VNUHCM Journal of Engineering and Technology 2026, 9(2):2872-2879

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Research Article

Study on Landslide Mechanism on Basaltic Soils in Lam Dong Province, Vietnam

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History

- Received: 25-09-2025
- Revised: 26-12-2025
- Accepted: 16-03-2026
- Published Online: 02-06-2026

DOI : https://doi.org/10.32508/vnuhcmj-et.v9i2.1545

ABSTRACT

This study investigated the key physical and chemical properties of basaltic soils in Lam Dong Province, Vietnam, and assessed their influence on slope stability under the region's distinct tropical monsoon climate. The integrated research methodology combined comprehensive field surveys, sampling across representative slopes with detailed laboratory analyses and numerical modeling. A total of 90 soil samples were collected and subjected to a series of tests to determine critical physical and mechanical parameters, including natural moisture content, Atterberg limits (liquid limit, plastic limit, and plasticity index), specific gravity, and grain size distribution. The stability of representative slopes was then simulated under varying rainfall infiltration scenarios using the finite element method in Plaxis 2D software. The experimental results revealed that the soils are characterized by a significant clay fraction ($\geq$ 30%), with the presence of expansive montmorillonite group minerals. This mineralogical composition promotes pronounced shrink-swell cycles in response to seasonal moisture variations, generating cracks and fissures that facilitate deeper water infiltration. The modeling and analysis further demonstrated that prolonged and intense monsoon rainfall critically reduces soil shear strength by markedly increasing pore water pressure and decreasing effective stress within the soil matrix. Concurrently, the chemical weathering process, particularly the dissolution and alteration of iron oxide (Fe_2O_3) cementing agents under the influence of naturally acidic rainwater, contributes to the long-term weakening of soil structure and further slope destabilization. Moreover, the slope stability modeling conclusively quantified the detrimental impact of rainfall, showing a significant reduction in the factor of safety for slopes during simulated events. This research elucidates the coupled hydro-mechanical and chemical mechanisms driving landslides in this setting, where intense weathering, high clay content, and monsoon hydrology interact. The findings substantially deepen the understanding of failure mechanisms in tropical red basaltic soils. Consequently, they provide a scientific basis for selecting and designing appropriate slope stabilization, drainage, and land-use planning interventions. This work is pivotal for developing integrated geotechnical and hydrological management strategies to mitigate landslide risks not only in Lam Dong Province but also across similar terrains in the Central Highlands of Vietnam, thereby contributing to enhanced resilience and natural disaster prevention.

Key words: Basaltic soil, slope stability, weathering, landslide

INTRODUCTION

Basaltic soil, also known as red basaltic soil, originates from the weathering of basalt, an igneous rock rich in iron and magnesium [1]. Under the influence of natural conditions (temperature, humidity, rainfall,...), the weathering process occurs strongly in humid tropical conditions, leading to the formation of fine-grained and clay-rich soils, significantly affecting the physical properties of the soil, especially the strength and stability of the slope [2,3]. In terms of physical properties, basaltic soil has high porosity, increasing the ability to absorb and retain water. Under conditions of prolonged heavy rain, rainwater can accumulate in the soil, reducing the interparticle bonding, leading to reduced shear strength [4,5]. In addition, the plasticity index of basaltic soils is often high, causing significant volume changes when humidity changes, causing swelling and shrinkage [3]. This increases the risk of cracking in the soil, creating favorable conditions for water to penetrate deeply, weakening the soil structure and increasing the risk of landslides. The weathering process and physical properties are strongly dependent on weather conditions, leading to the instability of basaltic soils in mountainous areas.

Under natural conditions, the permeability coefficient depends on the degree of weathering of basaltic soils [6]. For soils in a strongly weathered state, the permeability coefficient is usually low (<10^{-6} m/s), causing water accumulation in the soil, while soils with a weak weathering level may have a higher permeability coefficient, creating unstable seepage, causing underground erosion and destroying the soil struc-

Cite this article : Son N H, Ly K T, Tin H T. **Study on Landslide Mechanism on Basaltic Soils in Lam Dong Province, Vietnam**. *VNUHCM J. Eng. Technol.* 2026; 9(2):2872-2879.

ture[3,7]. In addition, the effective porosity in clay components is closely related to the permeability coefficient, a factor governed by the groundwater level in the soil. When the groundwater level rises, the pore water pressure increases, reducing the frictional force between soil particles and the shear strength of the soil, leading to slope instability[8]. The level of weathering, porosity and permeability of soils are governed by the weathering process and groundwater dynamics, contributing to the stability of slopes[6,9].

