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Investigation of the relationship between texture coefficient and abrasivity properties of granite building stones

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Abstract

In this study, a comprehensive investigation has been done on 10 different types of granite building stones from various mines in Iran. The study aims to investigate the relationship between the texture coefficient (TC) and abrasivity properties of the studied stones. Abrasivity of stones was quantified through six indices, including equivalent quartz content (EQC), rock abrasivity index (RAI), Schimazek abrasivity factor (F), Cerchar abrasivity index (CAI), building stone abrasivity index (BSAI), and the Taber wear index (Iw). Bi-variate regression analysis was applied to develop the predictive equations for relationship between TC and abrasivity indices. The investigations demonstrated that there is a direct relationship between TC and all abrasivity indices. Furthermore, TC has moderate to high relationship with abrasivity indices. After developing the equations, their accuracy was evaluated by performance criteria including determination coefficient (R2), the normalized root mean square error (NRMSE), the variance account for (VAF), and the performance index (PI). The strongest relationship was found between TC and RAI (with R2, VAF, NRMSE, and PI value of 0.850, 0.074, 85.386, and 1.630, respectively), while the weakest relationship was observed between TC and F (with R2, NRMSE, VAF, and PI value of 0.491, 0.532, 47.605, and 0.435, respectively). This research demonstrates importance of the textural characteristics of stones, especially TC as a reliable index, on the abrasivity properties of granite building stones. Thus, the equations developed herein can be practically used for estimating the stone abrasivity in building stone quarrying and processing projects.

1. Introduction

Granite building stones have always been utilized as one of the most commonly used construction materials for both interior and exterior facades of buildings. These stones are known as abrasive stones due to the presence of quartz mineral within their compositions. So, the quarrying and processing of granite stones lead to accelerated tool wear and increased tool consumption, therefor significant cost escalation. Thus, awareness about the abrasivity properties of these is crucial for estimating expenses and choosing the appropriate drilling, cutting and polishing systems [1-4]. The physico-mechanical and petrographical properties of stones can significantly affect their abrasivity properties. Among stone properties, textural characteristics are major factors for determining the mechanical behavior and abrasivity of stones [5]. Williams et al. [6] defined the stone texture as the degree of crystallinity, grain size or granularity and the fabric or geometrical relationship between the constituents of a stone. In rock mechanics and geological engineering, various parameters are quantified for assessing textural properties of stones. Table 1 shows some of the common textural properties of stones. The required

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geometrical features for calculating textural properties can be obtained from visual inspection of a stone and the microscopic image analysis of thin sections using image analysis software such as AutoCAD or Image J [7].

Table 1. Some textural properties of stones.

Parameter	Formula	Definition	Reference
Equivalent diameter	$D_{equi} = \sqrt{\frac{4A_i}{\pi}}$	Equivalent diameter parameter indicates the size of stone grains.	[8]
Compactness	$C = \frac{{L_p}^2}{A_i}$	Compactness indicates the shape of the cross-section of the studied grain, and generally, the grain shape is defined in the transition from a circular state to a linear state.	[9]
Shape factor	$SF = \frac{4\pi A_i}{{L_p}^2}$	The shape factor indicates the degree of circularity of the grain's cross-sectional shape and represents the deviation of the grain's cross-sectional shape from a perfect circle.	[9]
Aspect ratio	$AR = \frac{D_{max}}{D_{min}}$	This parameter serves as a measure for the elongation or evaluation of the ellipticity of stone grains.	[10]
Grain size homogeneity	$t = \frac{A_{avg}}{\sqrt{\sum(A_i - A_{avg})^2}}$	This index indicates the grain size distribution within the stone's texture.	[11]
Interlocking index	$g = \frac{1}{n} \times \sum \frac{L_P}{\sqrt{A_i}}$	This index has been developed to assess the complexity and contact between grains within a stone's texture. This parameter examines the area of grains and the boundary line where adjacent grains are in contact, essentially indicating the complexity and interlocking of grains within a stone's structure.	[11]
Texture coefficient	$TC = AW \left[\begin{array}{c} \left(\frac{N_0}{N_0 + N_1} \times \frac{1}{FF_0}\right) + \\ \left(\frac{N_1}{N_0 + N_1} \times AR_1 \times AF_1\right) \end{array} \right]$	This index is a quantitative index based on geometric properties of grains and stone texture, examining the stone fabric through the following aspects: - Measurement and analysis of the circularity of grains. - Measurement and analysis of grain elongation. - Measurement and quantification of grain orientation. - Weighting results based on grading degree.	[10]

