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H. Mahtali^{*1,2,3},
orcid.org/0009-0006-6787-496X,
A. Hafsaoui^{3},
orcid.org/0000-0002-1720-9527,
Z. Mezdoud^{4,5},
orcid.org/0009-0004-8569-7333,
A. Bouslama^{6},
orcid.org/0009-0004-5218-7708,
A. Idres^{3},
orcid.org/0000-0001-8029-0930

1 – Department of Mining, Metallurgy and Materials Engineering of National Higher School of Technology and Engineering, Annaba, Algeria
2 – Mining, Metallurgy and Materials Laboratory “L3M” National Higher School of Technology and Engineering, Annaba, Algeria
3 – Mining Department, Badji Mokhtar University, Annaba, Algeria
4 – Mathematic Department, Badji Mokhtar University, Annaba, Algeria
5 – Laboratory of Probabilities and Statistics “LAPS”, Badji Mokhtar University, Annaba, Algeria
6 – Architecture Department, Badji Mokhtar University, Annaba, Algeria
* Corresponding author e-mail: h.mahtali@ensti-annaba.dz

OPTIMAL PARAMETERS OF BLASTING DESTRUCTION IN THE BEN AZOUZ QUARRY BASED ON STUDY OF STRENGTH LIMESTONE ROCK

Purpose. This paper highlights the importance of taking into account the evaluation of the strength properties of limestone rock in the Ben Azzouz quarry. The purpose is to achieve optimum blasting quality based on the information on petro-physical and mechanical characteristics of the rock.

Methodology. Models have been developed to estimate physico-mechanical properties of limestone rock. The models are based on the results of many laboratory tests by petro-physical and mechanical methods. Statistical analysis was performed on simple and multiple regression equations.

Findings. Linear regression models have a higher estimated success rate, as expected. The best model for estimating the compressive strength of the rock (UCS, Uniaxial Compression Strength) based on simple regression is the model containing P-Velocity as an independent variable with a coefficient of determination R^2 of 0.81 and P-value = 0.000000003.

Originality. To benefit from the enormous reserves in the quarry of Ben Azouz, knowing that there is no evaluation of the physico-mechanical characteristics of the rock, a set of the tests in the rock mechanics laboratory of polytechnic faculty of Mons in Belgium was carried out and limestone rock strength was estimated.

Practical value. to Solid understanding of the physical and mechanical characteristics of the rock mass and the mechanism of blasting the rock is an essential step that must be taken gradually according to the development of mining works with the aim of minimizing the disadvantages in blasting and obtaining an optimal effectiveness.

Keywords: *Ben Azouz quarry, Algeria, Uniaxial Compressive Strength, multiple regression, blasting destruction, punching resistance*

Introduction. Controlled methods such as drilling and blasting can be used to fragment rock using explosives in mining and quarrying industries, as well as civil engineering works like tunnels and dams [1].

Although blasting is a more effective method of breaking rocks, it does have several drawbacks such as instability caused by vibration, damage and displacement of surrounding and flying rocks (rocks projected after blasting) [2].

To decrease these disadvantages in blasting and to obtain optimal blasting quality, it is essential to have a thorough comprehension of the physical and mechanical characteristics of the rock mass and the blasting mechanism [2].

Presentation of the study area. The study site represents a carbonate aggregate deposit, the Ben Azzouz quarry is located 48 km of Skikda (North East of Algeria). This deposit belongs to the Djebel Safia which extends north into the Djebel Filfila. Its Lambert coordinates are: $X = 905.1$ and $Y = 400.0$.

The region of Ben Azouz represents part of the alpine pleated area of North Africa whose structure is extremely complex. The geology of the region is conditioned by the existence of several complexes which are the formations of different facial structuro-zones, in most cases superimposed or strongly brought together by tectonic movements (Fig. 1). It belongs to the Tellian geological domain of the Tellian atlas. It is the domain of the great charriages, belonging to the Maghrebid Alpine Range (Villa, 1978), [3]. Limestone reserves for lime, all categories combined, were estimated at 33.32 and those of “Red dolomite” at 26.05 million tons. This gives a total of 59.37 million tons.

Methods and materials. The physical and mechanical characteristics of intact rocks are of great importance in the construction of mining, civil and oil, engineering projects that deal with rocks include tunnels, deep trenches, underground mines, caverns, rock slopes, rock foundations, dams, etc. [4].

Strength properties are very important for rock classification and the development of failure criteria. For this reason, the precise determination of rock properties is essential for the successful construction of the structures mentioned above to provide the optimal performance required of the project in terms of time, cost and safety [4].

To ensure a homogeneous quality of the aggregates exploited, it is crucial to pinpoint the areas where there are significant changes in strength. To do this, it is necessary to find a practical method for evaluating the UCS (Uniaxial Compression Strength) and Young modulus (E), based on physical properties that are easy to determine.

