Journal of Novel Applied Sciences
Available online at www.jnasci.org
©2013 JNAS Journal-2013-2-S3/1045-1048
ISSN 2322-5149 ©2013 JNAS

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

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ABSTRACT: Estimation of mechanical properties of rocks from the physical properties is essential in very construction projects. In this paper, indirect methods for approximating the tensile strength Brazilian (BITS) of limestone are investigated. A good estimate of BITS is obtained by the multiple regression and the best relation multivariate for the three independent variables namely dry density, saturated density and porosity were obtained for all samples. The obtain results show that all three independent variables namely dry density (ρd), saturated special gravity (ρs) and porosity (n) have the highest correlation coefficient and the lowest variance between values BITS and its laboratory values.

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

INTRODUCTION

Tensile strength is one of the most useful and the most common features of this research. It is both directly and indirectly determined by both standard (ASTM) and (ISRM). The laboratory 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 propose 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 the north of Iran.

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.

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, data are presented on the laboratory tests.

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	1.3-11.36	6.02	3.701	13.699

THE ANALYSIS OF SEVERAL VARIABLES

Since simple regression only suggests a relative and approximate result, therefore (BITS) research methods have been studied via multiple analysis. To start with, this analysis was conducted by means of two independent variable; and changing of the variables was carried out on the entire samples. The relations obtained had acceptable efficiency (Table 2) and the optimum relation was obtained based on two independent variables (n) and (ρd) in follow relation:

BITS = -0.204+2.817 (ρd) -0.378 (n) ,r = 0.976

In figure 1, the relation between (BITS) has been estimated via the relation 1 (Table 2) with (BITS) which had been obtained in the laboratory, it shows the estimated (BITS) from the relation 1 indicates a variance from +1.74 MPa to -1.42 MPa according to the laboratory measurements. Figures 2 and 3 are indicative of relation estimated in order by relations 2 and 3 (Table 2) with values measured in the laboratory.

But in the end the experimental data give for the purpose of estimating (BITS), have been analyzed with the use of all three variables and existing independent. And the relation 4 and figure 7 are the result of this analysis. In this analysis which has been conducted with the purpose of estimating the optimum (BITS), the estimated (BITS) from the relation 4 has a disparity ranging from -1.41 Mpa to +1.56 Mpa according to the values measured in the laboratory; which compared to the relations 1, 2, and 3 which had been estimated with two variables and independent (BITS) have better results and better correlation coefficients (r=0.979) provided:

BITS = -5.735 – 13.735 (ρs) – 8.949 (ρd) – 0.392 (n) , r = 0.979

Table 2. The obtained relations for estimating of the indirect and Brazilian tensile strength

Independent variables	No.	statistical relation of multi-variance	r	Variance Efficiency Brazilian Laboratory tensile estimated
Dry density & porosity	(1)	BITS = -0.204 + 2.817(ρd) - 0.378(n)	0.976	-1.42 to +1.74
Saturation density & porosity	(2)	BITS = -3.48 + 4.008(ρ_s)-0.371(n)	0.975	-1.54 to +1.58
Saturation density & dry density	(3)	BITS = -28.92 + 4.356(ρ_s) + 8.58(ρ_d)	0.743	-2.19 to +2.47

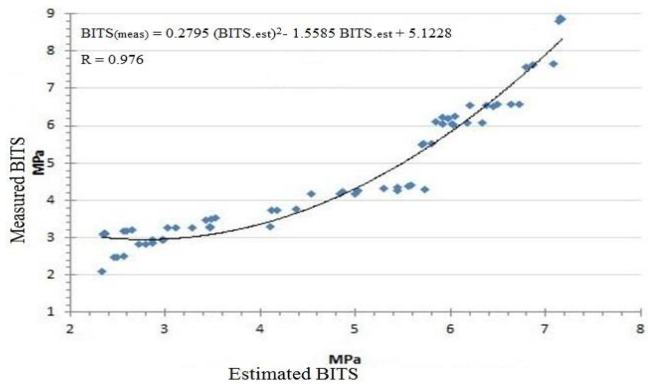

Figure 1. The relation between the estimated BITS in relation 1 and the value measured in the laboratory

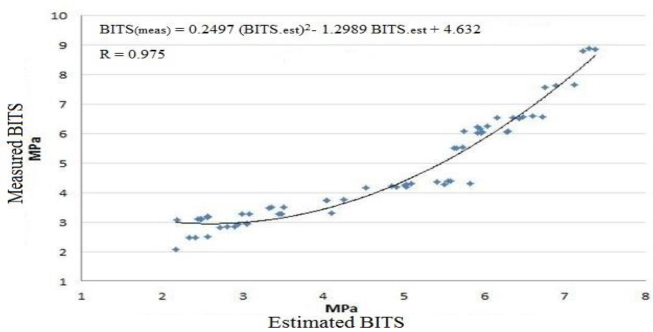

Figure 2. The relation between the estimated BITS in relation 2 and the value measured in the laboratory

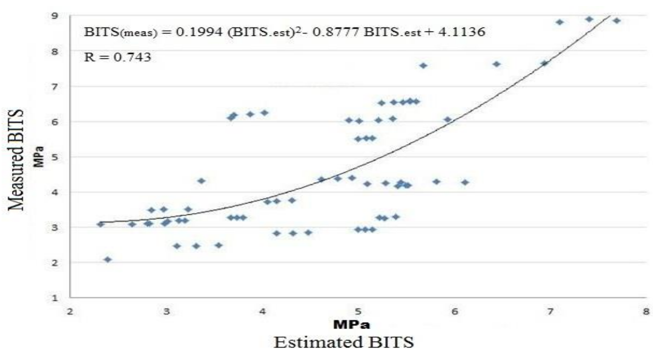

Figure 3. The relation between the estimated BITS in relation 3 and the value measured in the laboratory

CONCULSION

1. Using the regression methods with multi-variables resulted in much better estimation of BITS. In this case, the most optimum relation of multi-variable in terms of two independent variable, linear equation are with two separate variables ρd and n. The correlation coefficient for this relation is 0.976 and the rate of variance for estimated BITS with laboratory BITS range from vary from +1.74 MPa to -1.42 MPa.

2. For better estimate of BITS it is advisable to use equation with all three independent variables namely dry density (ρd), saturated special gravity (ρs) and porosity (n) which should have the highest correlation coefficient (r =0.979) and the lowest variance between values BITS and its laboratory values to be +1.56 MPa to -1.41 MPa.

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