where D_{equi} is diameter equivalent (mm), A_i is area of grain (mm^2), C is compactness, L_p is perimeter of grain (mm), SF is shape factor, AR is aspect ratio, D_{max} is maximum diameter (mm) and D_{min} is minimum diameter (mm), t is grain size homogeneity index, A_{ave} is average area of grains (mm^2), g is interlocking index, TC is texture coefficient, N_0 is number of grains with aspect ratio less than 2, N_1 is number of grains with aspect ratio greater than 2, FF_o is arithmetic mean of shape factor of all N_0 grains, AR_1 is arithmetic mean of aspect ratio of N_1 grains, AF_1 is angle factor orientation which is computed for all N_1 grains, AW is area weight.

Among textural properties of stones, texture coefficient (TC) is the most comprehensive and reliable index for quantifying stone texture by integrating geometrical features of grains and matrix [12,13]. TC, as a dimensionless coefficient, was originally devised to assess the stone fabric by Howarth and Rowlands [10]. The value of TC is evaluated by performing four processes, namely (1) measuring grain circularity, (2) measuring grain elongation, (3) measuring and quantifying grain orientation, and (4) weighting of results based on the degree of grain packing [9]. During recent years, numerous investigations have been conducted on the relationships between TC and engineering properties, drillability, and cuttability of stones. A summary of these studies can be found in Table 2.

In addition, Easoy and Waller [5] studied the effect of TC on drill bits performance. They found that TC can be used as a predictive factor for assessing the drillability and cuttability and wear performance of stones. Tiryaki and Dikmen [29] used TC for evaluating the specific cutting energy in sandstones, and they found that there is a significant correlation between the TC and specific cutting energy values. Ajalloeian and Kamani [30] found a meaningful correlation between TC and Los Angeles abrasion loss in carbonate aggregates with R^2 = 0.86. Atici and Comakli [31] investigated the relationships between the physico-mechanical properties and TCs of 12 different plutonic stones (including ten granites, one diorite, and one gabbro). Hosseini et al. [32] investigated the cutting of 10 granite stones and found no significant correlation between TC with the amount of electrical current consumed by the cutting machine. Fereidooni and Sousa [33] applied artificial neural networks to predict the stone engineering properties such as slake durability index, Schmidt rebound hardness, ultrasonic P-wave velocity, and uniaxial compressive strength based on TC.

However, little attention has been given to assessment of the relationships between TC and the abrasivity properties of building stones. In the other words, the effect of TC on the abrasivity properties of building stones is still not understood. The present study attempts to fill this gap. To provide a better understanding of this topic, various laboratory studies were performed on 10 granite building stones from Iran. Then, the relationship between TC and the abrasivity properties of these stones was investigated using regression analyses.

Table 2. Summary of studies conducted in the field of stone TC.

Researcher (s)	Samples	Description	Year
Azzoni et al. [14]	24 stone samples consisting of igneous, metamorphic and sedimentary stones	Assessment of TC for different stone types and correlation with uniaxial compressive strength and stone weathering	1996
Ozcelik et al. [4]	8 samples of marble and limestone	Investigation of the effects of TC on marble cutting with diamond wire	2004
Ozturk et al. [15]	12 different samples from the Zonguldak Coalfield	The assessment of relationship between TC with stone cuttability, and physical and mechanical properties of stones	2004
Alber and Kahraman [16]	24 stone samples from German mines of shale, sandstone and limestone	Predicting the uniaxial compressive strength and elastic modulus of a fault breccia from TC	2009
Ghaysari et al. [17]	7 samples of carbonate stone (marble) from mines in western Iran	Performance prediction of diamond wire saw with respect to texture characteristics of stone	2012
Tandon and Gupta [18]	60 stone samples including quartzite, granite, gneiss, metabasic and dolomite	The control of mineral constituents and textural characteristics on the petrophysical and mechanical properties of different stones of the Himalaya	2013
Ozturk and Nasuf [19]	34 stone samples including travertine, marble, limestone and sandstone	Strength classification of stone material based on textural properties	2013
Ozcelik et al. [20]	6 samples of limestone and 9 samples of marble	Prediction of engineering properties of stones based on textural properties	2013
Ozturk et al. [21]	46 stone samples from Turkish mines	Estimation of stone strength from quantitative assessment of stone texture	2014
He et al. [22]	20 stone samples including diorite, tuff, marble and sandstone	Study on the correlations between abrasiveness and mechanical properties of stones combining with the microstructure characteristic	2016
Esmailzadeh et al. [12]	14 stone samples from Iranian mines including marble and limestone	Relationship between texture and uniaxial compressive strength of stones	2017
Ajalloeian et al. [23]	36 samples of carbonate stones	The effects of carbonate stones texture on mechanical behavior, based on Koohrang tunnel data, Iran	2017
Dormishi et al. [24]	14 stone samples from Iranian mines, consisting of marble and travertine	Relations between texture coefficient and energy consumption of gang saws in carbonate stone cutting process	2018
Tumac et al. [13]	18 stone samples consisting of igneous, metamorphic and sedimentary types	Investigating the effects of textural properties on cuttability performance of a chisel tool	2018
Kamani and Ajalloeian [25]	28 carbonate stone samples from Iranian mines	Evaluation of engineering properties of carbonate stones based on corrected TC	2019
Rostami et al. [26]	11 different stone samples from Iranian mines	Use of stone microscale properties for introducing a cuttability index in cutting process with a chisel pick	2020
Diamantis et al. [27]	20 stone samples including limestone and mudstone	Effect of textural characteristics on engineering properties of some sedimentary stones	2021
Ghorbani et al. [28]	12 samples of limestone from different mines in Iran	Effect of TC on Vickers hardness of limestones	2023