Laboratory tests of limestone were carried out, which allowed progress towards this goal. The tests carried out made it possible to determine the interdependence between the different physical and mechanical characteristics. The models used in this study are inspired by the methods of evaluation of physical and mechanical properties published in the scientific literature, among which simple and multiple regressions were used.

At the microscopic scale, petrographic analysis was used to study the characteristics of rocks. Aggregate quality can be estimated by evaluating microscopic features, such as grain size or mineralogy composition [5].

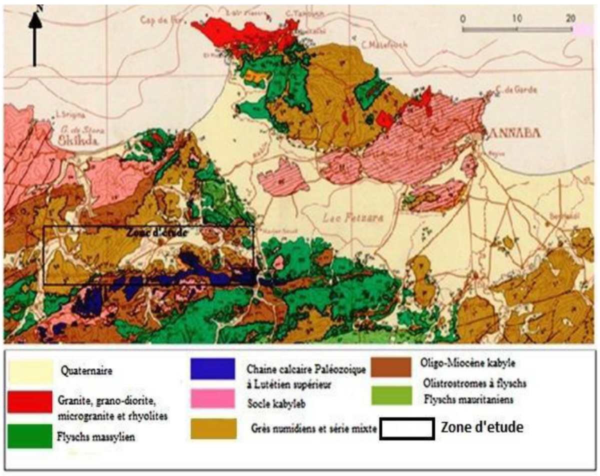
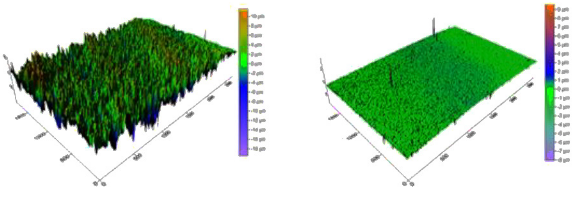


Fig. 1. Structural map at 1/500,000 of the Eastern Algerian Alpine Range (*Villa, 1978*), [3]

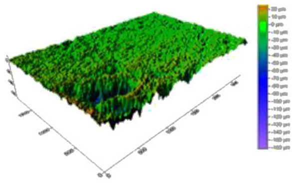
Physical and mechanical properties are strongly related to the mineralogy and the internal structure of the rocks that form the aggregates [5].

Petrographic study of Ben Azouz limestone. *Roughness is an important petro-physical property of rock.* Roughness refers to the texture of the surface of a rock, including its irregular surface or the presence of protrusions and depressions. This property can have a significant impact on the petro-physical properties of a rock, including its porosity, permeability, and ability to retain or release fluids. The surface texture of the limestone and the 2D profiles of the samples are shown in Figs. 2 and 3.



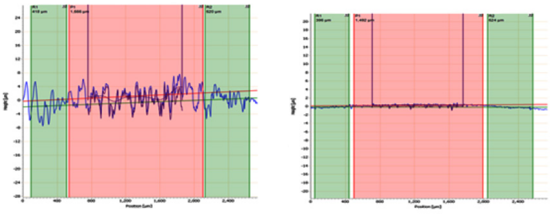
Sample 1. Greyish limestone

Sample 2. Whitish limestone



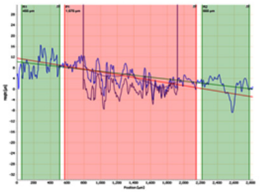
Sample 3. Red dolomitic limestone

Fig. 2. Surface texture of limestone rock



Sample 1. Greyish limestone

Sample 2. Whitish limestone



Sample 3. Red dolomitic limestone

Fig. 3. 2D profiles of roughness of limestone's samples

Fig. 2 shows that greyish limestone (Sample *1*) has a rougher surface than whitish limestone (Sample *2*) and red dolomitic limestone (Sample *3*); this is confirmed by the presence of a higher number of peaks with protrusions and depressions than (samples *2* and *3*). And from Fig. 3, it can be seen that the red dolomitic limestone (Sample *3*) has on the profile *3* larger dimensions of peaks and troughs than greyish limestone (Sample *1*) and whitish limestone (Sample *2*). And according to Table 1, the highest roughness value is obtained by Red dolomitic limestone (Sample *3*) equal to 2.17 µm.

The roughness of rocks, including limestones, can be influenced by their mineralogical composition and petrographic properties. Here are some ways roughness can be assessed based on these factors:

1. Microscopic Analysis: Microscopic examination of limestone samples helps identify the mineralogical composition and detect petrographic features that may influence roughness, such as the presence of hard minerals or clasts.
2. Hardness Measurements: some minerals present in limestones may have different hardness, which can influence surface roughness.

Petrographic analysis by polarized light microscopy. The polarizing microscope or microscope polarizer analyzer is an optical microscope equipped with two polarizing filters, called a polarizer and an analyzer. It is used in petrography for the observation and identification of minerals in rocks. The working principle is based on the use of a polarized light beam (by the polarizer). The sample of rock to be observed is prepared in order to obtain a thin blade, that is, the rock is cut into a thin block glued to a glass blade, the whole being thinned by polishing to a thickness of 30 micrometers precisely.

