Research Article

Correlation-Regression Statistics: Predicting Uniaxial Compressive Strength From Point Load Index For Hydrothermal Clay Materials

Statistik Korelasi-Regresi: Prediksi Kuat Tekan Uniaksial dari Point Load Index pada Material Lempung Hidrotermal

Muhammad Alfiza Farhan[1*], Akbar Aprian[2]

[1]Teknik Pertambangan, Institut Teknologi Sains Bandung, Kota Deltamas Lot-A1 CBD, Jl. Ganesha Boulevard No.1 Blok A, Pasirranji, Kec. Cikarang Pusat, Kabupaten Bekasi, Jawa Barat 17530, Indonesia
[2]Teknik Pertambangan, Fakultas Teknologi Industri, Institut Teknologi Sumatera, Jl. Terusan Ryacudu, Way Huwi, Kec. Jati Agung, Kabupaten Lampung Selatan, Lampung 35365, Indonesia

[*]Muhammad Alfiza Farhan
e-mail: muhammadalfizafarhan@gmail.com

ABSTRACT
This study addressed the difficulty of determining uniaxial compressive strength in hydrothermally altered breccia, where preparing intact core samples was not feasible. A field-based approach using point load index measurements was adopted to provide an alternative means of estimating rock strength. Twenty-one representative breccia samples from Pit C were tested through standardized point load procedures and laboratory uniaxial compression tests. Linear regression analysis was performed to examine the relationship between the two strength parameters. The results showed a strong and statistically significant linear trend, indicating that point load index values could reliably predict uniaxial compressive strength for the altered breccia. The analysis further demonstrated that most strength variability was explained by the regression model. These findings supported the use of point load testing as an efficient and practical method for strength estimation in geological conditions where conventional testing was limited.

Keywords: Uniaxial compressive strength, Point load index, Hydrothermal alteration, Rock strength characterization

ABSTRAK
Studi ini menjawab kesulitan dalam menentukan kekuatan tekan uniaxial pada breksi yang terubah secara hidrotermal, di mana persiapan sampel inti yang utuh tidak memungkinkan. Pendekatan berbasis lapangan yang menggunakan pengukuran indeks beban titik diadopsi untuk menyediakan sarana alternatif dalam memperkirakan kekuatan batuan. Dua puluh satu sampel breksi representatif dari Pit C diuji melalui prosedur standar beban titik dan uji tekan uniaxial laboratorium. Analisis regresi linier dilakukan untuk menguji hubungan antara kedua parameter kekuatan tersebut. Hasil menunjukkan tren linier yang kuat dan signifikan secara statistik, mengindikasikan bahwa nilai indeks beban titik dapat diandalkan untuk memprediksi kekuatan tekan uniaxial pada breksi yang terubah. Analisis lebih lanjut mendemonstrasikan bahwa sebagian besar variabilitas kekuatan dijelaskan oleh model regresi. Temuan ini mendukung penggunaan pengujian beban titik sebagai metode yang efisien dan praktis untuk estimasi kekuatan dalam kondisi geologis di mana pengujian konvensional terbatas.

Kata kunci: Kuat tekan uniaksial, Point load index, alterasi hidrotermal, karakterisasi kekuatan batuan

I. INTRODUCTION
Intact rock strength, typically measured as uniaxial compressive strength (UCS), is a fundamental parameter in geotechnical engineering for characterizing rock masses and designing stable slopes, tunnels, and foundations (Jamshidi & Sousa, 2023), where it is obtained from laboratory tests (Supandi, 2022). In practice, however, obtaining UCS values requires high-quality core samples for

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laboratory testing (ISRM, 1981), which are not always feasible on site (Wang et al., 2022), particularly in heavily jointed or altered rock masses where standard test specimens cannot be prepared (Kohno & Maeda, 2018). To address this limitation, an indirect approach using the point load index (PLI) test is often adopted to estimate UCS when direct UCS tests are impractical (Broch & Franklin, 1972). The PLI test is relatively quick, portable, and can be performed on irregular or smaller rock pieces, making it an efficient alternative for field conditions (Broch & Franklin, 1972; ISRM, 1985). Numerous studies have demonstrated a strong correlation between PLI and UCS, enabling empirical conversion of PLI results into approximate UCS values (Bieniawski, 1975; Tsiambaos & Sabatakakis, 2004; Basu & Aydin, 2006; Agustawijaya, 2007). Correlating PLI to UCS provides a feasible means to infer rock strength for engineering purposes, improving both effectiveness and safety in geotechnical design (Wang et al., 2022), such as at Pit C of PT Bumi Suksesindo's mine. In the absence of a UCS testing machine on site, a reliable UCS–PLI correlation allows practitioners to indirectly determine rock strength without time-consuming laboratory tests (Kohno & Maeda, 2018), thus supporting faster decision-making in mine planning and slope stability analysis.

