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Abstract

Weathering processes due to heating and cooling, wetting and drying cycles, salt decay, and acidic rains (atmospheric pollution) can affect the durability and long-term behavior of rock masses and aggregates. The resistance of rocks to weathering can be described using a durability parameter referred to as slake durability index. The main purpose of this study is to evaluate the influence of weathering processes simulated by heating and cooling and wetting and drying on the durability of fine-grained and porphyritic

granites rocks from Ado-Ekiti, southwestern Nigeria. Petrographic and physical tests were carried out on the rocks using appropriate international standards. The slake durability test followed the procedure stipulated by ASTM D4644 standard was performed. The test cycles were conducted in wet (with distilled water) and dry (without water) conditions. The granites contain minerals such as quartz, microcline, hornblende, biotite, and muscovite. The fine-grained granite has lower water content, water absorption capacity, and porosity compared to porphyritic granite. The rate of mass loss decreases as the number of slaking cycles increased. This rate of mass loss is found to be higher at the early cycles than the final cycles. The maximum mass loss was observed in samples used for wet slake durability test. Slake durability indices of the granitic rocks decreased as number of slaking cycles increases and is higher in dry test than in wet test. Comparison between the results of dry and wet slake durability tests show that the effect of water on the rate of rock degradation differs in both rocks. The porphyritic granite is sensitive to water in terms of their slake durability compared to fine-grained granite. This may be attributed to the variation in physical properties of the granitic rocks.

Keywords (separated by '-')	Slake durability - Weathering - Granite - Petrographic characteristics - Slaking cycle

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Slake Durability of Granitic Rocks in Wet and Dry Conditions

Lekan Olatayo Afolagboye, Abel Ojo Talabi, and Olubunmi Oluwadare Owoyemi

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Abstract

Weathering processes due to heating and cooling, wetting and drying cycles, salt decay, and acidic rains (atmospheric pollution) can affect the durability and long-term behavior of rock masses and aggregates. The resistance of rocks to weathering can be described using a durability parameter referred to as slake durability index. The main purpose of this study is to evaluate the influence of weathering processes simulated by heating and cooling and wetting and drying on the durability of fine-grained and porphyritic granites rocks from Ado-Ekiti, southwestern Nigeria. Petrographic and physical tests were carried out on the rocks using appropriate international standards. The slake durability test followed the procedure stipulated by ASTM D4644 standard was performed. The test cycles were conducted in wet (with distilled water) and dry (without water) conditions. The granites contain minerals such as quartz, microcline, hornblende, biotite, and muscovite. The fine-grained granite has lower water content, water absorption capacity, and porosity compared to porphyritic granite. The rate of mass loss decreases as the number of slaking cycles increased. This rate of mass loss is found to be higher at the early cycles than the final cycles. The maximum mass loss was observed in samples used for wet slake durability test. Slake durability indices of the granitic rocks decreased as number of slaking cycles increases and is higher in dry test than in wet test. Comparison between the results of dry and wet slake durability tests show that the effect of water on the rate of rock degradation differs in both rocks. The porphyritic granite is sensitive to water in terms of their slake durability compared to fine-grained granite. This may be attributed to the variation in physical properties of the granitic rocks.

Keywords

Slake durability • Weathering • Granite • Petrographic characteristics • Slaking cycle

1 Introduction

The properties of rock masses or aggregates are greatly affected by the hot, humid, and rainy climate of the tropical regions. Rocks in these regions are influenced by weathering processes such as heating and cooling and wetting and drying. As opined by Momeni et al. (2015), the most significant gradual natural destructive process is weathering due to heating and cooling, wetting and drying, and freezing and thawing, catalyzed by the presence of water and salt as a principals decay agents, as well atmospheric pollution (acidic rain). Slake durability represents an important engineering parameter (Gökceoglu et al., 2000) and denotes "the degradability of rocks due to the process of physical and chemical decay as in exfoliation, disintegration, hydration, oxidation, and abrasion". Over the past years, there have been several studies on the slake durability and slaking properties of different rocks (Arman et al., 2021; Ghobadi & Momeni, 2011). These rocks were subjected to different wetting and drying cycles to assess the combined influence of pH of slaking fluid, the number of slaking cycles, and mineralogical composition on the disintegration behavior and durability of rocks (Gupta & Ahmed, 2007; Momeni et al., 2017; Yagiz, 2018).