When cold, these rocks react to the HCl test by producing a great effervescence and take a very dark pink color on the alizarin test.

Following the analysis of the four samples, Fig. 4 shows the different facies of the rocks studied.

1. The rocks studied have a greyish color (Sample *1*) in fine grain (up to 100 µm) with calcite and dolomite crystals and clay minerals (< 10 %). Net stratification plane and absence of pores.
2. The rocks examined have a whitish color (Sample *2*), composed of fine grains (~ 10 µm) arranged according to stratification

Table 1

Value of roughness of limestones samples

	Sample *1*	Sample *2*	Sample *3*
Roughness *Ra* in (µm)	1.89	0.12	2.17

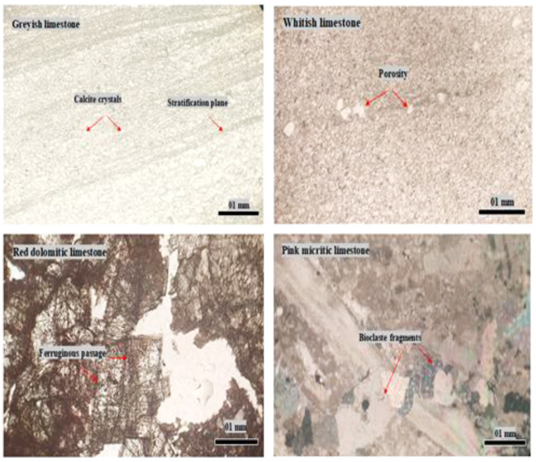


Fig. 4. Observation of facies in thin sections by microscopy in polarized light

(in thin parallel layers). The rock has micrometric voids parallel to stratification. The nature of carbonates is calcite and dolomite.

3. The rocks studied have a red color (Sample *3*), dolomitic limestone with medium grains (100 to 200 μm) fractured, and the fractures are filled by iron oxides (furriginised). The centimetric voids in the rock are filled with dolomite and ankerite crystals (after the formation of limestones). These minerals are millimeter-sized.

4. The rocks studied have a pink color (Sample *4*), micritic limestone with bioclaste (fragments of the heads of microorganisms and microfossils). It is characterized by intense porosity and fracturing where fractures and pores are filled with calcite in micrometric to millimeter ranges.

In conclusion, the rocks examined have a white and chalky appearance.

Laboratory tests. Punching resistance is a key parameter in the planning and implementation of blasting and firing mechanics, as it influences how explosives interact with rock or materials to be demolished. Accurate knowledge of the punching resistance of target materials is essential to ensure the efficiency and safety of these operations. It remains to be resolved once and for all despite the efforts of many scientists. It seems very important to evaluate the characteristics of the rocks that can be examined in the laboratory after preparation of the cylindrical samples [6].

Laboratory tests were performed using the suggested methods of the International Society for Rock Mechanics. The different tests were carried out to determine material density and porosity [7], to test uniaxial compressive strength (UCS) [8], to determine ultrasonic P-wave (P-velocity [9] and to determine Shore's hardness (SRH) and resistance of punching according to the Mons laboratory procedure. The samples were prepared at the laboratory of Rock Mechanics, polytechnic faculty of Mons in Belgium (Fig. 5). The tests results are presented in Table 2.

The data processing was carried out by the language *R*. It is statistics programming established by Ross Ihaka and Robert Gentleman. It is a computer language and a working midst, the commands execution process is performed through in-

Fig. 5. Cylindrical samples, Shore's Hardness, UCS machine and punching test

Table 2

Results of laboratory tests

Samples, *S*	Density, 1,000 kg/m^3	Porosity, %	*Vp*, 1,000 m/s	SRH	UCS, MPa	*E*, GPa	*Rp*, MPa	*Ed*, GPa
S-CR1	2.629	6.51	6.352	48	69.17	23.869	1,988	59.02
S-CR2	2.621	6.5	6.387	48.75	68.41	32.169	1,975	80.14
S-CR3	2.564	4.28	6.11	47.916	66.89	30.207	1,945	73.34
S-CP4	2.655	2	6.987	51.666	197.76	43.06	2,169	89.42
S-CP5	2.646	2.66	6.775	50.666	120.48	40.509	2,012	90.18
S-CP6	2.647	2.55	6.801	48.75	138.85	40.469	2,053	90.87
S-CP7	2.647	1.522	6.932	53.765	141.43	45.841	2,078	94.4
S-CG8	2.626	4.9	6.556	48.666	81.89	40.886	1,990	84.44
S-CG9	2.639	4.61	6.588	51	98.688	40.434	2,028	85.27
S-CG10	2.642	4.31	6.581	50.33	85.93	45.725	2,002	85.09
S-CG11	2.641	3.8	6.641	51.25	104.95	41.146	2,046	86.22
S-CBG12	2.696	0.652	7.057	58.333	152.512	44.357	2,123	98.99
S-CBG13	2.624	4.98	6.540	52.75	71.24	38.947	1,988	63.57
S-CBG14	2.646	3.2	6.719	51.916	120.18	41.784	2,070	88.73
S-CB15	2.645	2.92	6.755	50.333	124.374	41.338	2,098	89.64
S-CB16	2.648	1.21	6.977	55.333	150.26	42.874	2,151	95.63
S-CB17	2.468	7.34	5.936	45	40.687	29.63	1,997	70.61
S-CB18	2.672	0.709	7.031	56.248	141.54	36.952	2,079	96.24
S-CGR19	2.644	4.1	6.592	52.75	89.36	38.693	2,027	85.37
S-CGR20	2.63	4.65	6.579	49.083	85.76	41.297	2,023	85.03
S-CBR21	2.647	0.812	7.015	56.248	151.982	43.986	2,214	96.68
S-CBR22	2.698	0.511	7.223	59.833	152.622	43.615	2,169	102.5
S-CRG23	2.623	5.12	6.487	49.45	75.81	39.721	2,092	64.44