Numerous empirical correlations between PLI and UCS have been proposed in the literature. Early studies suggested a roughly linear relationship: UCS ≈ k·Is(50), where Is(50) is the point load strength index standardized to a 50-mm core diameter, and k is a conversion factor on the order of 20–25 for many hard rocks (Broch & Franklin, 1972; Rai et al., 2014). For example, Broch and Franklin originally found k ≈ 24 for Norwegian sandstones (Broch & Franklin, 1972), and a value of k ≈ 23 has been widely cited as a general estimate for intact igneous and sedimentary rocks (Rai et al., 2014). In reality, the UCS–PLI ratio can vary widely with rock type and condition, as demonstrated by subsequent research. Kohno and Maeda reported a much lower factor (k ≈ 16.4) for hydrothermally altered soft volcanic rocks (Kohno & Maeda, 2012), while Schrier found an even more attenuated relationship in brecciated igneous rock (UCS ≈ 6.1·Is(50) – 3.3) (Schrier, 1988). Conversely, studies on stronger sedimentary rocks have obtained higher conversion coefficients—for instance, Adriansyah et al. observed k ≈ 24.27 in a sandstone unit (Adriansyah et al., 2021)—whereas another investigation on claystone-rich rock gave k ≈ 12.93 (Kahfi, 2021). Similar variability has been noted in international case studies; for example, an analysis of a South African sandstone (QwaQwa formation) yielded its own site-specific UCS–PLI regression distinct from the above values (Kolapo & Munemo, 2021). As a result of these differences, the goodness-of-fit of proposed PLI–UCS equations spans a broad range; in a recent comparative review, coefficients of determination (R^2) ranged from ~0.45 to ~0.98 depending on the dataset and regression model (Jamshidi & Sousa, 2024). This wide scatter reflects the influence of many factors on the PLI–UCS relationship, including inherent lithological variations, weathering/alteration degree, and test conditions. For example, specimen size and anisotropy can affect strength indices and thus the correlation: Sadeghi et al. showed that accounting for core diameter and porosity was necessary to reliably predict UCS of carbonate rocks from index tests (Sadeghi et al., 2022), and Jamshidi demonstrated that even the testing procedure (axial vs. diametral point load application) can impact the resulting UCS correlation for laminated sandstones (Jamshidi, 2022). These findings underscore that a single empirical conversion factor is not universally applicable, and site-specific calibration is often required (Kohno & Maeda, 2012; Jamshidi & Sousa, 2024).

The study area for this research, Pit C of the Tumpang Pitu gold mine in Banyuwangi (East Java), provides a unique geological setting of hydrothermally altered breccia within the Batuampar Formation (PT Bumi Suksesindo, 2024). The Batuampar Formation consists of Miocene volcaniclastics, including volcanic breccia, tuff, volcanic sandstone, and interbedded andesite lava with limestone lenses (PT Bumi Suksesindo, 2024). During the Mid-Miocene, this formation was intruded by multiple stocks of microdiorite, diorite (including hornblende diorite), quartz diorite, and andesite porphyry, which triggered extensive hydrothermal activity in the Tumpang Pitu area (PT Bumi Suksesindo, 2024). Consequently, the breccia units in Pit C have undergone pervasive hydrothermal clay alteration, evidenced by clay-rich matrix and altered clasts. Such alteration is known to significantly weaken rock materials by replacing original minerals with clays and oxides, leading to reduced intact strength and greater heterogeneity in mechanical properties (Kohno & Maeda, 2012). The hydrothermally altered breccia at Pit C is therefore expected to exhibit considerable variability in UCS, and its strength may not be reliably predicted by generic UCS–PLI equations derived from unaltered rocks. This motivates a site-specific investigation into the PLI–UCS relationship for the altered breccia.

Over the past decade, Wong et al. investigated volcanic rock lumps and confirmed that UCS–PLI correlations can vary with rock texture and alteration state (Wong et al., 2017). Recent studies have further refined these correlations: Jamshidi and Sousa (2023), for instance, compiled a wide range of regression equations and reported that UCS–PLI formulas may be linear, power-law, or logarithmic. This variability underscores the need to calibrate empirical correlations to specific lithological and alteration conditions. Indeed, relying on a generic empirical equation can lead to significant errors if the tested rock differs in fabric or weathering state from those used to develop the equation, as demonstrated by Hawkins (1998). Thus, for the clay-altered breccias of Pit C, it is essential to establish a tailored correlation that reflects their particular geological condition.