2. Materials and methods

2.1. Texture properties of samples

To conduct this study, 10 different types of Iranian commercial granite building stones with various mineralogical compositions were collected. Since the main aim of this study is to assess the relationships between TC and the abrasivity properties of building stones, granite building stones were chosen because these types of stones are harder and more abrasive than the other stones. For all stone types, the block samples with large enough dimensions were provided and were brought to the laboratory for sampling and testing. All of these samples were free from any observable cracks or signs of weathering.

In order to calculate the TC of each type of stone, two thin sections (parallel and perpendicular) were prepared from each studied stone. These sections were photographed using a polarized microscope with high resolutions (Nikon Eclipse LV100POL). Subsequently, these images were imported into the Image J software, and the TC was calculated for each stone. The sample code, commercial name, scientific name and TC for each stone sample are given in Table 3.

Table 3. The studied stone samples and their TC.

Sample	Commercial name	Scientific name	Mine location	TC
S1	Khorram-darreh	Syenogranite	Zanjan	2.326
S2	Golpanbehi Nehbandan	Granite	South Khorasan	2.975
S3	Taibad	Syenogranite	Razavi Khorasan	3.942
S4	Boroojerd	Granite	Lorestan	2.089
S5	Zahedan	Granite	Sistan and Baluchestan	4.026
S6	Morvarid Mashhad	Granite	Razavi Khorasan	2.567
S7	Sabze Birjand	Granite	South Khorasan	0.997
S8	Toosi Astan	Granite	South Khorasan	3.601
S9	Porteghali Nehbandan	Granite	South Khorasan	4.043
S10	Maraghe	Syenogranite	East Azerbaijan	2.068

2.1. Abrasivity properties of samples

Stone abrasivity is defined as the ability of stone to wear down a tool [34]. During recent years, several methods have been developed for estimating the abrasivity of stones. These methods can be broadly divided into two categories, namely, petrological methods and mechanical methods [35]. Petrological methods often assess the stone abrasivity based on a combination of hardness, compressive strength and other fundamental stone properties, while mechanical methods employs laboratory tests in which there is a relative movement between stone sample and tool under standard controlled test conditions [36]. In mechanical methods, the weight loss of components during test is usually considered as a criterion for assessing stone abrasivity. A comprehensive review of various stone abrasivity measurement methods can be found in previous literature [36-38].