Table 3

Descriptive statistics of the studied samples (Realized by the language *R*)

	Min.	1^{st} Qu.	Median	Mean	3^{rd} Qu.	Max.	Standard deviation	Coefficient of Variation, %
Density, 1,000 kg/m^3	2.603	2.627	2.644	2.642	2.647	2.698	0.023301	1.699
Porosity, %	0.511	1.761	3.800	3.472	4.775	7.340	2.015083	58.038
Vp, 1,000 m/s	5.936	6.548	6.641	6.679	6.955	7.223	0.311145	4.658
SRH	45.00	48.92	51.00	51.65	53.26	59.83	3.618794	7.006
UCS, MPa	40.69	78.85	104.95	110.03	141.49	197.76	38.85376	35.311
E, GPa	43.87	58.82	60.89	59.46	62.97	65.84	5.527831	14.008
Rp, MPa	1,945	2,000	2,046	2,057	2,095	2,214	71.3157	3.466
Ed, GPa	59.02	82.29	86.22	85.04	92.64	102.50	11.69287	13.749

Where: UCS (Uniaxial Compressive Strength), SRH (Shore's Hardness), *Vp* (*P*-wave velocity), *E* (Young's Modulus), *Ed* (Dynamic Modulus of elasticities) and *Rp* (punching resistance)

structions encoded in a comparatively simple language. This software is utilized for manipulating data, plotting graphs, and performing statistical analysis [10].

Descriptive statistics of different physico-mechanical parameters are shown in Table 3. Depending on the values of the standard deviation, it can be seen that the greatest data dispersions were given by the results of the punching resistance and the UCS tests; conversely, the lowest dispersion of the data occurred in the P-velocity and density tests. However, for greater accuracy, the dispersion of the data can be compared by the coefficient of variation. The greatest dispersion is given by porosity and UCS tests.

To graph the correlation matrix (Fig. 6), we used the CORRPLOT package by the *R* software. It creates a correlation matrix with colored squares and black labels. It may also be useful to display labels representing the correlation coefficient on each square of the matrix. We had to make a clearer palette for the text to be readable, and we had to remove the color legend because it is redundant. The coefficient of correlation (*r*) of the different physical and mechanical properties of limestone is presented in Fig. 6. Where r is the Pearson correlation coefficient ($r = -1$ to 0) is a negative correlation and ($r =$ = 0 to 1) is positive correlation.

All physical and mechanical parameters have a negative correlation with porosity, this means that an increase in porosity results in a decline of all other parameters. Pores act as weak points in the rock, creating areas of stress concentration that can lead to breakage. Therefore, an increase in porosity tends to decrease the compressive strength.

The UCS has a higher correlation with density with ($r =$ = 0.77), porosity with ($r = -0.9$), and velocity *Vp* with ($r =$ = 0.9). E (Young's Modulus) has a higher correlation with porosity with ($r = -0.67$) and P-velocity *Vp* with ($r = 0.73$), and a moderate relation with remainder of the properties. Porosity has a very strong interdependence with density with ($r = -0.82$) and P-velocity *Vp* with ($r = -0.92$). SRH hardness is also strongly correlated with density with ($r = 0.87$), porosity with ($r = -0.84$) and P-velocity *Vp* with ($r = 0.86$). There is a strong correlation between punching resistance *Rp* and UCS with ($r =$ = 0.83) and P-velocity *Vp* with ($r = 0.81$). Young's modulus dynamic *Ed* has a strong correlation with porosity ($r = -0.85$) and P-velocity *Vp* with ($r = 0.82$).

Estimation models of UCS and E (modulus of elasticity). In the last few years, rock engineering approaches have seen a significant rise in the use of numerical modeling which has become an essential tool in research and project designing. This tool was employed in the field of rock mechanics research to model real cases and recreate various tests performed in the laboratory [11].