From a practical engineering perspective, developing a robust UCS–PLI correlation for the Pit C breccia has several key applications. First, it enables more reliable and rapid estimation of rock mass strength for pit slope design and stability assessments, which is vital for safety and optimization in mining operations. Slope stability analyses require input parameters such as intact UCS; having a quick method to obtain UCS from PLI tests allows slope designs to be updated efficiently as new materials are exposed (Hoek & Bray, 1981). Second, the correlation supports rock mass classification efforts. Systems such as Rock Mass Rating (RMR) classify intact strength either by UCS or by point load index; a site-specific conversion allows field PLI results to be confidently translated into UCS-based strength ratings. Third, PLI testing improves efficiency and cost-effectiveness, as point load tests are simple, portable, and inexpensive compared to UCS laboratory tests, allowing more samples to be tested and improving statistical reliability (Jamshidi & Sousa, 2023). This efficiency is particularly beneficial in mines where decisions must be made quickly and suitable UCS cores may be difficult or expensive to obtain.

In summary, an empirical PLI–UCS correlation specific to the altered breccia at Pit C not only fills a scientific knowledge gap but also provides a practical tool for the mine's geotechnical program. Therefore, this study aims to formulate an empirical correlation between the point load index (Is(50)) and uniaxial compressive strength for the hydrothermal clay-altered breccia in Pit C, PT Bumi Suksesindo. By performing a series of point load tests and UCS tests on breccia samples from the site, this work establishes a regression model that links PLI to UCS for this specific material. The contributions of the study are twofold: (1) it enhances understanding of how hydrothermal alteration influences the PLI–UCS relationship in breccia-type rocks, and (2) it provides a site-calibrated equation that improves geotechnical evaluations for slope design and rock mass classification in similar geological environments.

II. METHODS

This research, the author uses quantitative data and applied research methods, the data will be interconnected and will be developed using mathematical equations related to the incident. This research can be one solution to the problem of unavailability uniaxial compressive test instrument at PT Bumi Suksesindo.

The Uniaxial Compressive Strength Test (UCS), based on the standards of the International Society for Rock Mechanics, is an index test that has been widely used to predict the UCS value of rocks [7]. The rock samples used for testing can be in the form of cylinders or rock blocks. The recommended sample diameter is 50 mm in cylindrical form. According to (Broch & Franklin, 1972), the Point Load Index (I_s) of the rock sample can be calculated utilize Equation 1.

$$I_s = \frac{P}{D^2} \qquad (1)$$

Information :

$I_{s(50)}$ = Point-load strength indeks (MPa)

P = Maximum load (kN)

D = Cone distance (mm)

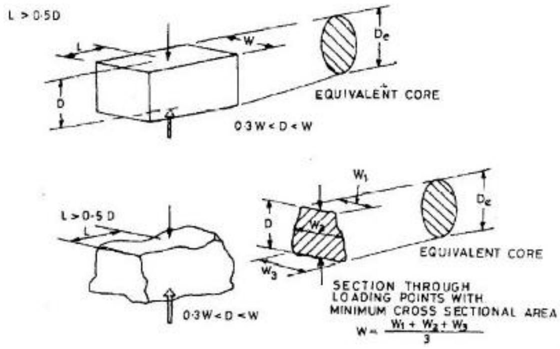

Figure 1. Point-Load Test Ilustration

The UCS test based on the (ISRM, 1981) Standard is conducted using a compression machine with a stress rate between 0.5–1.0 MPa/second. Compressive force is measured using a manometer gauge, while axial and lateral displacements are measured by installing dial gauges vertically and horizontally. According to the standard, the rock specimen should be cylindrical with an L/D ratio ranging from 2.5 to 3.0. The diameter of the rock sample should exceed NX size (approximately 54 mm). Both ends of the specimen must be ground flat to within 0.02 mm. The sides must also be smooth to ensure straightness along the length of the sample. An illustration of the UCS test is presented in Figure 2 (Kahfi, 2021).

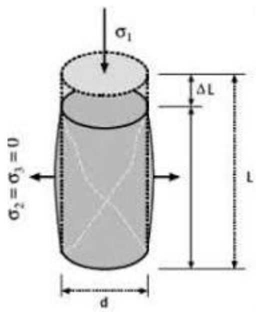

Figure 2. Uniaxial Compressive Test Ilustration

$$\sigma_c = \frac{F}{A} \qquad (2)$$

Information:

σ_c = Uniaxial-test strength indeks (MPa)
F = Force (kN)
A = Surface area sample (mm²)

The correlation between PLI and UCS is established based on the output obtained from previous mechanical property tests. in the book 'rock mechanics' written by Made Astawa Rai, it is stated that the conversion value from PLI to UCS is 23 (Rai, Kramadibrata, & Wattimena, 2014). Previous studies have shown that the conversion value varies for different types of rock, and even differs by location. To achieve greater accuracy, the equation is developed specifically for different rock types and locations. based on the data analysis conducted, the equation for σ_c presented in Table 1.