Understanding the deterioration of rocks after repeated heating–cooling cycles is also important in places experiencing large daily temperature variations (thermal shock weathering) due to alternate heating and cooling of the rock

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surface because of solar radiation. This article aims to predict the effect of the weathering process on the durability of granitic rocks from Ado-Ekiti, SW Nigeria. This aim was achieved by carrying out Slake Durability Tests (SDT) in wet and dry conditions on samples of Fine-Grained Granite (FGG) and Porphyritic Granite (PG) from Ado-Ekiti, SW, Nigeria. A comparison between the dry and wet SDT results is used to elucidate the possible impact of water on the alteration of the granitic rocks.

2 Materials and Methods

Rock samples used in this study were collected from granitic batholiths in Ado-Ekiti, Nigeria. These granitic batholiths are part of the rocks of the Precambrian basement complex (PBC) of southwestern Nigeria, which underlies most parts of Ado-Ekiti. The granitic batholith comprises porphyritic granite, medium-grained granite, and fine-grained granite (Afolagboye et al., 2016). Rock samples were obtained from two varieties of granite found in Ado-Ekiti: fine-grained granite (FGG) and porphyritic granite (PG). The FGG and PG samples were taken, respectively, from their respective outcrops and a quarry site. About 400 * 400 * 600 mm block of each granitic rock samples was collected in the field. The selection of rock samples was based on freshness, weathering state, and homogeneity in macroscopic attributes such as fractures. Before performing slake durability tests (SDT), physical, textural, and mineralogical properties of the FGG and PG rock samples were determined using ISRM Standard (2007).

The mineralogical properties of the granitic rocks were observed by preparing thin sections and studying under a polarizing microscope and the images analyzed. The modal composition was obtained by point counting method. The physical and index tests including dry density, water absorption capacity, water content, porosity, point load test (PLT), as well Schmidt Rebound Hammer (SRH) test. The SHR test was held perpendicular to the surface of the block samples, and the readings were taken by a single operator. PLT was carried out at least three times, and the average values recorded.

On the granitic rock samples, two series of SDT were performed. The first series were undertaken under wet conditions ($T°$ of water = 20 °C) following the procedure stipulated by ASTM D4644 (2008). In order to evaluate the long-term durability of granitoids by monitoring mass loss and basing on the work of Momeni et al. (2017), eight slaking cycles were applied instead of two stipulated in this standard. The second series of SDT was like the first series in procedure except that the slaking was conducted under dry conditions, i.e., the test was conducted without slaking fluid in the trough. The rock fragments retained in the drum (after approximately 10 min of rotation) in both dry and wet SDT tests were heated at 110 °C for twenty-four hours for each slaking cycle, cooled, and their mass determined. In both dry and wet SDT, the mass loss was calculated following the formulate indicated by ASTM D4644 (2008).

3 Results and Discussion

3.1 Petrography

Two PG and two FGG samples from granitic batholiths were investigated petrographically for their mineralogical composition. The petrographic characteristics of the granitic rocks reflect the mineralogical characteristics and textural variations observed in hand specimens and on the outcrops. The PG is comprised of quartz (12–18%), feldspars (microcline, 16–23%; orthoclase, 18–21%; plagioclase, 20–26%), altogether making up about 54–63% of the total composition. Hornblende (6–9%), biotite (8–12%), and muscovite (1–2%) constitute the minor mineral components. The fine-grained granite comprises quartz (40–46%), microcline (6–7%), hornblende (32–35%), and biotite (5–10%), altogether making up about 89–93%.