To evaluate the UCS and modulus of elasticity *E* in this work, models based on simple and multiple regressions were realized. To do this, the *R* language was used, allowing for the possibility of the establishment of regression models.

Simple regression models. The Uniaxial Compressive Strength and Young's modulus *E* are estimated by simple regression equations including specific relationships while considering that these parameters are dependent variables founded on the tested value of another property which is an independent variable [12].

The independent variables are taken from the parameters mentioned in Table 2, the density, porosity, *SRH, Rp, E, Ed* and P-velocity. The degree of success of a model is usually assessed by the coefficient of determination R^2. The modelling results are given in Fig. 7 for the UCS and Fig. 8 for Young's modulus *E* and in Table 4.

Out of all the simple models that were performed, equations (1, 2, 3 and 6) are the best models to estimate the UCS, which use density with ($R^2 = 0.5789$ and P-value = 0.0000151), porosity with ($R^2 = 0.7947$ and P-value = 0.000000007), P-velocity *Vp* with ($R^2 = 0.81$ and P-value = 0.000000003) and punching resistance *Rp* with ($R^2 = 0.6733$ and P-value = 0.0000009882) as independent variables. The best model for estimating *E* is presented in equation (9), which uses the P-velocity with ($R^2 = 0.5137$ and P-value = 0. 00007181) as an independent variable.

Modelling with Multiple regression. In statistical regression analysis, multiple regression technique is a commonly used method in which the output variable(s) can be estimated using a predictive equation based on the corresponding input (independent) variables. Many researchers have used the multiple regression approach widely in geosciences, especially in mining construction and rock mechanics [4].

Multiple regression models are represented by equation

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_i X_k + \varepsilon, \qquad (13)$$

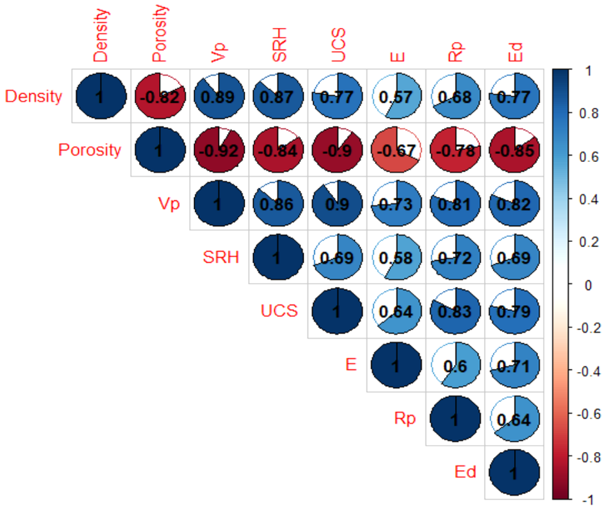


Fig. 6. Correlation between physico-mechanical parameters of limestone (Realized by the R language). The positive correlation is strong, the more the color is blue. The negative correlation is strong, the more the color is red

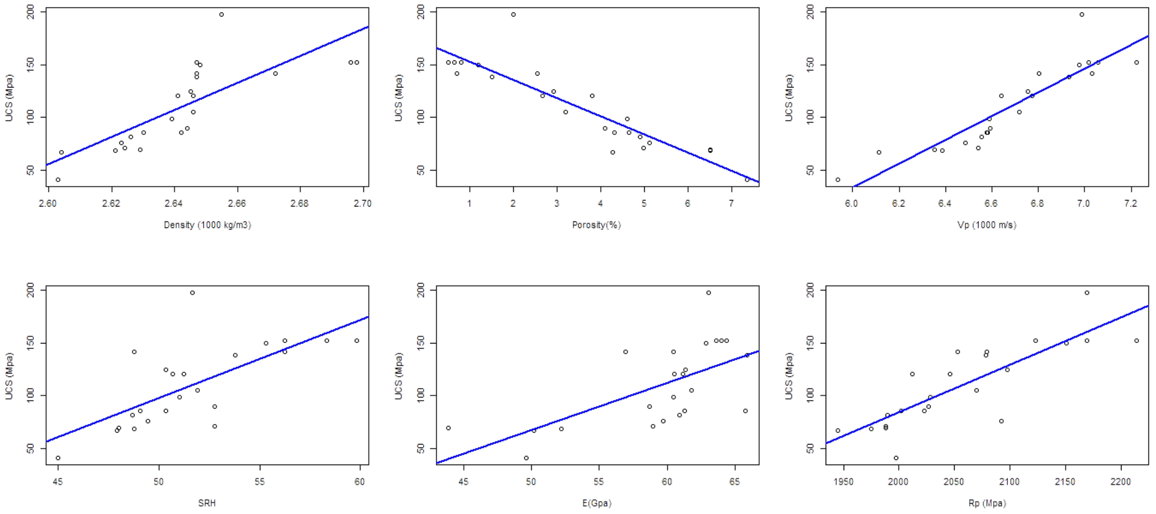


Fig. 7. Simple regressions for UCS estimation (Performed by the R language)

