Chapter 2
Prediction of The Uniaxial Compressive Strength of Rocks Materials

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ABSTRACT

This study briefly will review determining UCS including direct and indirect methods including regression model soft computing techniques such as fuzzy interface system (FIS), artificial neural network (ANN) and least squares support vector machine (LS-SVM). These have advantages and disadvantages of these methods were discussed in term predicting UCS of rock material. In addition, the applicability and capability of non-linear regression, FIS, ANN and LS-SVM SVM models for predicting the UCS of the magnetic rocks from east Pondite, NE Turkey were examined. In these soft computing methods, porosity and P-durability secon index defined based on P-wave velocity and slake durability were used as input parameters. According to results of the study, the performance of LS-SVM models is the best among these soft computing methods suggested in this study.

1. INTRODUCTION

The uniaxial compressive strength (UCS) of intact rocks is important and pertinent properties for characterizing rock mass and it is also one of the most widely used parameter in geological, geotechnical, geophysical and petroleum engineering project. UCS can be measured directly in laboratory experiments or estimated indirectly. UCS test requires high quality core samples of regular geometry. According to the ISRM (2007), the uniaxial compressive strength (UCS) test is conducted on cylindrical specimens under dry and saturated conditions. The laboratory tests are expensive, complicated and time consuming. These tests need expensive sophisticated laboratory equipment. Furthermore, UCS test and deformation test require high-quality core samples with regular geometry. Standard cores cannot always be extracted.

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from weak, highly fractured, thinly bedded, foliated and/or block-in-matrix rocks. In addition, a careful execution of this test is difficult, time-consuming, and expensive, as well as involving destructive tests (Gokceoglu and Zorlu 2004, Ceryan 2014). To overcome these difficulties, various predictive models based on index tests, including mineralogical-petrographic analyses, physical properties, an elastic wave velocity test and basic mechanical tests have been developed by many researchers (Yilmaz 2009; Heidari et al. 2010, Zhang et al. 2012; Ceryan et al. 2012; Mishra and Basu 2012; Yesiloglu-Gultekin et al. 2013a; Mushra and Basu 2013; Nefeslioglu 2013, Kumar et al. 2013). Another methods to estimate UCS of rock materials is to use existing tables and diagrams.

This study will briefly review direct and indirect methods to determine UCS of rock materials, and the development of prediction methods which are regression analysis and soft computing techniques in estimating of UCS of rock materials. Moreover, the applicability and capability of none-linear regression and soft computing methods including fuzzy interface system (FIS), artificial neural network (ANN) and least squares support vector machine (LS-SVM) for predicting the uniaxial compressive strength of the magmatic rock from NE Turkey was examined. Considering that the rock materials consist of a solid and porous portion, intrinsic properties that affect the UCS of rock materials can be divided into two groups; one is pore characteristics, and the second is microstructural variables, consisting of the mineralogical composition and rock texture. These cases were considered using soft-computing models to estimate the UCS of the volcanic rock materials herein. To represent the mineralogical composition and rock texture, the P-durability second index, a new engineering index, derived from the P-wave velocity in the solid portion of the rock materials, and the slake durability index were developed. Furthermore, the porosity was used as a characteristic of the porous rock material. The performance index (PI), Nash-Sutcliffe coefficient (NS) and weighted mean absolute percentage error (WMAPE) were used to determine the accuracy of the SVM, RVM, and ANN models developed.

2. BACKGROUND

Uniaxial compressive strength (UCS) of rock mass is very important parameter for the design of rock structures and can be measured directly and indirectly in laboratory.

The petro-chemical, mineralogical and textural characteristics of rocks significantly affect their mechanical behavior, including UC. These properties were widely used to estimate the UCS (Shakoor and Bonelli 1991; Ulusay et al. 1994; Tugrul and Zarif 1999; Singh et al. 2001; Gokceoglu 2002; Hale and Shakoor 2003; Jeng et al. 2004; Ceryan 2008, Zorlu et al. 2008; Ceryan et al. 2008; Sabatakakis et al. 2008; Török and Vásárhelyi 2010; Yesiloglu-Gultekin et al. 2012a; Ceryan 2012, Yesiloglu-Gultekin et al. 2013b; Tandon and Gupta 2013, Ceryan 2015a). Eliminating the real effects of rock fabric parameters on the mechanical properties of rocks by applying complex fabric coefficients inhibits their practical use in petrography applied to geomechanics. (Přikryl 2006); these conditions are valid for the aforementioned indices developed for specific rocks. Simple indices, such as slake-durability, elastic wave velocity and physical properties, for rock materials are indicative of petrographic features, including the mineralogical composition, fabric and weathering state. Therefore, these indices are widely used to estimate UCS of rock material (Kahraman 2001; Karakus et al. 2005; Yilmaz and Yuksel 2009; Ceryan et al. 2008 a-b, Ceryan et al. 2012; Ceryan et al. 2013a). Weathering indices are commonly used to estimate UCS of weathered rocks (Ceryan et al 2008 a-b, Ceryan 2008, Ceryan 2015a).
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