

Utilizing the Aggregate Impact Value (AIV) for the Indirect Determination of Uniaxial Compressive and Tensile Strengths in Weak and Altered Dacites

Kadir Karaman^{1*}, Mustafa Emirhan Elbir¹

¹ Mining Engineering Department, Engineering Faculty, Karadeniz Technical University, 61080 Trabzon, Türkiye

* Corresponding author, e-mail: kadirkaraman@ktu.edu.tr

Received: 10 November 2025, Accepted: 01 April 2026, Published online: 22 April 2026

Abstract

Aggregates play a crucial role in geotechnical engineering, serving applications such as railway and road construction, hydraulic structures, and as the base material for concrete. While various tests are commonly employed to characterize aggregates, the Aggregate Impact Value (AIV) can also provide indirect information on fundamental rock properties. In this study, AIV was used to estimate Uniaxial Compressive Strength (UCS) and Brazilian Tensile Strength (BTS) for very weak, fractured, and altered rocks where preparing standard specimens is challenging or impossible. Statistical analyses were performed separately for two categories to support preliminary engineering assessments: weak rocks (dacite, limestone, lapilli tuff and claystone) (UCS < 50 MPa) and altered dacitic rocks. The results revealed a strong and statistically significant inverse correlation between AIV and both UCS and BTS across all categories. The coefficients of determination (R^2) for the best-fitting regression models ranged from 0.87 to 0.94, indicating high predictive performance. Predicted UCS and BTS values based on AIV exhibited strong agreement with measured values, with correlation coefficients (r) between 0.90 and 0.96. These findings confirm the reliability of AIV as a predictive tool for mechanical properties in challenging rock environments. Overall, the proposed AIV-based regression equations provide a practical and efficient approach for preliminary assessment of UCS and BTS, offering valuable insight for geotechnical design when conventional sample preparation is difficult or infeasible.

Keywords

aggregate impact value (AIV), uniaxial compressive strength (UCS), Brazilian tensile strength (BTS), weak rocks, altered dacite

1 Introduction

Understanding the mechanical and physical characteristics of rocks – such as Uniaxial Compressive Strength (UCS), direct and indirect tensile strength, bulk density, and porosity – is essential for the safe and efficient design of geotechnical and civil engineering structures, including tunnels, dams, mining galleries, and open-pit operations [1–3]. The determination of these parameters is carried out in accordance with the methods recommended by ISRM and ASTM, which define sample preparation and testing procedures [4, 5]. For weak or very weak rocks (UCS < 50 MPa), however, obtaining suitable intact samples is often challenging, making data collection time-consuming and expensive [6]. In many field conditions, particularly during rotary drilling in highly fragmented formations, only crushed fragments or cuttings are available, emphasizing the need for a rapid and

practical method to estimate the parent rock's mechanical properties from granular materials, such as drill cuttings or aggregates delivered to concrete plants. Indirect methods such as the Point Load Index (PLI) test are frequently used to estimate UCS and provide partial solutions to the difficulties of sample preparation [7–9]. Nonetheless, PLI still requires intact specimens of minimum dimensions, which may be difficult to obtain in highly fractured or very weak rock masses. Other alternative tests, including needle penetration and block punch index tests, are highly sensitive to fissures and discontinuities in the rock mass, which can compromise reliability [10].

This study explores the use of the Aggregate Impact Value (AIV) test as a potential indirect indicator of rock strength parameters. AIV measures the resistance of aggregates to repeated impact, reflecting their crushing

behavior [11]. The mechanical influence of aggregates has also been demonstrated in concrete materials, where Seyam and Nemes [12] showed that the use of different aggregate types significantly affects compressive strength and thermal resistance at elevated temperatures. Although prior studies have investigated the relationship between AIV and rock strength, these efforts have been limited. For instance, Kamani and Ajalloeian [11] observed a moderate correlation between UCS and AIV in carbonate rocks (UCS range: 16.6-159.2 MPa), whereas Karaman and Bakhytzhan [13] reported a stronger correlation for rocks with a UCS range of 12-183 MPa. Yet, no comprehensive investigation has focused on predicting the UCS and tensile strength of weak or very weak rocks ($UCS < 50$ MPa) using AIV. The test offers a practical advantage for weak and very weak rocks, as only 500 g of aggregates passing the 12.5 mm sieve and retained on the 10 mm sieve are required.

The main goal of this study is to propose a practical and reliable method for estimating rock strength parameters under conditions where conventional sample preparation is difficult or impossible, such as with drill cuttings or aggregates. The study employs AIV to develop predictive models for UCS and Brazilian Tensile Strength (BTS) in weak rocks, and evaluates the general applicability of these models across different strength ranges. By doing so, this research addresses a notable gap in the literature, providing a rapid and dependable approach to characterize weak and fragmented rocks for geotechnical engineering applications. Moreover, predictive equations were also developed for UCS and BTS in altered dacitic rocks, extending the applicability of the proposed method beyond weak rocks.

