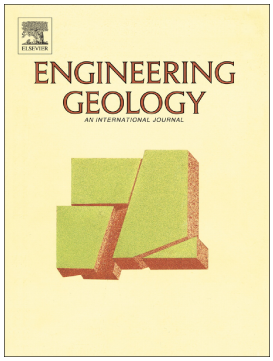

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Prediction of cementitious grout take for a mine shaft permeation by adaptive neuro-fuzzy inference system and multiple regression

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Abstract

Cement grouting is a common technique implemented for permeation and ground improvement in civil and mining engineering projects. Basically, it is the injection of cement and water mixture into a fractured rock mass. Due to the presence of water bearing and permeable rock mass, permeation grouting was applied prior to the shaft sinking operation in an underground mine, located in Soma coal basin, Turkey. The Drill-Grout-Drill (DGD) method was used in permeation grouting for a flood prone mine shaft project with a circular pattern covering the proposed shaft opening. Data collection was mainly based on recording borehole data, however, during shaft sinking, field observations were continued to check and validate data, especially the rock mass properties. Widely used classification systems, such as RQD and RMR discontinuity condition rating were selected to define rock mass parameters. The rock mass parameters and the grout take data were pre-processed and cleaned to be used as input for multiple regression modelling and Adaptive Neuro Fuzzy Inference System (ANFIS). Linear, nonlinear, and Box-Cox multiple regression models provided accurate results. ANFIS with subtractive clustering and with manual dictations resulted in improved predictions compared to the regression analysis. Since grouting has great complexity and dependence on numerous variables, particular limitations and omissions had to be defined within the scope of the research. All influential factors could not be interpreted. The methodology and variable conditions are the main novelties of this study and enhance the implementation of the method specifically in the mine project where the study was carried out.

Keywords: grouting, grout take, rock mass, ANFIS, nonlinear multiple regression

1. Introduction

Groundwater control plays an essential role in engineered structures both underground and on the surface since it has direct effects on stability, operations, and safety. In a rock mass, discontinuities constitute pathways for groundwater to flow inside the underground opening (Zimmerman and Bodvarsson, 1996). Water tightness is necessary for several surface structures, such as dam foundations (Karagüzel and Kilic, 2000). In underground works, groundwater presence and behaviour should be investigated to prevent any delay and remove any risk, which endangers the task (Vutukuri and Singh, 1995). Water drainage can be a necessary step for an underground operation, which might add another parameter to the workload and cause additional cost for shaft bottom drainage.

For underground mining operations, shaft sinking is one of the most susceptible operations to flooding. The restricted working environment of the shafts leads to additional complexity during dewatering operations. Due to their vertical structure, intruded water is collected at the shaft bottom where the sinking operations take place. It is possible to find shaft flooding cases worldwide (Shuxun et al., 1986)). In Turkey, partial and complete flood events occurred and most of them were encountered in the carboniferious coal basin, Zonguldak. Dewatering, grouting, and plug