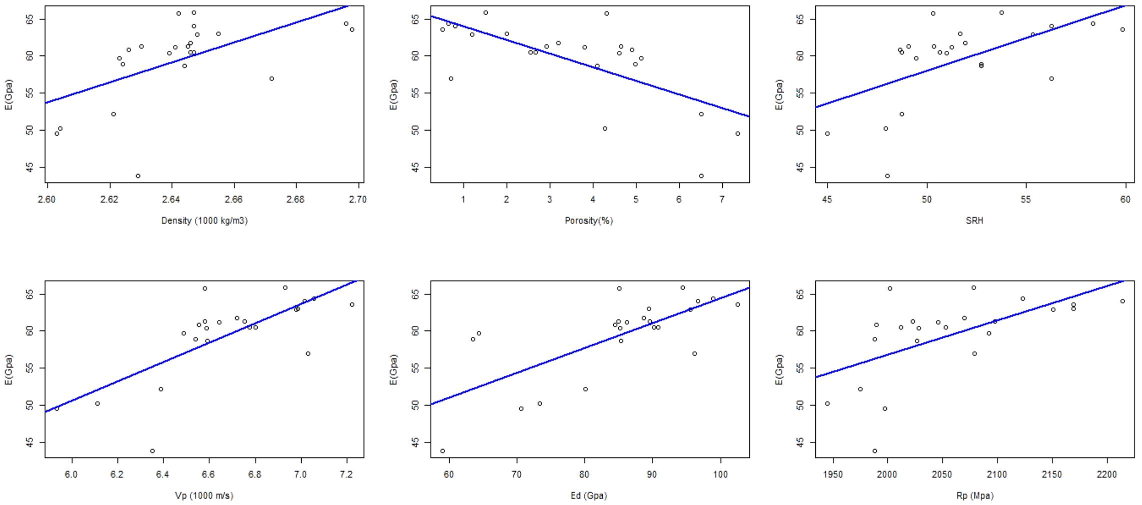


Fig. 8. Simple regressions for Young's Modulus E estimation (Performed by the R language)

Table 4

Simple regression equations for UCS and Young's modulus E estimation

Dependent variables	Independent variable	Simple regression equations	Equation No	R^2	P-value
UCS	Density	$UCS = -3{,}297.2 + 1{,}289.5\rho$	(1)	0.5789	0.0000151
UCS	Porosity	$UCS = 170.056 - 17.29n$	(2)	0.7947	0.000000007
UCS	P-velocity	$UCS = -644.59 + 112.98Vp$	(3)	0.81	0.000000003
UCS	SRH	$UCS = -274.088 + 7.436SRH$	(4)	0.455	0.0002494
UCS	*E*	$UCS = -156.114 + 4.476E$	(5)	0.3773	0.001084
UCS	*Rp*	$UCS = -819.752 + 0.451Rp$	(6)	0.6733	0.0000009882
E	Density	$E = -297.12 + 134.95\rho$	(7)	0.2914	0.004618
E	Porosity	$E = 65.86 - 1.844n$	(8)	0.4261	0.0004394
E	P-velocity	$E = -27.405 + 13.005Vp$	(9)	0.5137	0.00007181
E	SRH	$E = 13.96 + 0.88SRH$	(10)	0.3007	0.003975
E	*Ed*	$E = 31.069 + 0.333Ed$	(11)	0.4748	0.0001663
E	*Rp*	$E = -35.711 + 0.046Rp$	(12)	0.3255	0.002645

where Y is the dependent variable; X_1 et X_2... X_k are the independent variables; β_i represent the contribution of the independent variable X_i; ε is the random error [12].

The results of multiple regression modelling are presented in Figs. 9 and 10 and in Table 5.

The model that included porosity and SRH with a coefficient of determination ($R^2 = 0.8006$ and P-value = 0.00000003831) and the model that included density and velocity Vp with ($R^2 = 0.8058$ and P-value = 0.00000002935) and the model that included P-velocity Vp and punching resistance Rp with ($R^2 = 0.8322$ and P-value = 0.000000006819), shows that they are best for estimating the uniaxial compressive strength UCS.