2 Material and method

2.1 Sampling and mineralogical petrographic studies

Within the scope of the study, dacitic rocks exhibiting various degrees of alteration were collected from two distinct rock masses around Gümüşhane-Torul and Trabzon-Zigana Pass (northeastern Türkiye). In addition, biomicritic limestone samples were obtained from Araklı district of Trabzon Province. Claystone and lapilli tuff samples were collected from the Samsun Province. Fig. 1 presents the regional and local geological setting of the study area, where different colors and patterns represent the main lithological units and their geological ages [14]. Sampling locations are also indicated on the map. For clarity, only the sampling locations of the dacitic units, which form the core focus of this study, are highlighted in Fig. 1, while other lithologies are included to provide geological background. In the



Fig. 1 Simplified geological map of the study area (modified from Karaman and Koyaylı [14])

initial phase of the study, rock blocks with a wide range of compressive strengths, from very weak ($UCS < 25$ MPa) to strong (e.g., $UCS \approx 122$ MPa), were transported to the Karadeniz Technical University Mining Engineering Laboratory (Fig. 2). Mineralogical and petrographic analyses were then performed on these collected samples.

Thin section examination of representative rock blocks reveals that the Gümüşhane dacite blocks are composed of approximately 65% plagioclase, primarily albite and oligoclase phenocrysts, exhibiting extensive albitization, calcitization, and sericitization, as shown in Fig. 3(a). Quartz constitutes about 30% of the rock, biotite occurs in trace

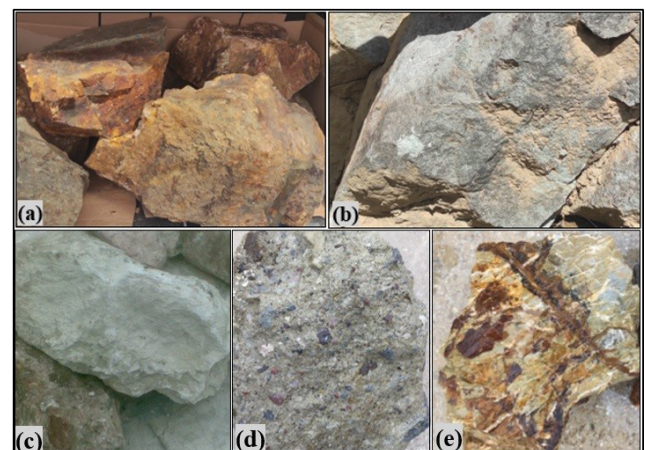


Fig. 2 Rocks examined in this study: (a) dacite blocks from Gümüşhane, (b) dacite blocks from Trabzon, (c) biomicritic limestones, (d) lapilli tuff, and (e) claystone.

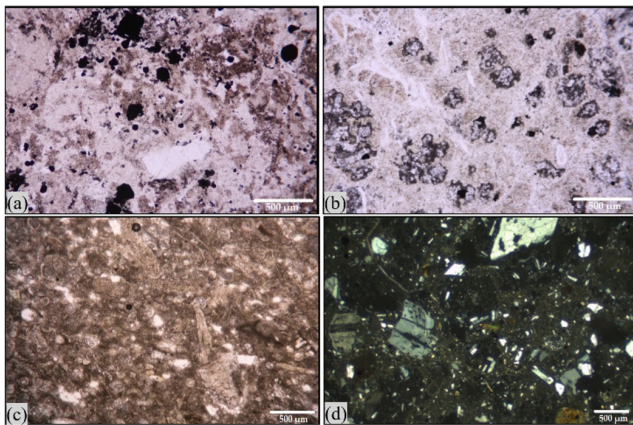


Fig. 3 Petrographic thin section images of the rocks used in this study: (a) Gümüşhane dacite, (b) Trabzon dacite, (c) biomicritic limestone, and (d) lapilli tuff

amounts and is chloritized, and pyrite accounts for roughly 5% of opaque minerals. Secondary minerals include calcite, sericite, albite, and chlorite. According to the thin section analysis presented in Fig. 3(b), plagioclase is the dominant light-colored mineral, partially or completely altered to albite, calcite, sericite, and secondary quartz, with abundant calcite, secondary quartz, and opaque minerals, including pyrite. Paleontological thin sections of biomicritic limestone samples from Fig. 3(c) display dense bioclast distributions, comprising benthic foraminifera, bivalve fragments, radiolaria, echinoid fragments and spines, bryozoa, and pelagic fossils. The pyroclastic samples were identified as lapilli tuff based on detailed macro and microscopic evaluations. Macroscopically, the rock exhibits a yellowish-gray color and a distinctly clastic, heterogeneous texture with varied grain sizes. Petrographic examinations show a matrix with 20–30% lithic fragments, including granitic inclusions. The mineralogy consists of volcanic glass shards, plagioclase, quartz, and traces of biotite and hornblende. Since more than 25% of the fragments exceed 2 mm (Fig. 3(d)), the samples are formally classified as lapilli tuff [15]. The mineralogical assembly of the claystone sample shown in Fig. 2(e) was verified via XRD (Rietveld) analysis [13].

2.2 Experimental studies

Core samples with a diameter of 54.7 mm (NX) and a length-to-diameter (L/D) ratio of 2.5 were prepared from the rock blocks delivered to the laboratory. The ends of the cores were trimmed and their flatness ensured using a core grinding machine. The following experimental tests were conducted in this study: the AIV, the UCS, the BTS, the PLI, and density and apparent porosity tests.

