Estimation of Groutability of granular soils using laboratory data and several intelligent classification methods

Hadi Fattahi[1*], Fateme Jiryaee[1]

1- Dept. of Earth Sciences Engineering, Arak University of Technology, Arak, Iran

* Corresponding Author: h.fattahi@arakut.ac.ir

(Received: April 2021, Accepted: February 2022)

Keywords

Classification
Artificial Neural Network
Support Vector Machine
Groutability of granular soils
Orange software

English Extended Abstract

Summary

In this study, in order to construct and validate several classification models, a set of laboratory data was used in the grouting operations in several literature. Classification models include Artificial Neural Network (ANN), Support Vector Machine (SVM), K-Nearest Neighbor (KNN), Random Forest (RF) and Naive Bayes (NB). Orange software has been used in this regard. The results showed that the models have a high accuracy in estimating groutability, and among them the artificial neural network method with 0.86% precision has better performance than other methods. In addition, in examining the importance of input variables based on scoring indices, the N2 and N1 variables are the most influential variables in the process of correctly predicting groutability.

Introduction

The purpose of grouting is to strengthen and improve the mechanical and hydraulic properties of the rock and soil. The fluid that is injected into the cavities and fissures of the environment is like a viscous liquid consisting of grains whose size is important in the grouting operation. Therefore, determining the groutability ratio in grouting operation is considered as an important parameter. Today, studies using data mining science show that the groutability of granular soils, in addition to grain size, is affected by various factors of the soil and the material of grout, which predicts groutability more accurately. Throughout history, many researchers have predicted groutability through experimental relationships. However, today, the capability of data mining methods in accurate predictions has shown that one approach in predicting groutability is to use a variety of data mining models and inferential systems.

Methodology and Approaches

The purpose of this study is to evaluate several models of data mining methods, including ANN, SVM, KNN, RF and NB. For this purpose, a set of laboratory information related to groutability has been used in four literatures that include 87 data in order to develop efficient models for predicting groutability. Classification models are created in Orange software.

Results and Conclusions

The output variable is a property of groutability, which as a binary variable has two states of zero meaning nongroutable and 1 meaning groutable. Input variables also include the ratio of water cement in the grout or viscosity (W/C), the relative density of the soil (Dr), grouting pressure (P), the percentage of the soil particles passing through a 0.6 mm sieve (FC), $N_1 = D_{15soil} / D_{85\ grout}$ and $N_2 = D_{10\ soil} / D_{95\ grout}$. The values of the evaluation criteria for the methods are almost close to each other. Based on the AUC index, the random forest is the best model and the k-nearest neighbor method has the lowest value of this index. However, in terms of other criteria, the artificial neural network is higher than other methods and the k-nearest neighbor method is very close to it. On the other hand, the random forest model has the lowest value of criteria. Ignoring the AUC criteria, ANN and KNN methods are the best methods.

One of the capabilities of Orange software is to study the effect and importance of input variables on the prediction of the target variable, in other words, the sensitivity of the output variable to input variables. The results show that variable N2 is in the first level based on the three criteria of information gain, relative information gain and Gini index, and variable N1 is in the second level with a very small difference in the values of the criteria. In addition, in the last row, W/C has the lowest value of the criteria and shows a small role in the correct prediction of groutability.