Concerning the estimation of Young's modulus E using multiple regression proved that the model that included density and P-velocity Vp is the best with ($R^2 = 0.5255$ and P-value = 0.000223). It should be noted that it is represented by a

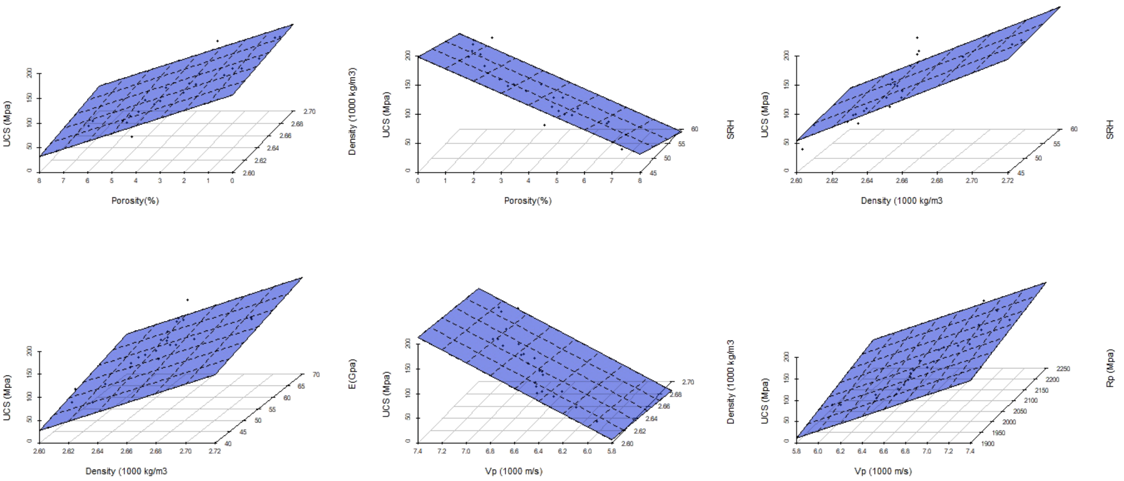


Fig. 9. Multiple regressions for UCS estimation (*Performed by the R language*)

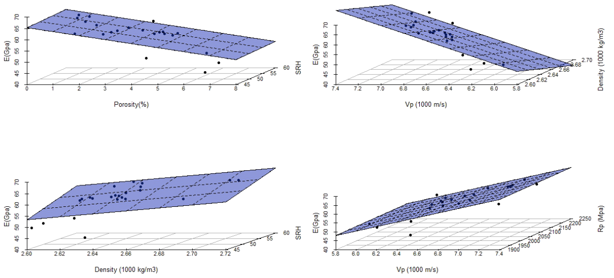


Fig. 10. Multiple regressions for Young's modulus E estimation (*Performed by the R language*)

higher coefficient of determination than that determined with simple regressions by the model that includes the P-velocity *Vp*.

Results and discussion. Rocks play a significant role in mining design, construction, and analysis through their uniaxial compressive strength (UCS) and Young's modulus (*E*). These parameters show the strength and deformation characteristics of rock, which are the main factors that affect the stability of any mining engineering structure. The specific energy of drills is predicted using (UCS) and (*E*), also to determine the rock factor when determining the size of muck pile fragments from blasting operations [13].

For these reasons, it is necessary to determine the physico-mechanical properties of limestone rock in the Ben Azzouz quarry, models to estimate UCS and Young's modulus *E* have been developed based on laboratory tests. We had to find a simple model based on feasible tests. Density, porosity and SRH tests can be easily evaluated. These are the preferred parameters for evaluating UCS and *E*.

After analysis of the results obtained, it was determined that the best model for estimating the UCS based on a simple regression is the model including the P-velocity *Vp* as an independent variable which has a coefficient of determination (R^2 of 0.81 and P-value = 0.000000003), and the best model to estimate *E* is the one with an independent variable P-velocity *Vp* with (R^2 = 0.5137 and P-value = 0.00007181). More complex models of multiple regressions can be considered more successful if they have an R^2 value higher than the above-mentioned values. So, we can consider that the model that included the P-velocity *Vp* and *Rp* proved to be the best to estimate UCS with a coefficient of determination (R^2 = 0.8322 and P-value = 0.000000006819) and as the punching and ultrasonic tests are not simple tests, therefore, it is assumed the model that included porosity and hardness SRH as better with (R^2 = = 0.8006 and P-value = 0.00000003831), and the best model of its kind to estimate *E* is the one with density and P-velocity *Vp*, independent variables with (R^2 = 0.5255 and P-value = = 0.000223).

Referring to the (P-value) values of the obtained equations are all less than 0.05. So all models are globally significant. This means that the results of the study can be considered statistically relevant.

Conclusion. Although laboratory tests can be expensive and take a long time to determine the physical and mechanical properties of rocks, they still have high precision. Also, preparing core samples for direct testing is a very difficult task that demands high accuracy. From all the above, it can be seen that indirect and non-destructive methods can be used as appropriate alternative for determining rock characteristics. To achieve this objective in this study, relations between physical and mechanical properties of limestone have been examined.