Table 1. Previously Published Research

Reference	Equation	Rock material
Brooch & Fransklin (1972)	$\sigma_c = 24\, I_{s(50)}$	Sandstone
Bienawski (1975)	$\sigma_c = 23\, I_{s(50)}$	Igneous Rock & Seminetary Rock
Kohno and Maeda (2012)	$\sigma_c = 16.4\, I_{s(50)}$	Hydrotermally Altered Rock
Schrier (1988)	$\sigma_c = 6.1\,(I_{s(50)}) - 3.3$	Igneous Rock (Breccia)
Adriansyah, et.,al. (2021)	$\sigma_c = 24.27\,(PLI)$	Sandstone
Kahfi (2021)	$\sigma_c = 12.93\,(PLI)$	Sandstone

The correlation-regression equation used by the author to determine the UCS value based on the PLI value in this research presented in Equation 3 to Equation 6.

$$r = \frac{n\,\Sigma(XY) - \Sigma(X)\,\Sigma(Y)}{\sqrt{(n\,\Sigma(X^2) - \Sigma(X)^2(n\,\Sigma(Y^2) - \Sigma(Y)^2)}} \quad (3)$$

$$Y_t = a + bX \quad (4)$$

With:

$$b = \frac{n\,\Sigma(XY) - \Sigma(X)\,\Sigma(Y)}{n\,\Sigma\,(X^2) - (\Sigma\,X)^2} \quad (5)$$

$$a = \frac{\Sigma(Y)\,\Sigma(X^2) - \Sigma(X)\,\Sigma(XY)}{n\,\Sigma(X^2) - \Sigma(X)^2} \quad (6)$$

Information:

r = Correlation value
n = Number of sample
a = Constant
b = Regression coefficient
X = Independent variable
Y = Dependent Variabel

Correlation values according to Guilford can be classified into several categories which can be seen in Table 2 (Guilford, 1973).

Table 2. Level of correlation value

Correlation (r)	Level
0,00 – 0,19	Very Low
0,20 – 0,39	Low
0,40 – 0,59	Medium
0,60 – 0,79	High
0,80 – 1,00	Very High

The resulting regression values still need to be tested for significance to meet the requirements through a comparison beetwen t_{table} and t_{count} (Figure 3). The α value is the maximum error determined (5%). Equation of t_{table} and t_{count} presented in Equation 7 and Equation 8.

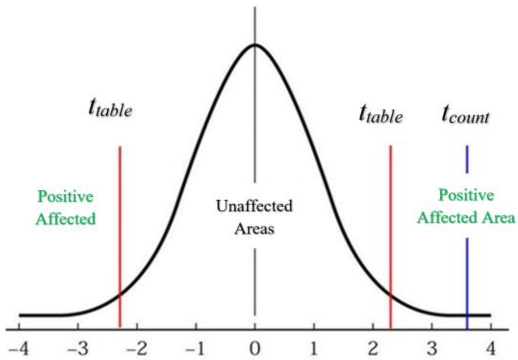

Figure 3. T-test

$$t_{table} = t_{\left(\frac{\alpha}{2}\right);(n-2)} \quad (7)$$

$$t_{count} = \frac{r\,\sqrt{n-2}}{\sqrt{1-r^2}} \quad (8)$$

The geological conditions of the Tumpang Pitu area are characterized by volcanic rock compositions consisting of volcanic breccia, tuff, volcanic sandstone, and interbedded andesite lava and limestone, which are included in the Batuampar Formation. During the Miocene, this formation was intruded by microdiorite, diorite, hornblende diorite, quartz diorite, and andesite porphyry. These intrusive rocks triggered hydrothermal activity that resulted in alteration in Tumpang Pitu and the surrounding area. Regional geological map is illustrated in Figure 4.