3.2 Physical and Index Properties

The physical and index properties of the PG and FGG are presented in Table 1. The average water content, water absorption capacity, and porosity of the FGG are lower compared to those of the PG. On the other hand, the point load strength (PLS) and SRH values of FGG are higher compared to those of PG. The variation in properties of the two granitic rocks may be due to the variation in texture and degree of compactness of the rocks.

3.3 Slake Durability Test

Figure 1a shows the effects of the drying–cooling and wetting–drying cycles on the variation of mass loss of the granitic samples during the SDT. In both sets of tests, the rate of mass-loss decreased as the number of slaking cycles increased. The rate of mass loss is higher in the initial cycles than in the final cycles. In addition, the rate of mass loss is higher in wet SDT than in dry SDT. The greatest mass loss was observed in PG samples (wet SDT), while the least was observed in FGG samples (dry SDT).

Figure 1b shows the effect of the number of slaking cycles on the slake durability index in the two series of SDT. In the two-test series, slake durability indices of the granitic rocks decreased as the number of slaking cycles increased.

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Table 1 Physical and index properties of the granitic rocks

Rock type		*W* (%)	WAC (%)	η (%)	ρ (g/cm^3)	PLS (MPa)	SRH
PG	Range	0.27–0.5	0.51–0.98	0.45–0.56	2.6–2.64	7.84–9.81	50–56
	Mean	0.37	0.71	0.52	2.61	9.02	52.80
FGG	Range	0.06–0.1	0.39–0.53	0.089–0.67	2.53–2.65	14.71–16.67	50–52
	Mean	0.078	0.49	0.34	2.57	14.76	50.4

w water content; *WAC* water absorption capacity; η porosity; ρ density; *PLS* point load strength; *SRH* Schmidt rebound hammer

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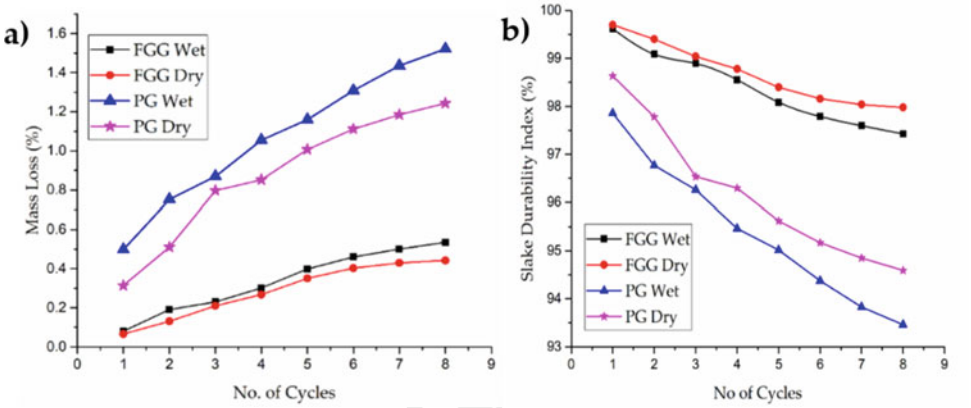


Fig. 1 Effect of slaking cycles on **a** mass loss, **b** slake durability index of the FGG

The slake durability index is higher in the dry test than in the wet test. Like mass loss, the rate at which the durability index decreased during the initial cycles was faster than during the end cycles. The FGG samples possessed a higher slake durability index in all the cycles and test series.

Comparison between the dry and wet SDT results suggests that the effect of water on the rate of rock degradation differs for the different granitic rock types. The PG is sensitive to water in terms of slake durability. For FGG, the obtained SDI values from the dry and wet testing were relatively similar, indicating that water has little influence on their rate of degradation. When compared with the durability classification provided by Broch and Franklin (1972), the most durable appeared to be the FGG, which has extremely high durability according to the classification. The PG, on the other hand, has very high to extremely high durability. The difference in the slake durability (in wet and dry tests) may be attributed to the slight difference in texture, degree of compactness, strength, and porosity of the rocks.