AIV tests were performed on the 10.0–12.5 mm aggregates fraction prepared from the block samples, following the procedures recommended by BSI [16].

The UCS tests were performed in accordance with the ISRM and ASTM suggested methods [4, 5, 17]. The experiments were carried out using a computer-controlled compression testing machine. For weak rock types, low-capacity loading frames (50–300 kN) were used to ensure high measurement sensitivity and accuracy. The BTS was determined by averaging the results of ten core samples with a diameter-to-height ratio of 2.5–3.0, loaded at a constant rate of 200 N/s.

The PLI tests were carried out axially using a digital apparatus and the obtained values were corrected to a 50 mm equivalent diameter ($I_{s(50)}$) according to the size correction procedures defined by ISRM [4].

Density and apparent porosity (n^0) were determined using the saturation and buoyancy techniques. The physical and mechanical properties of the samples are summarized in Table 1, and the experimental setup is illustrated in Fig. 4.

3 Results and discussion

Based on the physical and mechanical properties summarized in Table 1, the investigated rock types display a wide range of strength and porosity values, reflecting their heterogeneous composition. The dacite groups (G-Dacite and Z-Dacite) generally show moderate to high UCS ranging



Fig. 4 Images from experimental studies: (a) core grinding, (b) appearance after the UCS test, (c) AIV test, (d) representative dacite cores, (e) disc samples, (f) BTS test, and (g) PLI test

Table 1 Physical and mechanical properties of rock specimens

Sample code	Rocks	AIV (%)	UCS (MPa)	BTS (MPa)	PLI (MPa)	ρ_D (g/cm ³)	ρ_S (g/cm ³)	n (%)
1	G-Dacite-1	11.26	55.28	8.11	7.94	2.76	2.78	2.29
2	G-Dacite-2	6.99	73.45	13.89	9.24	2.77	2.78	1.31
3	G-Dacite-3*	14.17	30.86	5.2	4.9	2.74	2.76	1.85
4	G-Dacite-4	6.28	122.3	16	9.52	2.81	2.82	0.82
5	G-Dacite-5*	9.78	50	5.4	4.2	2.79	2.83	4
6	G-Dacite-6*	16.25	20.3	4.5	2.2	2.44	2.51	7.55
7	G-Dacite-7*	16.19	19.36	3.5	2	2.43	2.51	7.49
8	G-Dacite-8*	18	22.95	3.5	2.6	2.56	2.65	8.61
9	G-Dacite-9	8.59	101.57	11	8.1	2.68	2.73	4.8
10	Z-Dacite-1	8.83	97.78	10.1	7.6	2.64	2.68	4.7
11	Z-Dacite-2	6.39	106	11.7	9	2.69	2.73	4.1
12	Z-Dacite-3*	14.21	28	4.3	2.9	2.59	2.64	5.43
13	Z-Dacite-4	11.02	56.15	5.3	3.3	2.55	2.63	8.22
14	Z-Dacite-5*	14.32	33.25	3.2	2.1	2.53	2.64	10.32
15	Z-Dacite-6	10.45	60	6.7	4.6	2.62	2.66	4.64
16	Z-Dacite-7	8.82	76.41	8.66	5.6	2.64	2.69	5.1
17	Z-Dacite-8*	10.77	38.93	6.5	5	2.73	2.78	4.74
18	Z-Dacite-9*	12.47	37.98	6.1	4.2	2.64	2.69	5.24
19	Z-Dacite-10	9.06	61.55	8.9	5.6	2.67	2.73	5.36
20	Limestone-1*	28.53	7.7	0.8	0.92	2.05	2.3	23.76
21	Limestone-2*	25.71	11.6	0.9	1.02	2.01	2.23	19.7
22	Claystone*	19.0	25	2.4	2.3	2.4	2.48	7.8
23	Lapilli tuff*	24.6	12	1.4	1.3	1.73	2	27.2

G-Dacite: Gümüşhane dacite, Z-Dacite: Zigana (Trabzon) dacite, Samples marked with an asterisk (*) were included in the statistical analyses of the weak-strength rock group ($n = 13$)

from 19.36 MPa to 122.3 MPa, coupled with relatively low porosity ($n < 10\%$), demonstrating a clear inverse relationship between porosity and strength. In contrast, limestone specimens (rock codes: 20-21) exhibit the lowest average UCS (~8-12 MPa) and the highest AIV values (~26-29%), indicating the weakest resistance to mechanical stress. The lapilli tuff sample, with the highest porosity ($n = 27.2\%$), confirms its highly porous and lightweight structure, whereas the claystone sample exhibits lower apparent porosity and higher strength.

To quantitatively evaluate these observations, correlations of UCS with BTS and PLI were analyzed for altered dacites (19 samples) and weak rock groups (13 samples; 9 dacites, 2 limestones, 1 lapilli tuff and 1 claystone) (Fig. 5).

