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Estimation of tensile strength of limestone from some of its physical properties via simple regression

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ABSTRACT: In this study, indirect methods for approximating the tensile strength Brazilian of limestone using dry density (ρd) and porosity (n) are investigated. Furthermore, the simple regression techniques are used in order to obtain relations between the tensile strength and physical parameters. The obtained results indicate that simple regression methods have better efficiency in porosity (n) and the BITS values of limestones has the most correlation with porosity and show r =0.956 n.

***Keywords*:** Brazilian indirect tensile strength (BITS), Dry density (ρd), Saturation density (ρs), Porosity (n), Simple regression

INTRODUCTION

Elika formation in the north of Iran is wide spread and it is mainly composed of limestones and other sedimentary rocks. Tensile strength is one of the most useful and the most common features of this research. It has many benefits in the original rock properties, the fragility of the evaluation criteria, and in preliminary design, and the method of measuring these attributes. It is both directly and indirectly determined by both standard (ASTM) and (ISRM). Conducting of accurate experimentations to determine tensile strength, direct and indirect tension resistance (known, as the Brazilian test) is common particularly in clay and shale rocks. They are very difficult to be carried out and require careful preparation of samples.

In addition, the results are highly dependent on the specimen dimensions and loading procedures, human errors, external factors, etc. In order to overcome the above problems, simple experiments in this study, tests such as dry density, saturated bulk density, and porosity are considered and the methods used to determine the indirect tensile strength (Brazilian) are applied, using geophysical properties.

Research has been done numerous times in the past in order to estimate the indirect strength characteristics of rocks, including compression strength, mono-axial, experimental relation has been proposed a lot, although no relation is observed here for the indirect tensile strength Brazilian estimation.(Zhang et al, 2001; Meng, 2000; Vallejo et al, 1989; Shakoor and Bonelli, 1991; Kahraman, 2001; Anikoh and Olaleye, 2013) But in the meantime, there was not any relations observed for estimation of indirect Brazilian tensile strength.

The main theme of this study is to evaluate dry density (ρd), saturation density (ρs) and porosity tests in estimation of the Brazilian indirect tensile strength BITS of limestones that are found in the area of Chalus Valley in north of Iran. For this purpose, laboratory experiments have been carried out on the tiny crystalline limestone samples of Elika formation (Lower- middle Triassic age). Empirical relations have been studied, that exists between BITS and other rock properties.

PETRO-GRAPHIC PROPERTIES OF ROCKS

Although there have been little differences in the constituents of limestones, which have been studied, there was many differences observed in the mechanical behavior of the rocks. This by itself is indicative of a significant impact on density, porosity, method of data communication, presence or absence of microscopic cracks within the mechanical behavior of rocks.

Homopolymer removal:

After the desired reaction time, the gel mass poured over 500 ml of ethyl alcohol where a precipitate was formed, which consisted of pregelled starch graft copolymer and the homopolymer. The homopolymer poly (methacrylamide) was removed from the reaction mixture by washing the precipitate five times with 400 ml of water / ethanol mixture (30:70, v/v) for 15 min. at room temperature on magnetic stirrer, filtered and finally dried in an electric oven at 50^0C for 3h. It was found experimentally that washing five times with a mixture of water / ethanol mixture (30 / 70, v / v) is quite enough for complete removal of homopolymer in physical mixture of pregelled starch / poly (methacrylamide), by estimating nitrogen content [19] of the mixture after each wash until constant value.

N.B. To prepare poly (methacrylamide) - pregelled starch graft copolymers having different graft yields, different amount of methacrylamide ranged from (0.5, 1.0, 1.5, 2.0, 3.0 and 4.0 g) were added to the reaction mixture keeping all other parameters constant.

RESEARCH METHOD

Since most of the mechanical behavior of rocks is strongly influenced by the non-homogeneity therefore, this study is conducted in order to avoid any effect of non-homogeneity. Number of 75 specimens, tiny crystalline limestones in which the drill core axis is perpendicular to the layers direction is selected and tested.

Determination of physical and mechanical properties such as tensile strength, the indirect Brazilian (BITS), dry density (ρd) saturated density (ρs) and porosity (n) in rock mechanics laboratory, of Tehran Polytechnic University was done. All experiments are consistent with the methods proposed by the standard (ISRM).

Relation between physical and mechanical properties obtained from all laboratories were considered together by means of examining the correlation coefficient, and the characteristics of virgin ore, the best correlation showed with BITS and yet they are the indirect estimation methods BITS as presented. All mathematical analysis realized using statistical software (SPSS) Statistical Package for Social Sciences.