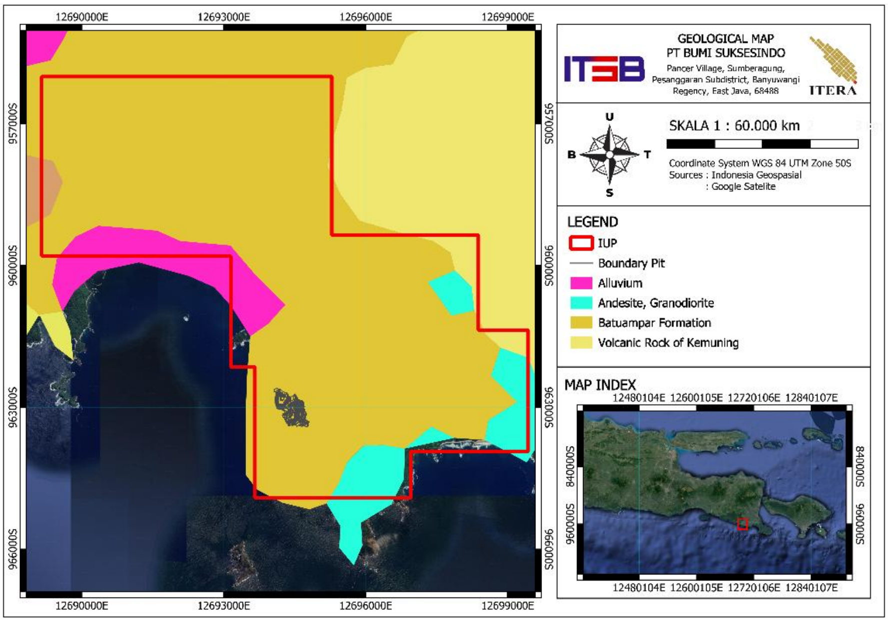

Figure 4. Regional Geological Map

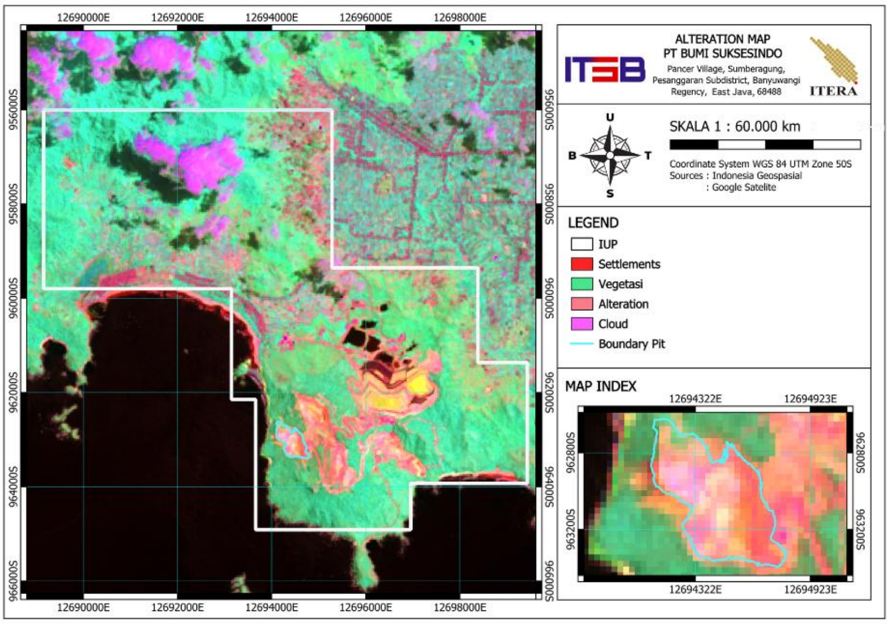

Figure 5. Research location alteration

III. RESULTS AND DISCUSSION

Results

The research location of Pit C PT Bumi Suksesindo is in Pesanggaran, Banyuwangi, East Java (8°37'9.12"S, 114° 2'13.30"E). Material sampling in Pit C PT Bumi Suksesindo was 21 samples at 4 drill points with coordinates shown in Table 3. The sampling location illustrated in Figure 6.

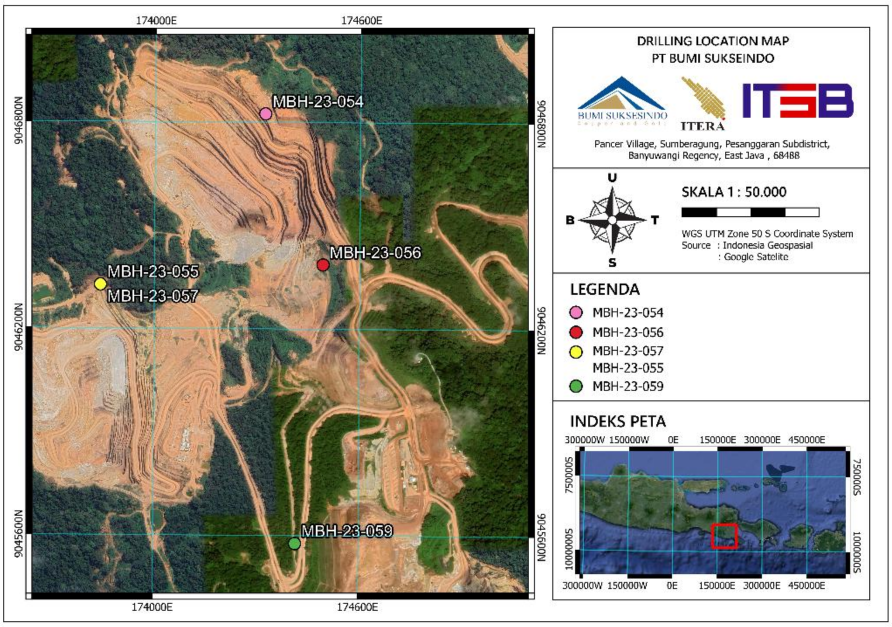

Figure 6. Research location map

Table 3. Material coordinate sampling

Sample Number	Easting (X)	Northing (Y)	Elevation (Z)
MBH-23-054	174321.45	9046824.17	375.24
MBH-23-055	173842.53	9046326.70	189.19
MBH-23-056	174492.13	9046386.54	356.50
MBH-23-057	173842.53	9046326.70	189.19

Utilize 21 of test data projected on a scatter plot in Microsoft Excel. Correlation-regression graphs based on UCS and PLI test data ilustrated in Table 4.

