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A new thermal conductivity estimation model for weathered granite soils in Korea

Gyu-Hyun Go [1], Seung-Rae Lee [*1], Young-Sang Kim [2], Hyun-Ku Park [3] and Seok Yoon [1]

[1] *Department of Civil Engineering*, *Korean Advanced Institute for Science and Technology*, 291 *Daehak-ro*, *Yuseong-gu*, *Daejeon* 305-701, *Republic of Korea*
[2] *Department of Marine and Civil Engineering*, *Chonnam National University*, 50 *Daehak-ro*, *Yeosu*, *Jeonnam* 550-749, *Republic of Korea*
[3] *Engineering & Construction Group Civil Engineering Division*, *Samsung C&T*, 1321-20 *Seocho* 2-*Dong*, *Seocho-Gu*, *Seoul* 137-857, *Republic of Korea*

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Abstract. Thermal conductivity of ground has a great influence on the performance of Ground Heat Exchangers (GHEs). In general, the ground thermal conductivity significantly depends on the density (or porosity) and the moisture content since they are decisive factors that determine the interface area between soil particles which is available for heat transfer. In this study, a large number of thermal conductivity experiments were conducted for soils of varying porosity and moisture content, and a database of thermal properties for the weathered granite soils was set up. Based on the database, a 3D Curved Surface Model and an Artificial Neural Network Model (ANNM) were proposed for estimating the thermal conductivity. The new models were validated by comparing predictions by the models with new thermal conductivity data, which had not been used in developing the models. As for the 3D CSM, the normalized average values of training and test data were 1.079 and 1.061 with variations of 0.158 and 0.148, respectively. The predictions became somewhat unreliable in a low range of thermal conductivity values in considering the distribution pattern. As for the ANNM, the 'Logsig-Tansig' transfer function combination with nine neurons gave the most accurate estimates. The normalized average values of training data and test data were 1.006 and 0.954 with variations of 0.026 and 0.098, respectively. It can be concluded that the ANNM gives much better results than the 3D CSM.

Keywords: thermal conductivity; predictive model; artificial neural network model; transfer function; weathered granite soils

1. Introduction

In general, ground-surface temperatures fluctuate with seasonal air temperature, while the temperature below a depth of 15 m remains relatively constant throughout the year because the overlying ground acts as an insulator (Bennett 2008, Olgun *et al*. 2012). Ground-Source Heat Pump (GSHP) systems utilize this relatively constant temperature as an energy source by circulating fluid through heat exchangers. Owing to this tremendous and free source of stored

*Corresponding author, Professor, E-mail: srlee@kaist.ac.kr

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