Novel thermal conductivity estimation model for unsaturated Korean weathered granite soils

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The soil thermal conductivity is one of the most important parameter in the design of shallow depth geothermal system such as energy piles (EP) and horizontal ground heat pump systems (HGCHPs). Especially an exact estimation of unsaturated soil thermal conductivity plays a key role in evaluating the thermal characteristics of shallow depth ground. Besides, several existing studies have shown that the thermal conductivity of soil above ground water table (G.W.T) significantly affects the heat exchange rate of shallow depth geothermal system. Hence, this study develops a novel thermal conductivity estimation model for unsaturated weathered granite soil and provides curve fitting coefficients of the model based on the experimental data. The results show that the degree of saturation (S) – thermal conductivity (λ) plot varies with local ground conditions such as particle mineral characteristic and soil porosity. As the porosity of soil decreases, the plot exhibits a loose S-shape. Furthermore, the thermal conductivity of dry or fully saturated soil is also affected by particle mineralogy composition. The higher the proportion of quartz, the higher the soil thermal conductivity. After accumulating the database of curve fitting coefficients with varying porosity and degree of saturation, this study finally aims at developing an artificial neural network (ANN)-based model with genetic algorithm (GA) optimization technique to predict the curve fitting coefficients of the model. According to the analysis result, the ANN model shows a coefficient of determination of over 95%, and it implies that implementation of the developed ANN model can be a highly-reliable and practical tool in predicting the unsaturated thermal conductivity of weathered granite soils.

Keywords: soil thermal conductivity; unsaturated condition; genetic algorithm optimization technique; ANN model; coefficient of determination;

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