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EXTENDED ABSTRACT

Estimation of Mechanical Properties by Statistical Analysis, Artificial Neural Network and Support Vector Regression "Case Study: Samples Related To Godar-Khosh Reservoir Dam Site"

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1. Introduction

Due to the difficulties of conducting tests, especially in weak rocks and the cost of these experiments, by examining the relationships between their mechanical and physical properties can be provided and reduce the cost of tests to identify mechanical properties (Minaeian and Ahangari, 2013; Azadan and Ahangari, 2014).

2. Methodology

In this study, petrographic, physical and mechanical experiments on 62 cores of shale and marl of Gurpi Formation were conducted in Godar-Khosh dam site, west of Iran. Non-destructive tests were performed on cores according to the ISRM standard. Physical properties such as water absorption, density and porosity of the samples were determined according to the ISRM standard. Also, uniaxial compressive strength (UCS) test according to the ASTM standard D2938 (ASTM, 1986) was performed. For each sample, the modulus of dynamic elasticity (Ed) and the dynamic Poisson ratio were calculated (Goodman, 1989). Using statistical analysis, artificial neural network (ANN) and support vector regression (SVR) with radial base kernel function, several relationships for estimating UCS, Es and shear wave velocity were presented. The root mean square error (RMSE), the mean absolute percentage error (MAPE) and the variance account for (VAF) were also used to evaluate the results.

3. Results and discussion

Petrographic results showed that illite is the predominant clay mineral. The ratio of dynamic elastic modulus to static elastic modulus of the samples was 8.51. Also, the ratio of dynamic to static Poisson was equal to 1.41. The results of statistical analysis showed that the static elastic modulus is highly correlated with the dynamic elastic modulus (R = 0.91, RMSE = 0.22, MAPE = 0.14) and the shear wave velocity (Vs) is highly correlated with the compressional wave velocity (Vp), (R = 0.98, RMSE = 0.08, MAPE = 0.03) (Fig. 1).

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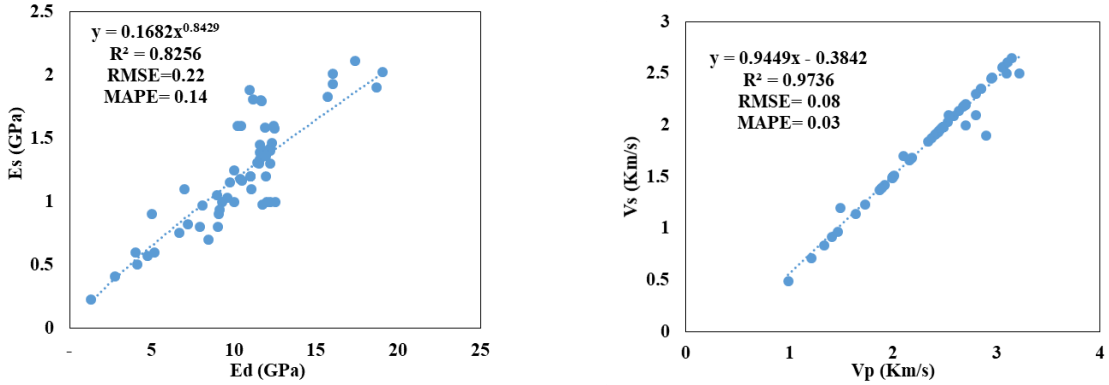

Fig. 1. Relationship between static elastic modulus and shear wave velocity with dynamic properties

Equations 1 and 2 using multivariate linear regression to estimate UCS and Es based on water absorption, porosity, density in dry conditions, and density in saturated conditions and compressional wave velocity in Godar-Khosh dam site were presented. Table 1 shows the accuracy of the models.

$$UCS = 0.556\rho_s + 1.231\rho_d - 0.122W_a - 0.095n + 0.002V_p + 3.597 \quad (1)$$

$$Es = 0.143\rho_s + 0.802\rho_d - 0.056W_a - 0.011n + 0.0001V_p + 2.164 \quad (2)$$

Table 1. Accuracy of the models

Model	R	R Square	Adjusted R Square	MAPE	RMSE	Durbin-Watson	ANOVA results
1	0.94	0.88	0.876	0.91	4.55	2.24	F=69.75, sig.=0
2	0.87	0.76	0.732	1.04	2.98	1.95	F= 32.10, sig.=0
Predictors: (Constant), Vp, n, ρ_d , ρ_s , wa; Dependent Variable: UCS and Es							

The results of the neural network in this research are presented in Table 2. Also, Fig. 2 shows the performance of the SVR method for predicting the uniaxial compressive strength and modulus of elasticity of the studied clay rocks.

Table 2. Results of artificial neural network correlation coefficient, RMSE and SSE for estimating UCS and Es

		Es	UCS
Criteria	Number of neuron in hidden layer	6	6
	Epoch	100	100
Correlation coefficient	Train	0.9	0.96
	Validation	0.94	0.97
	Test	0.95	0.98
	Total	0.91	0.96
RMSE	Train	0.1	0.08
	Validation	0.1	0.08
	Test	0.1	0.08
	Total	0.1	0.08
SSE	Train	0.42	0.25
	Validation	0.42	0.25
	Test	0.42	0.25
	Total	0.42	0.25

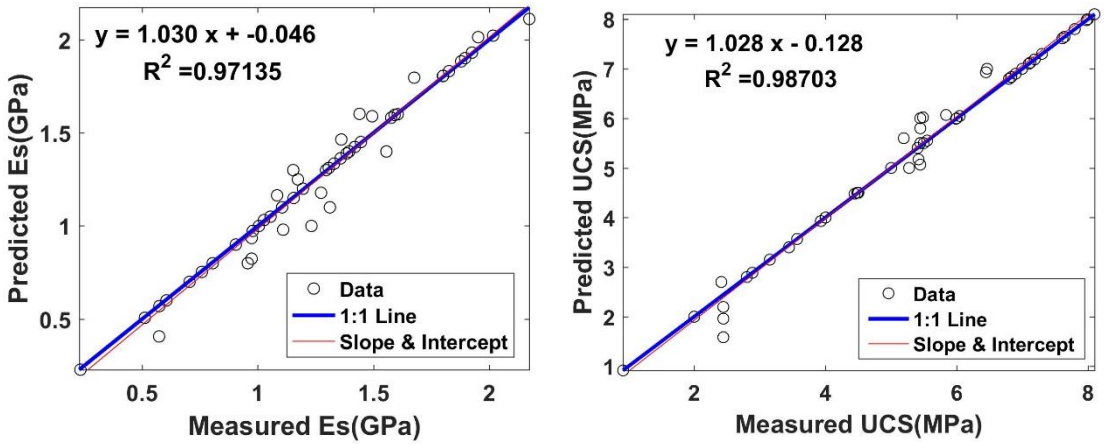

Fig. 2. Relationship between measured and estimated parameters by SVR method (for all data)

4. Conclusions

Multivariate regression results showed that both UCS and Es have a significant correlation with physical parameters and Vp. The UCS relationship with these parameters was more than Es relationship with these parameters. In addition, the relationship between static and dynamic parameters with Vp had a higher correlation than the relationship among these parameters and other physical parameters. Comparison of the methods performance in estimating static properties showed that SVR has higher accuracy than multivariate regression and ANN.

5. References

ASTM Standard test method of unconfined compressive strength of intact rock core specimens, D2938, 1986.

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