3.1 Correlations between rock parameters

The UCS/BTS ratio (R), also known as the Brincke number, is commonly used to characterize the mechanical relationship between compressive and tensile strengths of rocks [18]. Although the R ratio for most rock types

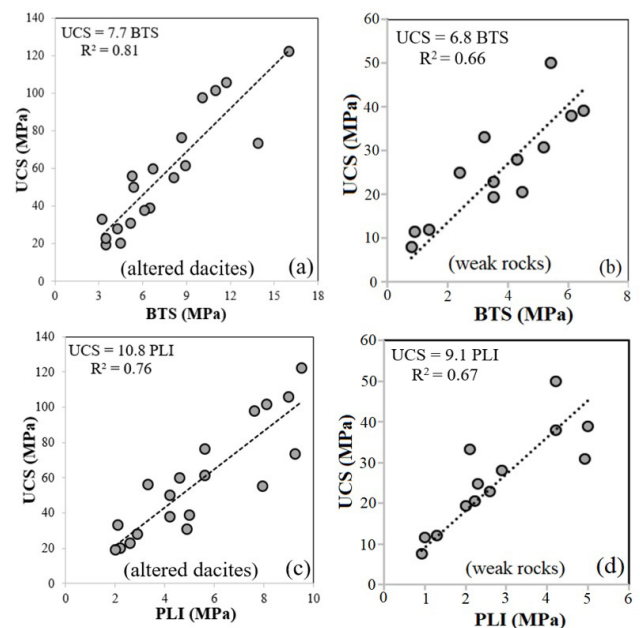


Fig. 5 Relationships between strength parameters: (a) UCS and BTS for altered dacites, (b) UCS and BTS for weak rocks, (c) UCS and PLI for altered dacites, and (d) UCS and PLI for weak rocks

is generally reported to range between 10 and 50, often approximated as 10 [19, 20], the current study yielded R values of 7.7 for altered dacites ($R^2 = 0.81$, Fig. 5(a)) and 6.8 for weak rock specimens ($R^2 = 0.66$, Fig. 5(b)). These values are considerably lower than commonly cited approximations, demonstrating that the UCS–BTS relationship is highly lithology-dependent and cannot be generalized using a constant R value [18]. The consistently low R values observed in this study, especially for weaker materials, align with recent findings [21], in which the R ratio for coal and weak adjacent rocks was reported between 5.4 and 7.0, highlighting that the commonly assumed $R = 10$ approximation is unreliable for the specific materials investigated.

The relationship between UCS and PLI for altered dacites yields a correlation coefficient (R^2) of 0.76 and is expressed by the equation $UCS = 10.8 \times PLI$ (Fig. 5(c)). However, when the analysis is limited to weak rock specimens, the resulting relationship ($UCS = 9.1 \times PLI$) shows a slight decrease in both the k factor (9.1) and the coefficient of determination ($R^2 = 0.67$) (Fig. 5(d)). The reduction in the conversion factor for softer rocks agrees with literature findings, suggesting that k is lower for weaker lithologies and higher for stronger ones. Furthermore, the low k value obtained for the weak rock group is in general agreement with studies focusing on altered and soft rocks. For instance, Kohno and Maeda [22] investigated this relationship for hydrothermally altered soft rocks, while other researchers such as Tsiambaos and Sabatakalis [23] and Agustawijaya [24] reported k factors of 13 and 13.4, respectively, which are also lower than the generally accepted $k = 24$ value. In addition, Topal [25] maintained that assuming a k value of 24 is erroneous, suggesting that for weak rocks like tuff, this ratio should be below 20, typically around 13 to 14. The k values obtained in this study clearly support Topal's [25] assertion that lower conversion factors should be adopted for weak and altered rock materials.

3.2 Estimating UCS and BTS from the AIV parameter of rocks

The relationships between the AIV parameter and UCS and BTS were examined through regression analyses, focusing specifically on weak rock specimens ($UCS < 50$ MPa). The highly altered basalt specimen ($UCS = 43$ MPa) was not included in this set (Fig. 6), as it showed a noticeable deviation from the general weak rock trend and was therefore evaluated separately. The regression analyses presented in Fig. 6 were derived from the 13 weak rock samples described above. The analysis confirmed that the F -statistic

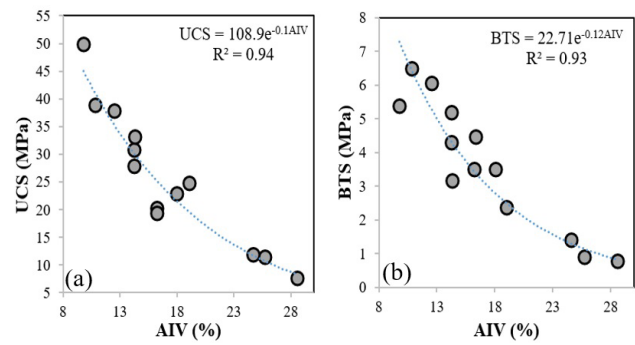


Fig. 6 Regression relationships between AIV and (a) UCS and (b) BTS for weak-strength rocks ($n = 13$)

probabilities ($p < 0.001$) and the p -values for the AIV coefficient were below the 0.05 significance level in all models, establishing AIV as a statistically significant and reliable predictor of both UCS and BTS within the investigated weak rock dataset. Among the regression models analyzed, the exponential regression model yielded the highest correlation, explaining approximately 93.5% of the variance in UCS ($R^2 = 0.935$) and approximately 93.0% of the variance in BTS ($R^2 = 0.93$). Consequently, these findings indicate that the exponential function is the most appropriate model for estimating UCS and BTS values from the AIV parameter for weak rocks represented by this dataset.

