect is more pronounced for the mixtures with lower water contents. The experimental data are processed via an analysis of variance (ANOVA), and the results indicate that the factors included in the simulation are statistically significant at a confidence level of 95%. A multiple linear regression model is proposed to relate the thermal conductivity with the composition of mixtures and compaction conditions. The interpretation methods developed in this study can be extended to enhance the understanding to the thermal characteristics of compacted geomaterials in engineering applications.

Keywords: Tire crumbs; Mine tailings; Thermal conductivity; Compaction; Anisotropy; Statistics

1. Introduction

Geomaterials mostly consist of mineral solids, water and air at various proportions. The study on heat transfer through geomaterials is important in geoengineering applications such as oil and gas pipelines, high-power electric cables, radioactive waste disposal facilities, and ground heat exchangers. Thermal transport takes place through conduction, convection and radiation, in which conduction is most predominant in granular materials and the rate of heat transfer is quantified by the thermal conductivity. The thermal conductivity of a geomaterial is strongly dependent on the volumetric fractions of its constituents. The thermal conductivities of basic geomaterial constituents vary across several orders of magnitude, for example, mineral solids (order of 10 W/mK), water (order of 1 W/mK) and air (order of 0.01 W/mK).

In civil engineering applications, reusing solid wastes can be beneficial to reduce greenhouse gas emissions. The solid wastes that have a potential to be recycled for use as construction materials include scrap tires and mine tailings. Waste rubber tires exhibit low density, high durability, good thermal insulation, high energy absorption and relatively low cost. Edil and Bosscher (1994) assessed the engineering properties of soil-scrap tire mixtures such as compactivity, compressibility, permeability, strength and deformability. They concluded that the behavioral characteristics of scrap tires would be beneficial for practical applications. Scrap tires are grinded to particles of various sizes for

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