Table 4. PLI and UCS data

	Sample Number	UCS	PLI
1	MBH-23-054_UCS	45.30	3.05
2	MBH-23-054_UCS	56.18	2.82
3	MBH-23-054_UCS	37.64	2.34
4	MBH-23-054_UCS	43.83	2.75
5	MBH-23-054_UCS	22.98	1.56
6	MBH-23-054_UCS	24.71	2.59
7	MBH-23-054_UCS-46	19.59	2.14
8	MBH-23-055_UCS	31.72	1.51
9	MBH-23-055_UCS-79	51.46	3.63
10	MBH-23-055_UCS-77	82.84	5.36
11	MBH-23-055_UCS	48.21	2.30
12	MBH-23-055_UCS	39.67	1.91
13	MBH-23-055_UCS	85.71	6.11
14	MBH-23-055_UCS	36.43	3.71
15	MBH-23-055_TRX-54	37.24	2.05
16	MBH-23-055_UCS-51	44.74	2.91
17	MBH-23-058_UTS-71	9.36	0.89
18	MBH-23-053_UCS	9.23	0.79
19	MBH-23-054_UCS-053	3.26	0.34
20	MBH-23-057_UCS	38.97	3.53
21	MBH-23-057_UCS	22.47	0.86

Table 5. Descriptive Statistics PLI and UCS

Variable	Mean	PLI
UCS	37.692	21.115
PLI	2.531	1.434

Based on the results of correlation-regression analysis utilize scatter plot with 21 samples of hydrothermal clay altered material in Pit C of PT Bumi Suksesindo, the UCS value can be determined through the PLI value presented in Equation 9 and Figure 7.

$$UCS = 13.34Is(50) + 3.93 \quad (9)$$

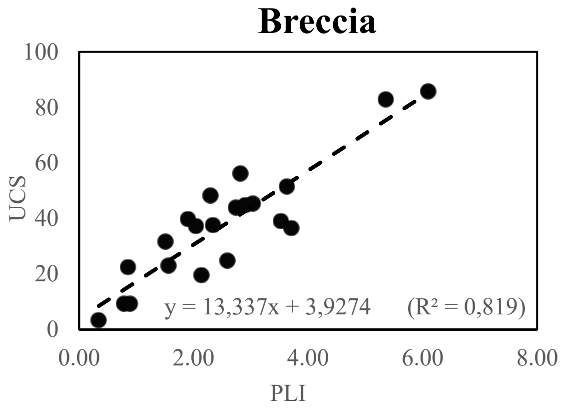

Figure 7. Correlation-Regression PLI Value to Predict UCS Value

Table 6. Model Summary of Linear Regression Between PLI and UCS

R	R Square	Adjusted R Square	Std. Error of the Estimate
0.905	0.819	0.810	921.596

Discussion

The analysis of variance (ANOVA) conducted for the linear regression model provides strong statistical evidence that the point load index (PLI) significantly explains the variability observed in uniaxial compressive strength (UCS). As shown in the ANOVA table, the regression sums of squares accounts for 7303.276 of the total variability, representing the portion of UCS variation that can be attributed to changes in PLI. In contrast, the residual sum of squares is substantially lower (1613.745), indicating that only a relatively small proportion of the variability remains unexplained by the model.

Table 7. ANOVA for Linear Regression Model (UCS as Dependent Variable)

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	7303.276	1	7303.276	85.988	0.000
Residual	1613.745	19	84.934	-	-
Total	8917.021	20	-	-	-

With df = 1 for the regression and df = 19 for the residuals, the computed mean square for the regression is 7303.276, whereas the mean square error is 84.934. The resulting F-statistic of 85.988 is exceptionally high, demonstrating that the explanatory power of PLI is far greater than what would be expected by chance alone. The associated significance value ($p < 0.001$) confirms that this effect is statistically significant at well beyond the 95% confidence level.

These results clearly indicate that the linear model provides a highly significant improvement over a null model with no predictors. In practical terms, the ANOVA outcome affirms that PLI exerts a meaningful and statistically reliable influence on UCS, thereby validating the suitability of the linear regression framework for describing the mechanical relationship between these two variables. The magnitude of the F-statistic further suggests that the regression model captures the essential structure of the data, with minimal unexplained variance relative to the total.