Table 5

Multiple regressions for UCS and Young' modulus *E* estimation

Dependent variables	Independent variable	multiple regression	R^2	P-value
UCS	Density, Porosity	$UCS = -321.044 + 183.566\rho - 15.543n$	0.7888	0.00000006812
UCS	Porosity, *SRH*	$UCS = 308.265 - 20.973n - 2.428SRH$	0.8006	0.00000003831
UCS	Density, *SRH*	$UCS = -2{,}997.5 + 1{,}156.771\rho + 0.987SRH$	0.5602	0.0001044
UCS	Density, *E*	$UCS = -2{,}689.185 + 1{,}013.335\rho + 2.047E$	0.6209	0.00002361
UCS	Density, P-velocity	$\mathrm{UCS} = -82.89 - 255.65\rho + 130.02Vp$	0.8058	0.00000002935
UCS	P-velocity, *Rp*	$UCS = -773.311 + 84.132Vp + 0.156Rp$	0.8322	0.000000006819
E	Porosity, *SRH*	$E = 63.251 - 1.775n + 0.045SRH$	0.3977	0.002422
E	Density, P-velocity	$E = 179.685 - 94.254\rho + 19.287Vp$	0.5255	0.000223
E	Density, *SRH*	$E = -141.301 + 65.947\rho + 0.5131SRH$	0.287	0.01309
E	P-velocity, *Rp*	$E = -28.692 + 12.716Vp + 0.0015Rp$	0.4896	0.0004629

Through development of estimation models in mining, it is essential to take into account the possibilities of the easiest application in situ. Therefore, simple regression methods should not be overlooked, even if their success parameters do not give better results than multiple regressions, as they have the advantage of simplicity of application.

Moreover, multiple regression methods that have a linear generalized form have been shown to be more effective than the nonlinear form of simple regression, and this remains valid only with the use of two parameters in modeling. Beyond two parameters the coefficients of determination R^2 will be decreased.

According to the coefficient of determination R^2, resulting from the relationships developed above for different parameter, the equations with a maximum R^2 in this study were the best proposed. The model that included the P-velocity Vp and Rp (Punching resistance) proved to be the best to estimate UCS with R^2 of 0.8322 and P-value = 0.000000006819, which shows that the model is very significant.

Finally, regression equations between compressive strength and other rock properties provide an assemblage of empirical relationships that can be used in mining engineering practice.

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Оптимальні параметри вибухового руйнування в умовах кар’єру Бен Азуз на основі досліджень міцності вапнякової породи

Г. Махталі[*1,2,3], *А. Хафсауі*[3], *З. Мездуд*[4,5], *А. Буслама*[6], *А. Ідрес*[3]

1 – Факультет гірничої справи, металургії та матеріалознавства Національної вищої школи технологій та інженерії, м. Аннаба, Алжир

2 – Лабораторія гірництва, металургії та матеріалознавства «L3M» Національної вищої школи технологій та інженерії, м. Аннаба, Алжир

3 – Кафедра гірничої справи, Університет Баджі Мохтар, м. Аннаба, Алжир

4 – Кафедра математики, Університет Баджі Мохтар, м. Аннаба, Алжир

5 – Лабораторія ймовірностей і статистики «LAPS», Університет Баджі Мохтар, м. Аннаба, Алжир

6 – Архітектурний факультет, Університет Баджі Мохтар, м. Аннаба, Алжир

[*] Автор-кореспондент e-mail: h.mahtali@ensti-annaba.dz

Мета. У цій роботі акцентується увага на важливості врахування оцінки властивостей міцності вапнякової породи в умовах кар’єру Бен Азуз. Мета – досягнення оптимальної якості вибухового руйнування, ґрунтуючись на інформації про петрофізичні й механічні характеристики породи.

Методика. Були розроблені моделі для оцінки фізико-механічних властивостей вапнякової породи. Моделі базуються на результатах багатьох лабораторних випробувань петрофізичними й механічними методами. Був проведений статистичний аналіз простих і множинних регресійних рівнянь.

Результати. Лінійні моделі регресії мають вищий передбачуваний успішний відсоток, як і очікувалося. Найкраща модель для оцінки міцності гірської породи при стисканні (UCS, випробування на необмежений стиск) на основі простої регресії – це модель, що містить швидкість P-хвиль як незалежну змінну з коефіцієнтом детермінації R^2 рівним 0,81 та значенням P-рівня = 0,000000003.

Наукова новизна. Щоб вигідно використати величезні резерви в умовах кар’єру Бен Азуз, ураховуючи відсутність оцінки фізико-механічних характеристик породи, було проведено ряд тестів у лабораторії гірничої механіки політехнічного факультету в місті Монс у Бельгії та дана оцінка міцності вапнякової породи.

Практична значимість. Глибоке розуміння фізичних і механічних властивостей гірського масиву, а також механізму вибухового руйнування гірської породи, є важливим кроком, що слід робити поетапно з урахуванням розвитку гірничих робіт з метою мінімізації несприятливих умов під час вибухового руйнування та отримання його оптимальної результативності.

Ключові слова: *кар'єр Бен Азуз, Алжир, міцність на стискання, багатофакторна регресія, вибухове руйнування, стійкість до ударів*

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