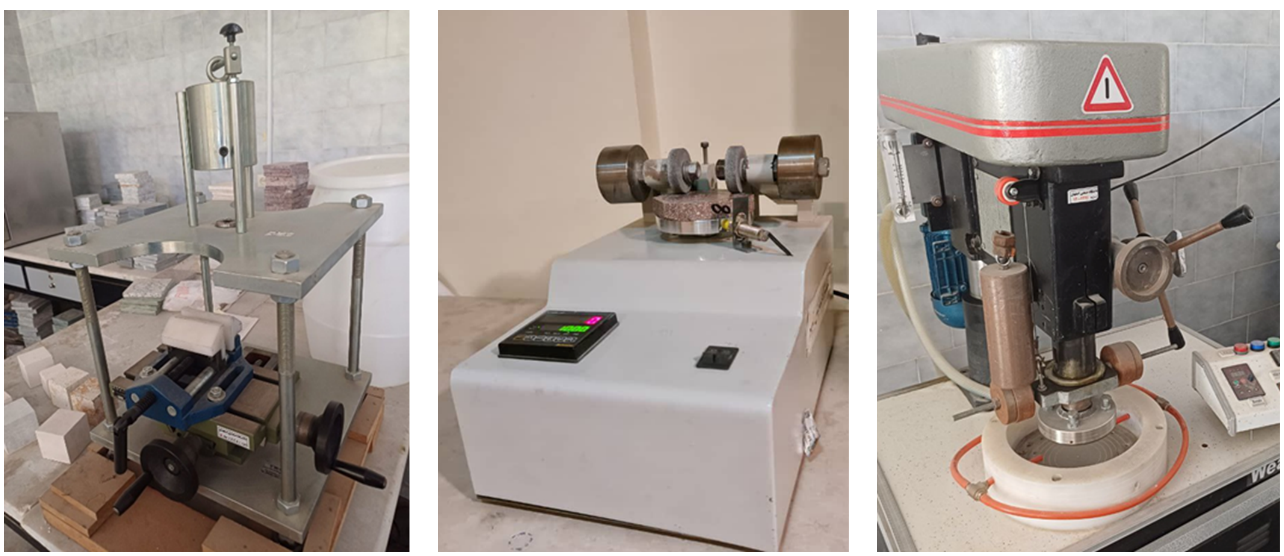
In this study, six common abrasivity methods are considered for evaluating the effect of TC on stone abrasivity properties. These methods include three petrological and three mechanical methods. Petrological methods are equivalent quartz content (EQC), rock abrasivity index (RAI), and Schimazek abrasivity factor (F). Furthermore, mechanical methods are cerchar abrasivity test (CAI) and Taber abrasion test (I_w), and building stone abrasivity test (BSAI). The definition and mathematical expression of each studied abrasivity properties is given in Table 4.

EQC, RAI, and F were calculated for each stone based on petrological and fundamental properties using mathematical expressions presented in Table 4. CAI was obtained according to ASTM D 7625 standard [42] using West Cerchar abrasivity index tester (Figure 1a). I_w was performed based on ASTM C 1353 standard [43] using the Taber Abraser 5130 device (Figure 1b). Additionally, BSAI was measured based on proposed procedure and developed laboratory test rig by Farhadian et al. [1] (Figure 1c). The value of EQC, RAI, F, CAI, I_w and BSAI of the different studied stones are listed in Table 5.

Table 4. The definition and mathematical expression of studied abrasivity indices.

Index	Formula	Definition	Reference
Equivalent quartz content (EQC)	$EQC = \sum_{i=1}^{n} P_i * R_i$	Quartz mineral, with a Mohs hardness of 7, exhibits the highest frequency among stones. Therefore, Rosiwal abrasiveness of quartz is considered as 100%, and to determine EQC, the hardness of other minerals is established relative to it.	[39]
Rock abrasivity index (RAI)	$RAI = EQC \times UCS$	This index is suitable for evaluating wear and fracturing caused by the breakage of tool components and is generally indicative of the resistance of stones and constituent minerals within the stone structure. In fact, the RAI applies a correction in the EQC and also involves the strength of the stone.	[40]
Schimazek abrasivity factor (F)	$F = \frac{EQC \times G_s \times BTS}{100}$	F is based on the characteristics of the stone and directly analyzes the abrasiveness of the stones. It is a function of the amount of quartz and other abrasive minerals, grain size, and indirectly of tensile strength (Brazilian) strength.	[41]
Cerchar abrasivity index (CAI)	$CAI = {}^{d}/_{10}$	CAI is primarily devised to determine tool costs and provide an estimate of tool lifespan. It is obtained by the abrasion and scratching of the sharp tip of a steel pin on a fresh surface. After creating the scratched diameter on the steel rod, it is measured under a specialized microscope.	[42]
Taber wear index (I_w)	$I_w = \frac{36.75}{W_0 - W_1} \times \rho \times \frac{N}{1000}$	The Taber abrasion test is conducted to determine an index for the abrasion resistance of architectural stones used in pedestrian walkways and building facades. This index is obtained in the laboratory by measuring the weight loss of a stone sample subjected to abrasion by standard interchangeable abrading wheels rotated for a specified number of cycles.	[43]
Building stone abrasivity index (BSAI)	$BSAI = M_0 - M_1$	BSAI designed for evaluating the abrasivity of building stones during polishing process based on weight loss of abrasive tool.	[1]