Overall, the ANOVA results substantiate the robustness of the PLI–UCS relationship and reinforce the conclusion that PLI is a strong and significant predictor of UCS within the studied hydrothermally altered breccia. This provides a rigorous statistical foundation for the development of an empirical strength estimation model applicable to geotechnical assessments where direct UCS measurements are limited.

Table 8. Results of t-test

Model	Unstandardized Coefficients (B)	Std. Error	Standardized Coefficients (Beta)	t	Sig.	95% Confidence Interval for B		Zero-order	Partial	Part
						Lower Bound	Upper Bound			
(Constant)	3.962	4.156	-	0.953	0.353	-4.738	12.661	-	-	-
PLI	13.327	1.437	0.905	9.273	0.000	10.319	16.335	0.905	0.905	0.905

Based on the regression results, the point load index (PLI) was found to be a statistically significant predictor of uniaxial compressive strength (UCS). The unstandardized regression coefficient for PLI is B = 13.327, indicating that for every 1-unit increase in PLI, the UCS is expected to increase by approximately 13.33 MPa, holding other factors constant. This magnitude of effect suggests a strong linear dependency between the two variables, which is also reflected in the standardized coefficient ($\beta = 0.905$). A β-value close to 1 implies that PLI accounts for a substantial proportion of the variability in UCS within the studied lithology.

The statistical significance of this relationship is reinforced by the t-value = 9.273, which far exceeds the critical t-value for 95% confidence, confirming that the slope coefficient differs significantly from zero ($p < 0.001$). The 95% confidence interval for the slope (10.319 to 16.335) does not cross zero, further validating the robustness of the linear association. In addition, the zero-order, partial, and part correlations are all equal to 0.905, reinforcing that the simple linear correlation between PLI and UCS is both strong and consistent even after controlling for model variance.

Based on the results and discussion above, the coefficient of determination ($R^2 = 0.82$) indicates that approximately 82% of the variation in UCS can be explained by PLI within this regression model. However, the use of R^2 as an indicator of relationship strength between two variables must be interpreted with caution. As noted by Ozer (1985), the coefficient of determination can be misleading when used to infer relational strength, and instead the correlation coefficient ($r = 0.905$) is a more appropriate metric for evaluating the strength of association. Using r aligns more closely with statistical principles governing bivariate relationships and provides a direct measure of correlation intensity.

Further supporting the strength of the model, the t-test yielded $t_{(count)} = 9.273$, which is substantially greater than $t_{(table)} = 2.093$ for $\alpha = 0.05$. Therefore, the null hypothesis—stating that PLI has no significant influence on UCS—is rejected with high confidence. This confirms that PLI is not only correlated with UCS but serves as a statistically reliable predictor. As such, the established regression model offers a defensible empirical basis for estimating UCS in altered breccia lithologies where conventional laboratory UCS testing is logistically constrained or impractical.

IV. CONCLUSION

This study set out to establish a site-specific empirical correlation between the point load index (PLI) and the uniaxial compressive strength (UCS) of hydrothermally clay-altered breccia from Pit C, PT Bumi Suksesindo, where conventional UCS testing is constrained by sample quality limitations and field logistical challenges. Through a combined methodological framework consisting of laboratory UCS tests, standardized point load testing, and regression–statistical analysis, the investigation successfully demonstrated that PLI can serve as a reliable and statistically significant predictor of UCS for this lithology.

The linear regression model derived from 21 representative samples yielded a high correlation coefficient ($r = 0.905$) and a coefficient of determination ($R^2 = 0.819$), indicating that approximately 82% of the observed variation in UCS can be explained by PLI. ANOVA confirmed that the model is highly significant ($F = 85.988$, $p < 0.001$), while the t-test showed that the regression slope is statistically different from zero ($t = 9.273 > t_{(table)} = 2.093$), affirming the robustness of the PLI–UCS relationship. The resulting empirical equation, $UCS = 13.34 \cdot Is(50) + 3.93$, reflects the mechanical response of hydrothermally altered breccia and highlights the influence of clay-rich alteration on weakening the intact rock strength relative to published correlations in unaltered or stronger rock units. These findings reinforce the necessity of site-specific calibration for altered volcanic terrains, where mineralogical and textural heterogeneity substantially modify strength behavior.

Overall, the study provides a practical and scientifically grounded correlation that can be directly integrated into the geotechnical workflow of Pit C. The model enables rapid estimation of UCS from point load measurements, thereby improving the efficiency of slope stability assessments, rock mass classification, and operational decision-making in environments where routine UCS testing is not feasible. Future work may expand this research by incorporating larger datasets, differentiating alteration zones (clay vs. non-clay dominant), or exploring non-linear and machine-learning–based predictive models to further enhance precision across broader geological conditions.