To ensure statistical consistency and reduce model bias, the regression analyses in this section focus on lithologically consistent groups; therefore, rock types with limited sample sizes, such as basalt and limestone, were excluded from the AIV-based strength models. Linear, exponential, and power regression analyses were performed to predict UCS and BTS values from AIV for dacite samples with various degrees of alteration (Figs. 7(a) and 7(b)). For the altered dacite dataset, both UCS and BTS exhibit clear inverse relationships with increasing AIV values. Among the tested regression models, the exponential function provided the best fit for UCS prediction (Fig. 7(a)), yielding a coefficient of determination

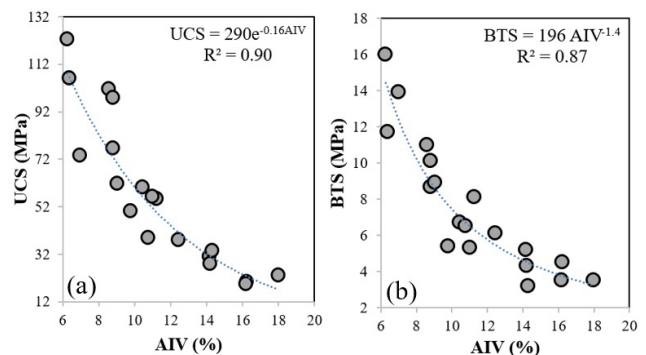


Fig. 7 Regression graphs between AIV and (a) UCS and (b) BTS for altered dacites

of $R^2 = 0.90$, which indicates that approximately 90% of the variance in UCS can be explained by the AIV parameter. Similarly, the power-law regression model for BTS (Fig. 7(b)) resulted in a high coefficient of determination ($R^2 = 0.87$), confirming the strong predictive capability of AIV for the tensile strength of altered dacite samples.

All regression coefficients were statistically significant ($p < 0.001$), demonstrating the robustness of the proposed relationships for dacites with varying degrees of alteration. These regression models are specifically applicable to altered dacite samples and reflect lithology-controlled mechanical behavior. As confirmed by the petrographic observations presented in Figs. 3(a) and 3(b), the relative enrichment of siliceous minerals such as quartz is associated with higher mechanical strength and lower AIV values. Conversely, the progressive development of alteration-related minerals (e.g., chloritization, sericitization and calcitization) corresponds to reduced strength and increased AIV values. This behavior can be explained by the microstructural control of impact fragmentation. Alteration-induced secondary minerals and associated microcracks weaken intergranular bonding, promoting particle breakage under impact loading and thereby increasing AIV values, whereas well-interlocked quartz-rich textures enhance resistance to fragmentation.

3.3 The relationships between measured and estimated UCS and BTS values

Fig. 8 presents the performance of the AIV-based estimation equations for UCS and BTS across two distinct sample groups: weak rocks and altered dacites. UCS predictions (Figs. 8(a) and 8(c)) yielded high correlation coefficients ($r = 0.92–0.96$), indicating strong agreement between measured and estimated values under varying rock conditions. In each sub-figure, data points closely follow the ideal 1:1 line (measured = estimated), with the line of best fit nearly parallel to it. This close alignment demonstrates the robustness of the proposed relationships and supports the suitability of AIV as an effective predictor of UCS under different geological and mechanical conditions. Similarly, the BTS predictions (Figs. 8(b) and 8(d)) showed high performance and reliability, with correlation coefficients (r) ranging from 0.90 to 0.94. Notably, the highest correlations occurred for altered dacites ($r = 0.94$). The strong linear relationship is visually confirmed by the tight clustering of the data points around the 1:1 line across the entire range of BTS values. These findings confirm that the AIV-based methodology can accurately and consistently

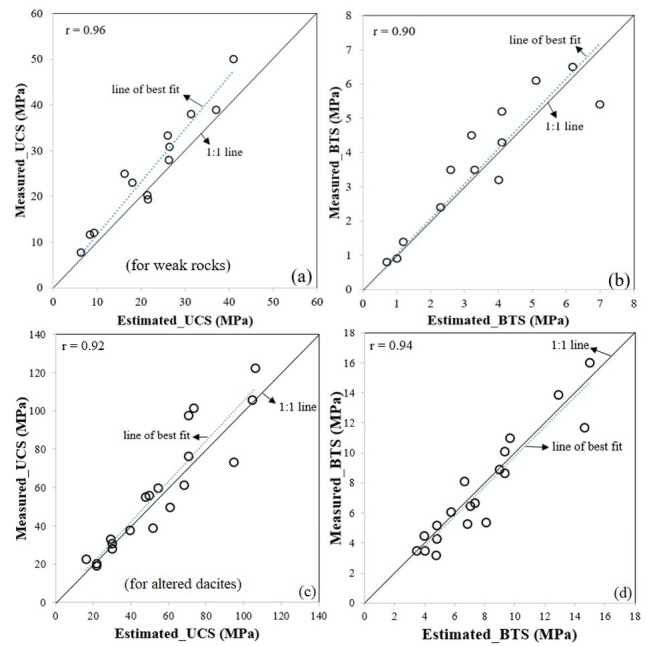


Fig. 8 Measured and estimated UCS and BTS values: (a) UCS for weak rocks, (b) BTS for weak rocks, (c) UCS for altered dacites, and (d) BTS for altered dacites

estimate tensile strength (BTS), a critical geomechanical parameter, with predictive performance comparable to that obtained for UCS.

