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A Simulation Approach to Predict Uniaxial Compressive Strength of Shale and Sandstone Samples Using Artificial Neural Network

Danial Jahed Armaghani [1], Mohsen Hajihassani[1], Koohyar Faizi[2], Edy Tonnizam Mohammad[3]

1- Ph.D Student, University Technology Malaysia, UTM

2- Postgraduate Student, University Technology Malaysia, UTM

3- Assoc. Prof. Dr. University Technology Malaysia, UTM

danialarmaghani@yahoo.com

Abstract

Proper determination of Unconfined Compressive Strength (UCS) of rocks is a crucial subject in design of geotechnical structures. Although direct determination of UCS through laboratory test appears to be relatively simple, obtaining proper core segments specifically for weathered rocks is difficult and expensive. It is well established that UCS can be estimated indirectly using rock index properties. In comparison to the direct test, indirect prediction of UCS is relatively easier and cheaper. This study involves extensive laboratory tests on 32 datasets of shale and sandstone in various weathering grades obtained from excavation site in Johor, Malaysia. The laboratory tests include UCS test, Brazilian Tensile Strength (BTS) test, Point Load Index Test (Is(50)), P-wave velocity (Vp) test Schmidt Hammer Rebound Number (Rn) and Dry Density (DD) measurement. The application of Artificial Neural Network (ANN) in UCS prediction is highlighted in this study. For this reason, BTS, Is(50), Vp, Rn and DD were considered as input parameters while the UCS was set to be the output. The ANN results shows the superiority of ANN in UCS prediction.

Keywords: Unconfined Compressive Strength UCS, Laboratory Tests, Artificial Neural Network.

1. INTRODUCTION

In analysis of geotechnical problems such as dam and tunnel design, drilling and mechanical rock excavation, determination of Unconfined Compressive Strength (UCS) of the rocks can be considered as a great factor (Bieniawski 1974). The UCS of the rock is determined directly by testing the behavior of the rock specimens under axial load in the laboratory. The UCS test is standardized by American Society for Testing and Materials (ASTM) and International Society for Rock Mechanics (ISRM). However, direct determining of UCS may have some kinds of constraints in the laboratory. Having access to sufficient number of high quality cores specifically when rocks are highly fractured, weak and weathered, is extremely difficult. Besides, direct method of UCS test is destructive, time consuming and expensive (Gokceoglu and Zorlu 2004).

An ANN is a form of analysis which is based on simulation of the human nervous system. One of the major advantages of ANN is its efficient handling of highly non-linear relationships in data, even when the exact nature of such relationship is unknown. Therefore, neural networks are well suited for UCS prediction, because of the complex nature of interrelationships among the various quality parameters, composition and processing conditions. In the present paper, an attempt has been made to predict UCS of shale and sandstone samples obtained from excavation site in Johor, Malaysia using ANN technique.

2. BACKGROUND

Numerous researchers worked on the prediction of UCS using soft computing methods. The possibility for implementation of both neural network and statistical models for prediction the UCS and other strength properties of schistose rock from the petrographic properties were investigated in a study by Singh et al. (2001). In their study the strength properties were estimated from mineral composition, grain size, aspect ratio, form factor, area weighting, and orientation of foliation planes of weakness. They have used 112 data