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REFERENCES

Adriansyah, Y., Krisnantara, G., & Setiadi, K. (2021). Korelasi point load index dan uniaxial compressive strength pada satuan batupasir dan batulempung Formasi Latih untuk penentuan koefisien kekuatan batuan di Pit X Tambang Batubara PT Berau Coal. Jurnal Geomine, 2(2), 9–16.

Agustawijaya, D. S. (2007). Mechanical characteristics of volcanic rocks in Indonesia. Engineering Geology, 90(1–2), 27–37.

Basu, A., & Aydin, A. (2006). A method for obtaining the point load strength index. International Journal of Rock Mechanics and Mining Sciences, 43(3), 399–415.

Bieniawski, Z. T. (1975). The point-load test in geotechnical practice. Engineering Geology, 9(1), 1–11.

Broch, E., & Franklin, J. A. (1972). The point-load strength test. International Journal of Rock Mechanics and Mining Sciences, 9(6), 669–697.

Hoek, E., & Bray, J. (1981). Rock slope engineering (3rd ed.). Institution of Mining and Metallurgy.

Hawkins, A. B. (1998). Aspects of rock strength. Bulletin of Engineering Geology and the Environment, 57, 17–30.

ISRM. (1981). Rock characterization, testing and monitoring: ISRM suggested methods (E. T. Brown, Ed.). Pergamon Press.

ISRM. (1985). Suggested methods for determining point load strength. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, 22(2), 51–60.

Jamshidi, A. (2022). A comparative study of point load index test procedures in predicting the uniaxial compressive strength of sandstones. Rock Mechanics and Rock Engineering, 55(10), 4507–4516.

Jamshidi, A., & Sousa, L. R. (2023). Correlation between point load index and uniaxial compressive strength: A state-of-the-art review. Geotechnical and Geological Engineering, 41, 1965–1987.

Jamshidi, A., & Sousa, L. (2024). Accuracy of point load index and Brazilian tensile strength in predicting the uniaxial compressive strength of rocks: A comparative study. Materials, 17(20), 5081.

Kahfi, M. Z. (2021). Analisis awal pendugaan nilai UCS dari nilai PLI untuk batu lempung dan batu pasir, PT Arutmin Indonesia Tambang Asam Asam, Kalimantan Selatan. In Prosiding Temu Profesi Tahunan (TPT) PERHAPI XXX dan Kongres XI (pp. 1–8).

Kohno, M., & Maeda, H. (2012). Relationship between point load strength index and uniaxial compressive strength of hydrothermally altered soft rocks. Geomaterials, 2(4), 85–91.

Kohno, M., & Maeda, H. (2012). Estimation of uniaxial compressive strength of soft rock based on point load index. *Japan Geotechnical Society Special Publication, 7*(1), 71–80.

Kohno, M., & Maeda, H. (2018). Influence of moisture conditions on point load index and UCS of hydrothermally altered soft volcanic rocks. Japan Geotechnical Journal, 13(1), 123–135.

Kolapo, P., & Munemo, P. (2021). Investigating the correlations between point load strength index, uniaxial compressive strength, and Brazilian tensile strength of sandstones: A case study of QwaQwa sandstone deposit. International Journal of Mining and Mineral Engineering, 12(1), 67–83.

PT Bumi Suksesindo. (2024). Point load test Pit C RL 135 Block 6 & 8: Sampling location and results. PT Bumi Suksesindo.

Rai, M. A., Kramadibrata, S., & Wattimena, R. K. (2014). Mekanika batuan. Institut Teknologi Bandung.

Sadeghi, E., Nikudel, M. R., Khamehchiyan, M., & Kavussi, A. (2022). Estimation of unconfined compressive strength of carbonate rocks by index tests and specimen size properties: Central Alborz Zone of Iran. Rock Mechanics and Rock Engineering, 55(2), 125–145.

Schrier, B. (1988). Correlation of point-load index with compressive strength for brecciated igneous rocks. Unpublished report cited in literature.

Supandi, S. M. (2022). Mekanika batuan. Mega Press.

Tsiambaos, G., & Sabatakakis, N. (2004). Considerations on strength of intact sedimentary rocks. Engineering Geology, 72, 261–273.

Wang, J., Yang, Y., Tan, Z., Li, D., & Liu, Q. (2022). Correction of point load strength on irregular carbonaceous slate in the Luang Prabang suture zone and prediction of uniaxial compressive strength. Applied Sciences, 12(18), 9147.

Wong, L. N. Y., Maruvanchery, V., & Liu, G. (2017). Strength of volcanic rock lumps using point load tests. Engineering Geology, 226, 236–244.