Evaluation of the Effect of Rock Texture on Engineering Properties in Carbonate Rocks

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Extended Abstract

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Introduction

Texture coefficient (TC) is a method of quantification rock texture by using the image of rock thin sections and image analysis. Many researchers have studied the effect of TC on engineering properties in different rock types (Ozturk et al., 2014). Also, some researchers are expressed that engineering properties of sedimentary rocks are mainly influenced by rock texture (Fahy and Guccione, 1979; Ulusay et al., 1994; Eberli et al., 2003; Khanlari et al., 2016; Ajalloeian et al., 2017). Carbonate rocks which are mainly sedimentary rocks are used in many different projects in Iran. In this research by using of TC, rock texture is quantified and also effects of TC are investigated on engineering properties of some carbonate rocks.

Grain shape and size can be quantified by the length (L), width (W), area (A) and perimeter (P) which are used to formulate the tow coefficients including aspect ratio (AR) and form factor (FF). Also, packing density can be quantified by area weighting of grains (AW) which is the relative proportion of matrix and grains. Angle factor (AF) is used to quantify the angular orientation of grains that is calculated only for elongated grains. The AF is computed by class weighted system applied to acute angular differences between elongated grains (Howarth and Rowlands, 1986, 1987).

High values of these factors can be interpreted as a rock texture which influences the geotechnical properties. The quantitative assessment of rock texture is formulated by these factors in Eq. (1) (Howarth and Rowlands, 1987).

$$TC = AW\left[\left(\frac{N_0}{N_0+N_1}\times\frac{1}{FF_0}\right)+\left(\frac{N_1}{N_0+N_1}\times AR_1\times AF_1\right)\right] \quad \text{Eq. (1)}$$

where N_0 and N_1 are the numbers of grains whose aspect ratio is below and above tow, respectively; FF_0 and AR_1 are the arithmetic mean of discriminated FF and AR, respectively; and AF_1 is proposed to divide the AF value by 5 (AF_1=AF/5).

TC equation is presented to evaluate mechanical properties like strength and drillability in different rocks, but some researchers found a high correlation between TC with other engineering properties of rocks. Generally, many researchers proposed TC as a good approach of describing and classifying different rocks and predicting some engineering properties in some rocks (Howarth and Rowlands, 1987; Ersoy and Waller, 1995; Ozturk et al., 2004; Alber and Kahraman, 2009; Ozturk and Nasuf, 2013; Ozturk et al., 2014).

Material and methods

28 samples of carbonate rocks were gathered from different Formation of Iran. Rock thin section for each sample was made to calculate TC value. TC was determined by a new method of image analysis. Also, some rock mechanics tests including unit weight, water absorption, porosity, point load index, uniaxial compressive strength (UCS), slake durability index and Los Angeles abrasion loss are conducted. Rock samples are tested according to the international standard ISRM (2007). The dependent variable is engineering properties and the independent variable is TC. The best nonlinear relations with highest correlations (R^2) were aimed to predict the engineering properties, to clarify the relationships between them. The efficiency of each prediction equations was investigated by the root mean square error (RMSE) and value account for (VAF). In each samples belonging to the same Formation, regression analysis has been done and compared to the results of all samples and also for UCS and previous equations presented by other researchers.

Results and discussion

There is a significant correlation between TC with some engineering properties. Highest correlation is between TC and UCS (R=0.942) and the

lowest with point load index (R=0.635). Overall, when the TC increased, parameters like unit weight, point load index, USC, and durability index increased too, but water absorption, porosity, and Los Angeles abrasion decreased. Increasing TC is correlated with enhancing geomechanical properties of carbonate rocks. Improving engineering properties of rocks (like UCS, Brazilian tensile strength, Young's modulus, density, shore hardness, porosity and point load index) by increasing TC value are presented by different researchers on different rocks (Howarth and Rowlands, 1987; Ersoy and Waller, 1995; Azzoni et al., 1996; Ozturk et al., 2004; Alber and Kahraman, 2009; Ozturk and Nasuf, 2013; Ozturk et al., 2014). However, in this research, data is limited to carbonate rocks that are abundant sedimentary rocks. Some researcher mentioned that geomechanical properties of sedimentary rocks are mainly influenced by texture (e.g. Fahy and Guccione, 1979; Ulusay et al., 1994; Eberli et al., 2003). In addition, It is mentioned that the strength of carbonate rocks are related to the various textural parameters (Tugrul and Zarif, 2000; Torok and Vasarhelyi, 2010; Jensen et al., 2010; Ajalloeian et al., 2016). Carbonate rocks don't have varied mineralogy's, but the texture in these rocks could be variable.

Results show that the highest correlation index is between TC and UCS and its correlate according to the other investigation (Howarth and Rowlands, 1987; Ozturk et al., 2004). TC equation doesn't cover all the criteria of rock texture, but it has a good correlation with some engineering properties of carbonate rocks. It can be possible to predict UCS, density and water absorption with VAF accuracy with more than 70 percent and lowest RMSE. TC can be showed some engineering properties of carbonate rocks. Therefore, it can be used in the preliminary design of the project for rock mechanic purposes and obviously, time and cost will be reduced. Moreover, it is very useful for a situation that suitable and enough samples cannot be extracted. It is important that rock samples don't have any alteration and weathering of minerals and macroscopic heterogeneity.

Conclusion

In this research, the effect of texture coefficient as a factor that represents the texture of rocks on physical, mechanical and durability properties of carbonate rocks in some parts of Iran was evaluated. Furthermore, it is a time-consuming process to determine the TC of rock, but preparing rock thin sections and microscopic analyses are a part of the preliminary studies in engineering geology. When image analysis methods which are used to determine TC, the time is shortened and accuracy will be increased. TC can be calculated simply by image analysis, but it doesn't cover all the criteria of rock texture. In addition, in TC equation, some factors play an important role, but some factors don’t have a direct effect, and these factors are not fully acknowledged in the original concept of TC. TC equation is presented to evaluate mechanical properties like strength and drillability in different rocks, but some researchers found a high correlation between TC with other engineering properties of rocks. The results indicate that TC value has a direct correlation with UCS, density, durability index and point load index and also, has a reverse correlation with water absorption, Los Angeles abrasion loss and porosity. The strong relationship is between TC and UCS (R^2=0.92) and the weak relationship is between TC and porosity (R^2=0.58). With regression analysis and TC value, it could be predicted UCS, density and water absorption with accuracy more than 70% VAF which considering previous equations and the proposed equation obtained from this research for UCS., it is showed that although the same trend exists, the noticeable difference is available. However, more studies are needed for investigating by more samples and different rock types and statistical analysis.

Keywords: Texture coefficient, Carbonate rocks, Engineering properties, Correlations coefficient

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