where P_i is the percentage content of present mineral in the stone, R_i is the Rosiwal hardness for the mineral, n is the number of minerals, UCS is uniaxial compressive strength (MPa), Gs is the equivalent grain size (mm), BTS is the Brazilian tensile strength (MPa), d is tip wear flat (mm), W_0 is initial weight of test specimen (gr), W_1 is weight of test specimen after 1000 revolutions (gr), ρ is bulk specific gravity, and N is number of revolutions actually run during the test. M_0 is weight of abrasive pins before the polishing test (gr), and M_1 is the weight of abrasive pins after the polishing test (gr).



(a) (b) (c)

Figure 1. Equipment for measuring abrasivity properties of studied stones: a) West Cerchar abrasivity index tester, b) Taber Abraser tester 5130, and c) BSAI laboratory test rig.

Table 5. Abrasivity properties of studied stones.

Sample	EQC	RAI	F	CAI	I_w	BSAI
S1	48.97	64.64	6.32	3.83	262.35	0.351
S2	49.83	69.73	7.67	3.96	275.10	0.444
S3	52.95	80.59	9.15	4.02	476.08	0.523
S4	46.14	54.58	5.99	3.61	287.32	0.325
S5	62.60	93.65	23.74	4.68	444.50	0.717
S6	45.94	63.17	3.01	3.79	324.63	0.403
S7	51.15	49.72	3.96	3.31	230.76	0.254
S8	57.95	85.32	29.86	4.42	274.05	0.650
S9	59.39	88.49	22.83	4.05	510.83	0.705
S10	49.70	72.49	14.06	3.83	261.84	0.469

3. Results and discussion

3.1. Relationship between TC and abrasivity indices

This section examines the relationship between TC and the abrasivity indices (EQC, RAI, F, CAI, I_w and BSAI) of the studied stones. In order to accomplish this objective, bi-variate regression analyses were conducted using linear, exponential, power, and logarithmic functions. In these analyses, abrasivity indices were considered as dependent variables and TC was considered as independent variable. Table 6 shows a summary of the best obtained equations. As can be seen in Table 5, R^2 obtained from the best equations vary between 0.491 and 0.850, which indicates the moderate to high relationships between TC and abrasivity indices. All the obtained equations were found to be statistically significant according to the student's t-test at a 95% level of confidence (Sig. level value ≤ 0.05). As can be seen, the F-values of all equations are considerably high. Hence, these derived equations can be reliably used, especially for predictive purposes. Figure 2 shows the relationship between TC and dependent variables based on the best bi-variate regression function. As can be observed, all abrasivity indices exhibit a direct relationship with TC, meaning that an increase in TC value leads to an increase in abrasivity properties. The lowest R^2 is associated with F value (R^2=0.491), while the highest is related to RAI (R^2=0.850).

Table 6. The Summary of obtained results from the bi-variate regression analysis for abrasivity indices.

Equation no.	Dependent variable	Best fit model	Equation	F-value	Sig.	R^2
1	F	Exponential	$F = 2.088\, e^{0.536TC}$	7.717	0.024	0.491
2	EQC	Linear	$EQC = 3.934\, TC + 41.198$	8.202	0.021	0.506
3	RAI	Exponential	$RAI = 41.455\, e^{0.187TC}$	45.178	0.000	0.850
4	CAI	Exponential	$CAI = 3.112\, e^{0.082TC}$	24.192	0.001	0.751
5	BSAI	Exponential	$BSAI = 0.189\, e^{0.309TC}$	43.893	0.000	0.846
6	I_w	Exponential	$I_w = 167.310\, e^{0.229TC}$	17.484	0.003	0.686