The mean absolute percentage error (MAPE) analyses were conducted to compare the accuracy of measured and estimated values. Lewis [26] identified MAPE as a useful metric for comparing forecast accuracy across different items because it measures relative performance. Based on MAPE analysis, lower percentage errors indicate more accurate forecasts. A MAPE value below 10% indicates "highly accurate forecasting," 10–20% indicates "good forecasting," 20–50% indicates "reasonable forecasting," and above 50% indicates "inaccurate forecasting". Based on the MAPE values presented in Table 2, error rates for estimating both UCS and BTS consistently fall within the 10% to 20% range across the investigated weak rocks and altered dacites. These results, based on the criteria outlined above, indicate that the predictions are classified as 'good forecasting'.

Table 2 MAPE (%) values between measured and estimated UCS and BTS

Rocks	MAPE (%)		Definitions
	UCS _M -UCS _E	BTS _M -BTS _E	
Weak rocks	17.32	15.68	Good forecasting
Altered dacites	14.65	14.82	Good forecasting

UCS_M: Measured UCS, UCS_E: Estimated UCS, BTS_M: Measured BTS, BTS_E: Estimated BTS

3.4 Discussion

Numerous studies in the literature investigate the relationships between fragmented particulate samples, such as aggregates, and the geomechanical properties of rocks. These studies often focus on correlating results from practical index tests – which are simpler and faster than traditional core tests – with fundamental rock properties (strength, durability, density, and porosity) to enable preliminary rock characterization and material selection, particularly when quality core samples are unavailable. Kahraman et al. [27] established prediction equations for geomechanical rock properties – including UCS, BTS, density, and porosity – based on strong correlations with the Crushability Index (CI) obtained from roll crusher tests, establishing the CI test as a valuable tool for estimating these properties when core specimens are unavailable. Köken and Özarıslan [28] developed methods to estimate the strength of ballast material using the PLI test on regular and irregular samples, addressing the challenge of obtaining cylindrical specimens and demonstrating the utility of the index for irregular samples.

Other studies focus on establishing predictive models for AIV and other degradation parameters, often using rock strength index tests. Kamani and Ajallooeian [11], for instance, evaluated the potential for estimating the Aggregate Degradation (AD) characteristics of carbonate aggregates using UCS and PLI tests. Their findings demonstrated that PLI is a superior predictor for AD properties (specifically AIV, $R^2 = 0.832$) compared to UCS, highlighting its utility for preliminary aggregate selection. Similarly, Esfahani et al. [29] investigated the predictability of Los Angeles Abrasion Loss (LAAL) from common rock aggregate properties and conventional aggregate tests (such as ACV and AIV). Using simple and multiple regression analyses on over 200 rock samples, they reported high correlations between LAAL and parameters such as Aggregate Crushing Value (ACV) and porosity. Furthermore, Kuna and Bögöly [30] conducted a comprehensive study, collecting and analyzing existing empirical relationships and datasets from the literature between rock strength parameters (UCS and PLI) and various aggregate degradation parameters, including AIV, to reliably predict these degradation properties. More recently, Tamrakar et al. [31] correlated the strength and durability of sandstones from the Dumri Formation using tests such as PLI, slake durability index, and AIV, demonstrating strong positive correlations between AIV and PLI ($r = 0.86$), which highlights the utility of PLI for estimating rock durability.

The findings of the present study are consistent with recent literature, particularly the work of Lógó and Vásárhelyi [32], who demonstrated a strong correlation between impact resistance and compressive strength in sandstones using the Charpy impact test. In addition, several other studies (e.g., Kamani and Ajallooeian [11]; Tamrakar et al. [31]) primarily focused on predicting aggregate degradation parameters from rock strength indices such as UCS or PLI, the present study reverses this relationship by considering AIV as an indicator of rock strength. This distinction is particularly significant for highly altered or weak rock masses, where conventional strength testing is not feasible.

It should be noted that reliable estimation of UCS and BTS from the AIV parameter requires the collection of sufficiently representative samples. Inadequate sampling may result in an insufficient test mass to meet the recommended 500 g requirement, thereby affecting the reliability of the results. Although the use of fragmented specimens generally facilitates sampling, careful planning and sufficient material collection are essential to ensure representative results. In addition, the applicability of the proposed and previously published empirical relationships is expected to be more reliable when similar lithologies and comparable data ranges are considered; therefore, even for the same rock type (e.g., altered dacites), variations in geological setting, mineralization, and alteration conditions may influence the accuracy of the predictions and should be considered when applying these equations to other regions.

4 Conclusions

This study examined the potential of the AIV test for the indirect determination of critical mechanical parameters of fractured and weak lithologies, predominantly altered dacites, where the preparation of standard laboratory specimens is often difficult or impossible. Regression analyses indicate that AIV demonstrated statistically significant predictive capability for UCS and BTS, with significance established across all models ($p < 0.001$).