4 Conclusions

This study deals with the effect of the weathering process on the durability of on samples of fine-grained and porphyritic granite from Ado-Ekiti, SW, Nigeria, by using the SDT in wet and dry conditions. Petrologically, the granitic rocks are not significantly different in terms of observed mineral constituents but differ in terms of texture. The average water content, porosity, and water absorption of the FGG are lower compared to those of the PG. The mass loss against the number of slaking cycles curve reveals that the rate of mass loss decreases as the number of slaking cycles increases. Maximum mass loss was observed in samples used for wet SDT. Slake durability indices of the granitic rocks decreased as the number of slaking cycles increased. The slake durability index is higher in the dry test than in the wet test. The FGG samples have a higher slake durability index in all the cycles and test series. A comparison between the results of dry and wet SDT shows that the effect of water on the rate of rock degradation differs in both rocks. The PG is sensitive to water in terms of its slake durability compared to FGG. The PG with coarse texture, high porosity, and low strength is relatively more susceptible to degradation when in contact with water. The variations in material properties of the granitic rocks may be responsible for the difference in sensitivity to water.

References

Afolagboye, L. O., Talabi, A. O., & Akinola, O. O. (2016). Evaluation of selected basement complex rocks from Ado-Ekiti, SW Nigeria, as source of road construction aggregates. *Bulletin of Engineering Geology and the Environment, 75*, 853–865. https://doi.org/10.1007/s10064-015-0766-1

Arman, H., Abu Saima, M., Abdelghany, O., & Paramban, S. (2021). Comparative study on degradability characteristics of evaporitic and carbonate rocks from Al Ain, United Arab Emirates. *IOP Conference Series: Earth and Environmental Science, 906*, 012130. https://doi.org/10.1088/1755-1315/906/1/012130

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Author Proof

ASTM D4644_08. (2008). *Standard method for slake durability of shales and similar weak rocks*. ASTM International.

Broch, E., & Franklin, J. A. (1972). The point-load strength test. *International Journal of Rock Mechanics and Mining Sciences, 9*, 669–676. https://doi.org/10.1016/0148-9062(72)90030-7

Ghobadi, M. H., & Momeni, A. A. (2011). Assessment of granitic rocks degradability susceptive to acid solutions in urban area. *Environment and Earth Science, 64*, 753–760. https://doi.org/10.1007/s12665-010-0895-6

Gökceoglu, C., Ulusay, R., & Sönmez, H. (2000). Factors affecting the durability of selected weak and clay-bearing rocks from Turkey, with particular emphasis on the influence of the number of drying and wetting cycles. *Engineering Geology, 57*, 215–237. https://doi.org/10.1016/S0013-7952(00)00031-4

Gupta, V., & Ahmed, I. (2007). The effect of pH of water and mineralogical properties on the slake durability (degradability) of different rocks from the Lesser Himalaya, India. *Engineering Geology, 95*, 79–87. https://doi.org/10.1016/j.enggeo.2007.09.004

ISRM (International Society for Rock Mechanics). (2007). The complete ISRM suggested methods for rock characterization, testing and monitoring: 1974–2006. In R. Ulusay & J. A. Hudson (Eds.), *Suggested methods prepared by the commission on testing methods* (p. 628). Kozan Ofset.

Momeni, A., Hashemi, S. S., Khanlari, G. R., & Heidari, M. (2017). The effect of weathering on durability and deformability properties of granitoid rocks. *Bulletin of Engineering Geology and the Environment, 76*, 1037–1049. https://doi.org/10.1007/s10064-016-0999-7

Momeni, A., Khanlari, G. R., Heidari, M., Bagheri, R., & Bazvand, E. (2015). Assessment of physical weathering effects on granitic ancient monuments, Hamedan, Iran. *Environmental Earth Sciences, 74*, 5181–5190. https://doi.org/10.1007/s12665-015-4536-y

Yagiz, S. (2018). The effect of pH of the testing liquid on the degradability of carbonate rocks. *Geotechnical and Geological Engineering, 36*, 2351–2363. https://doi.org/10.1007/s10706-018-0467-1

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