The relationship between TC and F lacks substantial strength, potentially accounting for the low coefficient of determination observed between these two parameters. This could be attributed to TC's focus on examining grain orientation, size, and elongation within the texture, which might not significantly relate to Brazilian tensile strength (BTS), the percentage and Rosiwal hardness of minerals. Thus, the figures do not illustrate a high correlation between TC and EQC (R^2=0.506). It can be inferred that the TC encompasses grain complexity and size without specifically correlating with mineral type. The RAI, essentially a modified version of the EQC parameter, incorporates the UCS parameter. Previous studies have indicated a robust correlation between the TC parameter and UCS [12,21,44]. Specifically, reducing the shape factor while increasing grain complexity, compactness, and interlocking contributes to an augmented TC, thereby enhancing the stone's strength. Consequently, the substantial correlation observed between TC and RAI may be attributed to this principle. A strong correlation exists between TC and CAI, demonstrating an exponential increase in CAI as TC value rises. Previous researches have extensively explored the association between CAI and stone strength. Scholars like Johnson et al. [45] have highlighted the impact of stone strength on CAI, establishing a robust correlation between stone strength properties and CAI. Additionally, Jager [46] has noted a linear relationship between CAI and UCS. Thus, it can be concluded that as the TC and texture complexity of the stone increase, so does the stone's resistance to tool penetration, resulting in greater wear at the tip of the steel pin. Ultimately, an increase in the TC directly corresponds to an escalation in the primary and secondary mass difference of abrasive pins during polishing process, signifying a direct correlation with BSAI. This implies that during the polishing process, the stones with a higher TC characterized by increased grain roughness and diverse grain orientations, cause a noticeable reduction in mass and augmented wear of the abrasive pins.

As can be seen in Figure 2f, the I_w exhibits a good direct exponential relationship with the TC. It means that I_w value increases as the TC increases. Essentially, this relationship demonstrates that higher TCs, indicating greater roughness and compactness of the grains, lead to a less significant mass reduction of stone samples. Similarly, the study conducted by Ajalloeian and Kamani [30] indicated that as the TC increases, the samples demonstrate a lower degree of mass reduction.