For weak rocks (UCS < 50 MPa), AIV exhibited a strong inverse relationship with both UCS and BTS. Among the tested regression models, the exponential regression model provided the highest correlation for both UCS ($R^2 = 0.935$) and BTS ($R^2 = 0.93$). For the altered dacite data sets, both UCS and BTS decreased systematically with increasing AIV values, confirming the inverse strength–impact resistance relationship. The exponential regression model yielded the best fit for UCS prediction ($R^2 = 0.90$), while

the power-law model provided the most accurate estimation for BTS ($R^2 = 0.87$). Additionally, the correlation coefficients (r) between measured and estimated values ranged from 0.90 to 0.96 indicating strong predictive capability of the developed equations. MAPE analyses further confirmed the accuracy of the predictions, indicating that the error rates for UCS and BTS in both the weak rock group and the altered dacite dataset fall within the 10% to 20% range, corresponding to the "good forecasting" category and supporting their practical applicability.

The study also highlights that the strength conversion factors (k and R) vary depending on rock type and degree

of alteration. For example, weak rocks and highly altered dacites exhibit lower R values compared to stronger lithologies, reflecting the influence of mineralogical composition and alteration on mechanical behavior.

Acknowledgments

The authors sincerely thank the Scientific and Technological Research Council of Türkiye (TÜBİTAK) for the financial support provided to this research project (Project Number: 1919B012405427).

References

- [1] Sülükçü, S., Ulusay, R. "Evaluation of the block punch index test with particular reference to the size effect, failure mechanism and its effectiveness in predicting rock strength", *International Journal of Rock Mechanics and Mining Sciences*, 38(8), pp. 1091–1111, 2001. [https://doi.org/10.1016/S1365-1609\(01\)00079-X](https://doi.org/10.1016/S1365-1609(01)00079-X)
- [2] Besharatinezhad, A., Török, Á. "The effect of freeze-thaw on mechanical and ultrasonic properties of hungarian oolitic stones", *Periodica Polytechnica Civil Engineering*, 68(3), pp. 1013–1020, 2024. <https://doi.org/10.3311/PPci.23268>
- [3] İnce, İ., Balci, M. C., Korkaç, M., Hatır, M. E. "Investigation of the effects of rock components for different pyroclastic rocks on Leeb hardness", *Periodica Polytechnica Civil Engineering*, 69(2), pp. 593–598, 2025. <https://doi.org/10.3311/PPci.38829>
- [4] Ulusay, R., Hudson, J. A. (eds.) "The complete ISRM suggested methods for rock characterization, testing and monitoring: 1974–2006", Commission on Testing Methods, International Society for Rock Mechanics, ISRM Turkish National Group, Ankara, Turkey, 2007. ISBN 978-975-93675-4-1
- [5] ASTM "ASTM D7012-13 Standard test methods for compressive strength and elastic moduli of intact rock core specimens under varying states of stress and temperatures", ASTM International, West Conshohocken, PA, USA, 2013. <https://doi.org/10.1520/D7012-13>
- [6] Wei, Z., Yang, W., Chen, Q., Liang, D., Wu, G. "Uniaxial compressive strength prediction based on measurement while drilling data: A laboratory study", *Journal of Applied Geophysics*, 229, 105499, 2024. <https://doi.org/10.1016/j.jappgeo.2024.105499>
- [7] Kahraman, S. "Evaluation of simple methods for assessing the uniaxial compressive strength of rock", *International Journal of Rock Mechanics and Mining Sciences*, 38(7), pp. 991–994, 2001. [https://doi.org/10.1016/S1365-1609\(01\)00039-9](https://doi.org/10.1016/S1365-1609(01)00039-9)
- [8] Kaya, A., Karaman, K. "Utilizing the strength conversion factor in the estimation of uniaxial compressive strength from the point load index", *Bulletin of Engineering Geology and the Environment*, 75(1), pp. 341–357, 2016. <https://doi.org/10.1007/s10064-015-0721-1>
- [9] Rahimi, M. R., Mohammadi, S. D. "The effect of mineral composition on the correlation between point load index with the uniaxial compressive strength of sulfate rocks and their point loading deformation", *Periodica Polytechnica Civil Engineering*, 68(4), pp. 1281–1313, 2024. <https://doi.org/10.3311/PPci.37013>
- [10] Kahraman, S., İnce, İ. "The needle penetration index for estimating the physico-mechanical properties of pyroclastic rocks", *Journal of the Southern African Institute of Mining and Metallurgy*, 123(9), pp. 463–470, 2023. <https://doi.org/10.17159/2411-9717/1433/2023>
- [11] Kamani, M., Ajallooeian, R. "Evaluation of the mechanical degradation of carbonate aggregate by rock strength tests", *Journal of Rock Mechanics and Geotechnical Engineering*, 11(1), pp. 121–134, 2019. <https://doi.org/10.1016/j.jrmge.2018.05.007>
- [12] Seyam, A. M., Nemes, R. "Influence of elevated temperatures on the compressive strength of concrete made with different types of aggregate", *Periodica Polytechnica Civil Engineering*, 68(4), pp. 1073–1085, 2024. <https://doi.org/10.3311/PPci.36784>
- [13] Karaman, K., Bakhytzhana, A. "Prediction of concrete strength from rock properties at the preliminary design stage", *Geomechanics and Engineering*, 23(2), pp. 115–125, 2020. <https://doi.org/10.12989/gae.2020.23.2.115>
- [14] Karaman, K., Kolaylı, H. "Effects of olivine alteration on micro-internal structure and geomechanical properties of basalts and strength prediction in these rocks", *Sustainability*, 16(13), 5490, 2024. <https://doi.org/10.3390/su16135490>
- [15] Karaman, K., Külekçi, G., Çakır, Y., Kolaylı, H. "Variability of Schmidt rebound values in volcanic rocks (basalt and lapilli tuff): comparative effect of surface roughness, alteration, and testing methods", *Applied Sciences*, 16(2), 886, 2026. <https://doi.org/10.3390/app16020886>
- [16] BSI "BS 812-112 Testing aggregates: methods for determination of aggregate impact value", British Standards Institution, London, UK, 1990.