PHYSICAL AND MECHANICAL PROPERTIES

In Table 1, the results obtained from the initial statistical analysis on the laboratory tests are presented.

DISCUSSION

Initial statistical analyses

The relations between all the properties obtained in the laboratory were analyzed together through applying simple regression methods, and based on the quadratic equation $y=ax2+bx+c$ and exponential equation $y=ae^{bx}$ were reviewed.

In Table 2, correlation coefficients between various properties of lime-stones were presented. In its best fit, according to the results of Table 2, shows the characteristic porosity (n) of the maximum dry density and weight correlation qualifiers saturation BITS.

The study of relation between porosity and tensile strength

Generally in sedimentary rocks, the overall strength characteristic decrease with the increase of porosity, due to distribution of the stone properties with increases porosity. In figure 1 the trends of BITS limestones versus n is shown.

The Study of relation between density and tension resistance

Density is a function of pores and other spaces existing in the stone. Density is obvious type of stone that increases with addition to the depth. This is so because with addition of depth the pressure of the upper layers of stone small cracks and fractures of stone gradually will be closed , therefore , stones with more resistance have more density.

Table 1. Statistical analysis of the results of tests

Name of tests	Mark	Variance Range	Ave.	Standard deviation	Variance
Brazilian indirect tensile strength	BITS	0.58-8.89	4.23	1.936	3.750
Saturation density	ρs	2.44-2.85	2.62	0.086	0.007
Dry density	ρd	2.40-2.84	2.58	0.101	0.010
Porosity	n	1.3-11.3	6.02	3.701	13.699

Table 2. The correlation between the physical and mechanical properties of rocks

	BITS	ρ_{sat}	ρ_d	n
BITS	1			
ρ_{sat}	0.689	1		
ρ_d	0.700	0.979	1	
n	-0.956	-0.636	-0.673	1

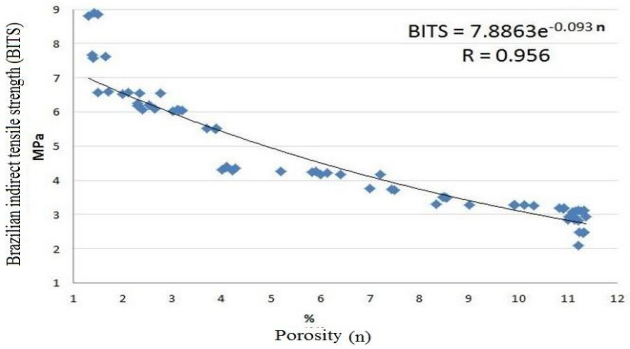

Figure 1. Diagram shows changes of BITS against porosity

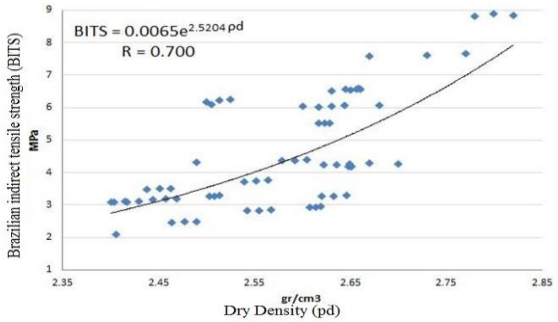

Figure 2. Diagram shows changes of BITS against ρd

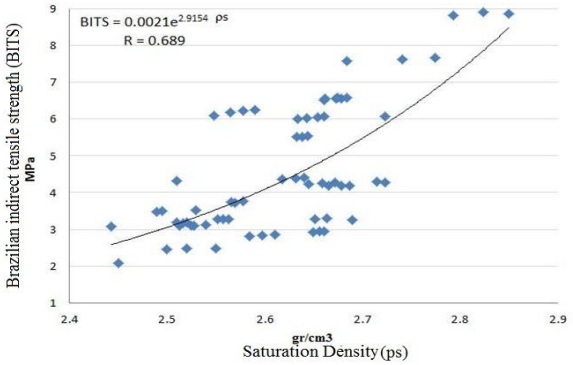

Figure 3. Diagram shows changes of BITS against ρs

CONCULSION

1. The BITS values of limestones has the most correlation with porosity and show r =0.956 n compare to r =0.700 ρd and r =0.689 ρs.

2. With respect to the low rate of variance between estimated BITS and those measured in majority of specimens and the calculated correlation coefficient , the obtained models in this research enjoy the acceptable efficiency in indirect estimation of BITS.

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