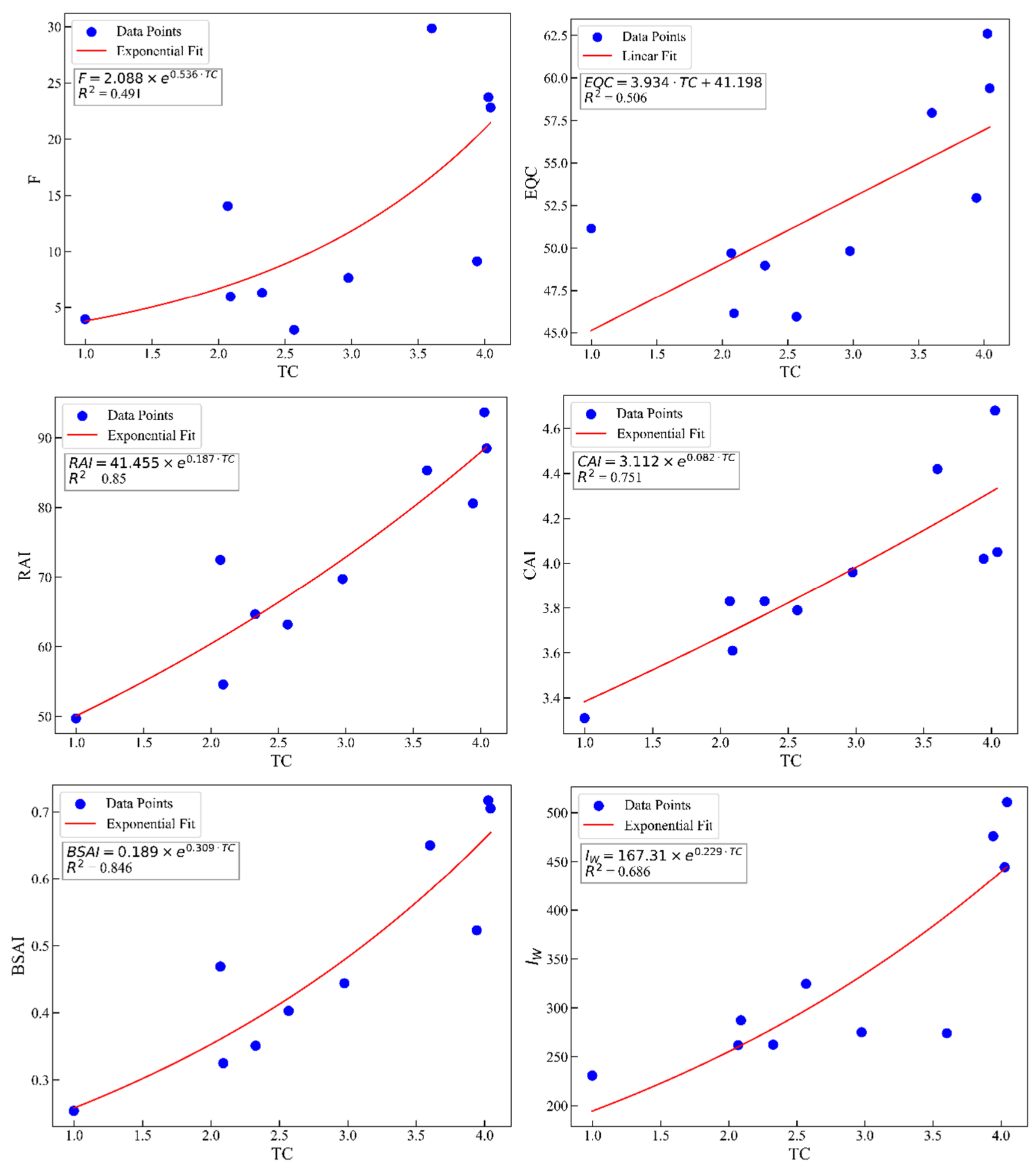


Figure 2. Relationships between TC and abrasivity indices.

3.2. Performances of the developed equations

In the previous section, the quality of developed equations was analyzed by R^2 performance index. In addition to R^2, there are various statistical indices for this purpose. Two of which, namely normalized root mean square error (NRMSE) and variance account for (VAF), are employed to evaluate the accuracy of the developed equations in this section. For a perfect predictive equation, the values of these metrics should be equal to their ideal value. The mathematical expressions for these metrics and their ideal values are presented in Table 7. The values of NRMSE and VAF for developed equations are given in Table 8. These metrics illustrate that these equations (especially Eqs. (3) to (6)) can predict abrasivity indices with acceptable accuracy for engineering purposes.

Table 7. The mathematical expressions of performance metrics [47,48].

Performance metric	Formula	Ideal value
NRMSE	$\mathrm{NRMSE} = \dfrac{\sqrt{\frac{1}{N}\sum_{i=1}^{N}(A_i - P_i)^2}}{\bar{A}}$	0
VAF	$\mathrm{VAF} = \left[1 - \dfrac{\mathrm{var}(A_i - P_i)}{\mathrm{var}(P_i)}\right] \times 100$	100
PI	$\mathrm{PI} = R^2 + \left(\dfrac{\mathrm{VAF}}{100}\right) - \mathrm{NRMSE}$	2

N: the total number of data, A_i: the i-th measured value, P_i: the i-th predicted value, and $\bar{A}$: the mean of all measured values.

Table 8. Performance metrics for developed equations.

Equation no.	NRMSE	VAF (%)
1	0.532	47.605
2	0.072	50.624
3	0.074	85.386
4	0.049	71.937
5	0.132	82.821
6	0.161	69.431

To select the most accurate equation, the performance index (PI) suggested by Yagiz et al. [49] was used according to the mathematical expression presented in Table 6. Theoretically, the PI value of excellent equation is equal to 2. Thus, the equation with the highest PI value is considered as the most reliable and accurate predictive equation. PI values for each equation are given in Figure 3. According to this index, among developed equations for prediction of abrasivity indices, Equation (3) shows the highest performance. As can be seen in Table 5, this equation predicts RAI based on TC, the predictive performance of which can be seen in Figure 4.

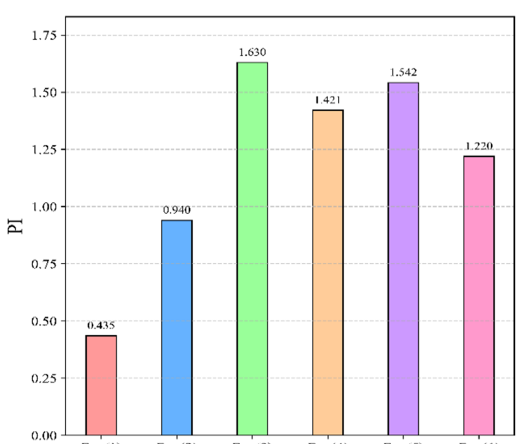


Figure 3. PI values for developed equations.