- [17] Ulusay, R. (ed.) "The ISRM suggested methods for rock characterization, testing and monitoring: 2007–2014", Springer Cham, 2015. <https://doi.org/10.1007/978-3-319-07713-0>
- [18] Cai, M. "Practical estimates of tensile strength and Hoek–Brown strength parameter m_i of brittle rocks", *Rock Mechanics and Rock Engineering*, 43, pp. 167–184, 2010. <https://doi.org/10.1007/s00603-009-0053-1>
- [19] Kahraman, S., Fener, M., Kozman, E. "Predicting the compressive and tensile strength of rocks from indentation hardness index", *Journal of the Southern African Institute of Mining and Metallurgy*, 112, pp. 331–339, 2012.
- [20] Sheorey, P. R. "Empirical Rock Failure Criteria", CRC Press, 1997. ISBN 9789054106715
- [21] Karaman, K., Şahinoğlu, E., İskender, Y. "Kömür Dayanımının Tahmininde Dönüşüm Faktörü ve Dayanım Oranının Kullanımının Araştırılması" (Investigation of the use of conversion factor and strength ratio in the prediction of coal strength), *Türkiye 23. Uluslararası Kömür Kongresi ve Sergisi Bildiriler Kitabı Zonguldak, Türkiye*, pp. 199–209, 2024. (in Turkish)
- [22] Kohno, M., Maeda, S. "Estimation of rock mass properties by point load test for hydrothermally altered soft rocks", *Rock Mechanics and Rock Engineering*, 45(6), pp. 1079–1087, 2012. <https://doi.org/10.1016/j.ijrmms.2012.01.011>
- [23] Tsiambaos, G., Sabatakakis, N. "Considerations on strength of intact sedimentary rock", *Engineering Geology*, 72(3–4), pp. 261–273, 2004. <https://doi.org/10.1016/j.enggeo.2003.10.001>
- [24] Agustawijaya, D. S. "The uniaxial compressive strength of soft rock", *Civil Engineering Dimension*, 9(1), pp. 9–14, 2007.
- [25] Topal, T. "Nokta yükleme deneyi ile ilgili uygulamada karşılaşılan problemler", (Problems faced in the applications of the point load index test), *Jeoloji Mühendisliği*, 24, pp. 73–86, 2000. (in Turkish)
- [26] Lewis, C. D. "International and Business Forecasting Methods", Butterworths, London, 1982. ISBN 9780408005593
- [27] Kahraman, S., Ince, I., Rostami, M., Dihavar, B. "Predicting the strength, density, and porosity of rocks from roll crusher tests", *Journal of the Southern African Institute of Mining and Metallurgy*, 124(2), pp. 53–58, 2024. <https://doi.org/10.17159/24119717/1528/2024>
- [28] Köken, E., Özarslan, A. "Development of proposals for utilization of point load strength to estimate the strength of ballast material", In: Şensoğut, C. (ed.) 8. Proceedings of the International Aggregate Symposium, Kütahya, Türkiye, 2016, pp. 73–83.
- [29] Esfahani, K. M., Kamani, M., Ajalloeian, R. "An investigation of the general relationships between abrasion resistance of aggregates and rock aggregate properties", *Bulletin of Engineering Geology and the Environment*, 78(3), pp. 3959–3968, 2019. <https://doi.org/10.1007/s10064-018-1366-7>
- [30] Kuna, E., Böğöly, G. "Overview of the empirical relations between different aggregate degradation values and rock strength parameters", *Periodica Polytechnica Civil Engineering*, 68(2), pp. 375–391, 2024. <https://doi.org/10.3311/PPci.22396>
- [31] Tamrakar, N. K., Dhungana, V., Dhamala, B., Poudel, S. "Correlation between strength and durability of sandstones from the Dumri Formation, Tinau khola Area, West-Central Nepal", *International Journal of Applied Natural Sciences*, 2(2), pp. 1–14, 2024. <https://doi.org/10.61424/ijans.v2i2.140>
- [32] Lógó, B. A., Vásárhelyi, B. "Estimation of the constitutive relationship between impact resistance and compressive strength in sandstones", *Periodica Polytechnica Civil Engineering*, 69(3), pp. 944–953, 2025. <https://doi.org/10.3311/PPci.40270>