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Rock Durability and Abrasion Characteristics: A Case Study of the Nawakot Group in Bagmati Province

Sanjeeb Pandey[1*] and Kabi Raj Paudyal[1]

Central Department of Geology, Tribhuvan University, Kirtipur, Kathmandu, Nepal

*(*Corresponding Email: pandeysanjeeb1127@gmail.com)*

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Abstract: Rock durability and abrasion resistance are critical parameters influencing the suitability of materials for engineering and construction applications. This study examines the correlation between the slake durability index (Id_2) and Los Angeles Abrasion (LAA) loss for quartzite and gneiss samples collected from the Lesser Himalaya of Central Nepal, within 3–4 km of the Main Central Thrust (MCT) zone. Ten oriented, unweathered samples were tested following ASTM D4644 and ASTM C131 standards. The LAA values ranged from 24.75–31.63 for quartzite and 42.3–51.7 for gneiss, while the corresponding Id_2 values ranged from 97.33–98.64 and 95.38–97.24, respectively. Regression analysis yielded empirical relationships: $Id_2 = 102.78 - 0.16 \times LAA$ ($R^2 = 0.85$) for quartzite and $Id_2 = 103.89 - 0.16 \times LAA$ ($R^2 = 0.56$) for gneiss. The results indicate a strong inverse relationship between durability and abrasion loss, providing a practical framework for estimating rock quality in engineering design and material selection.

Keywords: ***Slake durability index, Los Angeles abrasion, Engineering properties.***

Introduction

The durability and abrasion resistance of rocks are vital parameters that determine their stability, performance, and long-term behavior in engineering and construction applications. Rocks are continuously subjected to natural weathering and mechanical stresses, and their ability to resist these effects directly influences the safety and longevity of structures. The Slake Durability Test (SDT), developed by Franklin and Chandra (1972), is a widely accepted method for assessing a rock's resistance to disintegration through repeated wetting and drying cycles. This test provides important insight into a rock's long-term performance under environmental conditions such as rainfall, humidity variation, and temperature changes. Rock durability, as emphasized by Franklin and Chandra (1972), serves as a key indicator of material quality and stability, particularly in slope engineering, where less durable rocks are more prone to erosion and failure.

The Los Angeles Abrasion (LAA) Test is another essential test used to evaluate the resistance of rock aggregates to abrasion, impact, and mechanical wear. It measures material loss caused by the grinding and collision of rock fragments with steel spheres in a rotating drum, reflecting the toughness and mechanical integrity of the material. Aggregates with lower abrasion loss values are generally considered more durable and are preferred for roads, bridges, and other heavy-duty structures (Bowles, 1997).

The primary objective of this study is to determine the correlation between Id_2 and LAA values for quartzite and gneiss rock types collected from the Lesser Himalaya of Central Nepal. By developing empirical relationships between these properties. This study aims to establish a correlation between the Slake Durability Index (Id_2) and Los Angeles Abrasion (LAA) loss for quartzite and gneiss from the Lesser Himalaya of Central Nepal, developing empirical relationships to enhance rock characterization, material selection, and quality control in engineering design and construction applications.

Methodology

A total of ten oriented rock samples, comprising five quartzite and five gneisses, were collected from the Lesser Himalaya region of Central Nepal. Sampling was performed from fresh, unweathered rock exposures at approximately 1-meter depth from the surface to minimize the influence of weathering. The specimens were prepared in the laboratory following relevant ASTM standards to ensure uniformity in size and shape. Each test sample consisted of 10–12 pieces with diameters between 45–55 mm and a total weight of about 450–500 grams. The samples were thoroughly cleaned, oven-dried, and visually inspected prior to testing to remove impurities or surface defects that could affect results.

The Slake Durability Test (SDT) was performed using a standard slake durability drum as per ASTM D4644 to determine resistance against disintegration during wetting and drying cycles. Each sample was subjected to two test cycles, and the second-cycle slake durability index (Id_2) was recorded. The Los Angeles Abrasion (LAA) Test, conducted according to ASTM C131, assessed abrasion resistance using a 5000-gram rock sample and a specified number of steel spheres rotated for 500 revolutions. The percentage weight loss after sieving represented the LAA value. All tests were performed under controlled laboratory conditions using metric units, and results were analyzed to establish empirical correlations between Id_2 and LAA values for both rock types.

Results and discussion

The slake durability test (SDT) was performed on ten rock samples, comprising five quartzite and five gneiss specimens (Figure 1: sample locations). The results indicate that the percentage of material retained after two wetting and drying cycles ranged from 98.12% to 99.01% for quartzite and 96.45% to 97.75% for gneiss. Based on these values, all samples are classified as extremely highly durable, as the SDI values exceed 95%.

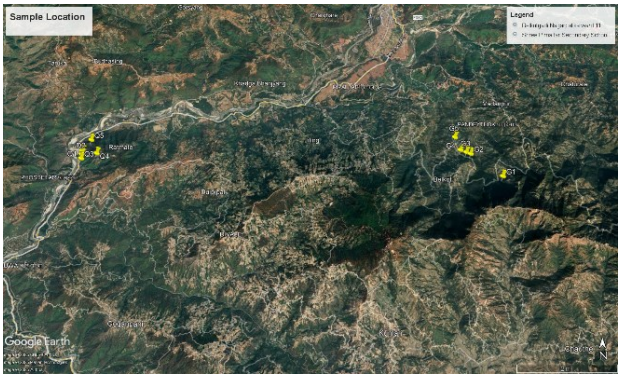

Figure 1, Sample location.

The Los Angeles Abrasion (LAA) test was conducted to evaluate the resistance of the same samples to mechanical wear and fragmentation. Quartzite samples exhibited LAA values ranging from 24.75 to 31.63, indicating moderate to high resistance, whereas gneiss samples showed values between 42.3 and 51.7, reflecting higher susceptibility to abrasion and fragmentation according to ASTM C131 standards. The detailed test results for all samples are presented in Table 1.

Table 1, Test result of quartzite and gneiss sample.

Sample No.	Los Angeles Abrasion Values	Slake Durability Index (Id1) Value	Slake Durability Index (Id_2) Value	Sample
Q-1	24.75	99.28	98.64	Quartzite
Q-2	26.35	98.96	98.47	
Q-3	29	99.38	98.25	
Q-4	30.95	98.61	97.89	
Q-5	31.63	98.84	97.33	
G-1	42.3	98.33	97.24	Gneiss
G-2	46.5	97.89	96.4	
G-3	49.3	98.25	97.02	
G-4	48.6	97.48	96.2	
G-5	51.7	96.82	95.38	

Conclusion

This study examined the relationship between the Slake Durability Index (Id_2) and Los Angeles Abrasion (LAA) values for quartzite and gneiss rock types collected from the Lesser Himalaya of Central Nepal. The findings indicate that quartzite possesses greater durability and abrasion resistance compared to gneiss, with Id_2 values ranging from 97.33–98.64 and LAA values from 24.75–31.63, while gneiss exhibits Id_2 values of 95.38–97.24 and LAA values of 42.3–51.7. The developed empirical relationships—$Id_2 = 102.78 - 0.16 \times LAA$ ($R^2 = 0.85$) for quartzite and $Id_2 = 103.89 - 0.16 \times LAA$ ($R^2 = 0.56$) for gneiss—demonstrate a distinct inverse correlation between durability and abrasion loss. These results highlight that rocks with lower LAA values tend to exhibit higher durability. The established correlations provide a practical approach for predicting one parameter from the other, thereby improving the efficiency, reliability, and cost-effectiveness of rock characterization for engineering design and material selection in construction projects.

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