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A Robust Approach to Estimate the Uniaxial Compressive Strength of Intact Rocks

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Abstract

The uniaxial compressive strength of intact rocks is extensively used in many rock engineering projects. High-quality core samples are required for the uniaxial compressive strength determinations. However, such core samples cannot always be obtained from weak rocks. For this reason, the predictive models are often employed to estimate indirectly. In present study, various models have been developed in order to predict uniaxial compressive strength. For this purpose different tests were accomplished. The root mean square error index was calculated as 6.1 from the neuro-fuzzy model and 13.63 from the multiple regression model. As a result, performance index reveled that the neuro-fuzzy exhibited a very high prediction capacity

Keywords: UCS, ANFIS, multiple regression, Exploratory Data Analysis, cluster analysis.

1. INTRODUCTION

Rock engineers widely use the uniaxial compressive strength (UCS) of rocks in designing tunnels, foundations and slopes. Measuring UCS has been standardized by both the ASTM [1] and ISRM [2] and it requires specimens prepared accurately. But it is often extremely difficult and time consuming to obtain such samples from weak, highly fractured and thinly bedded rocks. Therefore, some predictive models considering simple index parameters such as schmidt hammer, point load index, sound velocity, and physical properties were investigated by many researchers because these index tests require less or no sample preparation when compared with the UCS test. Also, they can be used easily in the field.

Soft computing methods like ANN (Artificial Neural Network) or ANFIS (Adaptive Nero-Fuzzy Inference System) can be used so as to model a system that lack of complete or computationally feasible analytic description.

The fuzzy-rule based approach introduced by Zadeh [3], Fuzzy-rule based modeling is a qualitative modeling scheme where the system behavior is described using a natural language [4]. During the last decades there were so many applications of fuzzy systems in geotechnical engineering.

The main objective of this study is to compare linear and multiple regression models compared with ANFIS (Adaptive Nero-Fuzzy Inference System) predictive model. For this purpose, a total of 16 different rock types have been chosen from different mining and civil engineering projects of Iran and were subjected to testes based on ISRM suggested methods.

2. NEURO-FUZZY SYSTEM

Neuro-fuzzy modeling refers to the way of applying various learning techniques developed in the neural network literature to fuzzy modeling or to a fuzzy inference system (FIS). The basic structure of a FIS consists of three conceptual components: a rule base, which contains a selection of fuzzy rules; a database which defines the membership functions (MF) used in the fuzzy rules; and a reasoning mechanism, which performs the inference procedure upon the rules to derive an output. FIS implements a nonlinear mapping from its input space to the output space. This mapping is accomplished by a number of fuzzy if-then rules, each of which describes the local behavior of the mapping. The parameters of the if-then rules (referred to as antecedents or premises in fuzzy modeling) define a fuzzy region of the input space, and the output parameters (also consequents in fuzzy modeling) specify the corresponding output. Hence, the efficiency of the FIS depends on the estimated parameters. However, the selection of the shape of the fuzzy set (described