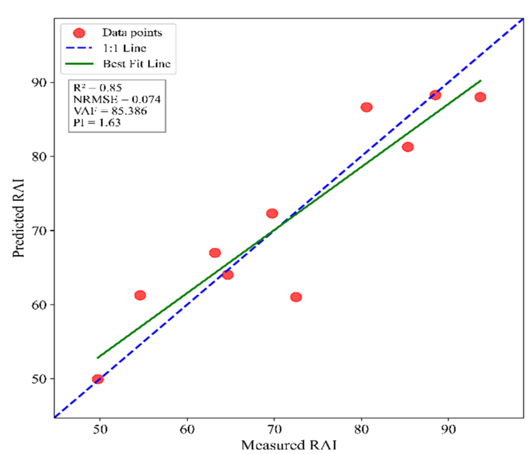


Figure 4. Prediction performance of Equation (3) for RAI prediction based on TC.

4. Conclusions

In this research, the effect of TC as a representative of stone texture on the abrasivity properties of granite stones has been investigated. The relationships between TC and the abrasivity indices such as EQC, RAI, F, CAI, I_w, and BSAI of 10 different granite building stones were investigated using regression analyses. It was observed that the TC has meaningful direct relationship with the abrasivity indices of the studied stones (with R^2 between 0.491 to 0.850). In other words, the stone abrasivity increases when the TC increases. Based on performance indices, among developed equations for prediction of abrasivity indices, Equation (3) for RAI prediction based on TC showed the highest performance. For this equation, the values of R^2, NRMSE, VAF, and PI were obtained 0.850, 0.074, 85.386, and 1.630, respectively. The proposed equation can provide a reliable and accurate estimation of the abrasivity of the building stones, which can be very helpful in choosing the right drilling, cutting and polishing tool with suitable lifetime according to the texture of each stone.

Finally, it is worth mentioning that the derived equations are valid only for the granite stones with similar characteristics. It is obvious that more experiments can be performed on other stone types such as marbles and travertines to improve the reliability of developed equations and to develop more comprehensive equations.

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بررسی ارتباط بین ضریب بافت و خواص سایندگی سنگهای ساختمانی گرانیتی

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کلمات کلیدی

سنگ‌های ساختمانی گرانیتی
سایندگی
ضریب بافت (TC)
تجزیه و تحلیل رگرسیون

چکیده

در این تحقیق بررسی جامعی بر روی ۱۰ نوع سنگ ساختمانی گرانیتی از معادن مختلف ایران انجام شده است. هدف از این مطالعه بررسی ارتباط بین ضریب بافت (TC) و خواص سایندگی سنگهای مورد مطالعه است. سایندگی سنگها از طریق شش شاخص شامل محتوای کوارتز معادل (EQC)، شاخص سایندگی سنگ (RAI)، ضریب سایندگی شیمازک (F)، شاخص سایندگی سرشار (CAI)، شاخص سایندگی سنگ ساختمانی (BSAI) و شاخص سایش تابر (Iw) به صورت کمی تعیین شد. تجزیه و تحلیل رگرسیون دو متغیره برای توسعه معادلات پیش بینی کننده برای ارتباط بین TC و شاخص¬های سایندگی استفاده شد. بررسی¬ها نشان داد که بین TC و تمام شاخص¬های سایندگی رابطه مستقیم وجود دارد. علاوه بر این، TC دارای ارتباط متوسط تا زیاد با شاخص¬های سایندگی است. پس از توسعه معادلات، دقت آنها با استفاده از معیارهای عملکرد شامل ضریب تعیین (R2)، خطای جذر میانگین مربعات نرمال شده (NRMSE)، شمول واریانس (VAF) و شاخص عملکرد (PI) مورد ارزیابی قرار گرفت. قوی¬ترین رابطه بین TC و RAI (با مقادیر R2، NRMSE، VAF و PI به ترتیب برابر با ۰.۸۵۰، ۰.۰۷۴، ۸۵.۳۸۶ و ۱.۶۳۰) یافت شد، در حالیکه ضعیف¬ترین رابطه بین TC و F (با مقادیر R2، NRMSE، VAF و PI به ترتیب برابر با ۰.۴۹۱، ۰.۵۳۲، ۴۷.۶۰۵ و ۰.۴۳۵) مشاهده شد. این تحقیق اهمیت ویژگی‌های بافتی سنگ‌ها، به‌ویژه TC به عنوان یک شاخص قابل اعتماد، بر خواص سایندگی سنگهای ساختمانی گرانیتی را نشان می‌دهد. بنابراین، معادلات توسعه‌یافته در اینجا می‌تواند عملاً برای تخمین سایندگی سنگ در پروژه‌های استخراج و فرآوری سنگ ساختمانی مورد استفاده قرار گیرد.

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