Chemically, basaltic soils contain high levels of iron oxide (Fe_2O_3), which tend to form stable compounds in dry conditions in the form of ferralitic soils[10]. Due to the leaching of alkaline cations (Ca^{2+}, Na^{+}, K^{+}), Fe and Al components will be concentrated, creating conditions for the formation of iron and aluminum oxides in the form of laterites[11]. The formation of laterites will facilitate the absorption of rainwater on the surface but the water retention capacity is poor, which reduces the consolidation capacity of the soil, causing instability of the slope.

The content of this study clarifies the influence of physico-chemical factors on soil stability under the influence of weathering factors and environmental conditions. The influence of weather conditions (rainfall, humidity,...) creates favorable conditions for the weathering process to take place strongly, contributing to reducing the stability of basaltic soil. In addition, when water seeps through cracks, water pressure can increase inside the soil and rock layer, reducing friction between the soil and the rock foundation, increasing the risk of landslides. In areas with large slopes, especially where there is strong erosion or human impact (excavation, construction), the instability becomes more serious[12].

This study provides the first integrated analysis of both the physical and chemical weathering mechanisms of basaltic soils in Lam Dong Province and incorporates these processes directly into rainfall-induced slope failure assessment. Understanding the above will help determine the landslide mechanism on basaltic soil, thereby being able to assess and control to prevent landslides from occurring. That is also the purpose of this study with the research scope being Lam Dong province, Vietnam.

RESEARCH METHODS AND NATURAL CONDITIONS

The research area is Lam Dong province, located on the southern part of the Central Highlands of Vietnam, with elevations ranging from about 800 m to over 1,500 m above sea level. This is situated at the headwaters of the Dong Nai – La Nga river system, with a relatively dense hydrographic network, including major rivers such as the Da Nhim, Da Dang, Cam Ly, and Dong Nai rivers, together with numerous streams and tributaries that play a vital role in the region's water balance and landscape dynamics. Lam Dong's climate is divided into two distinct seasons, the rainy season lasts from April to October, the dry season from November to April of the following year[13]. Rainfall statistics from 2014 to 2024, was collected at Da Lat Staion, most of which reach more than 2000 mm per year (see Figure 1). Heavy rains are often concentrated from June to September with the highest rainfall up to 80 mm/day.

In the research area, red-yellow ferralitic soil is at an altitude of 1000 – 1500 m and humus soil is at an altitude of 1500 – 2000 m above sea level[14]. With a humid tropical climate, steep mountainous terrain combined with high rainfall, and a long number of rainy days in the year, landslides frequently occur in the area[15].

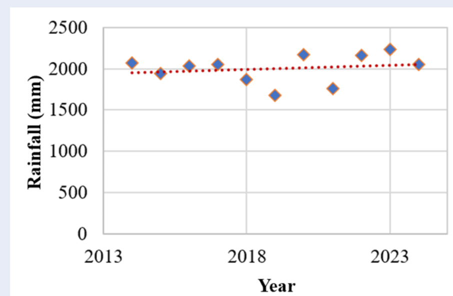

Figure 1: Annual rainfall at Da Lat station 2014 – 2024 (Source: The authors)

Field surveys were conducted to determine the natural status, geological structure and physical properties of basaltic soil in different areas. Soil samples were taken by hand drilling at depths of 0.5 m, 1.0 m and 1.5 m, three samples were carefully preserved at each depth to prepare for grain size analysis and testing of some basic physical and mechanical parameters in the laboratory. Figure 2 shows the survey location map.

The soil samples collected at the site will be analyzed in the laboratory. A total of 90 soil samples were tested in the laboratory with basic parameters such as grain size distribution, moisture content and plasticity index[15]. The dry sieving method is applied to particle size groups larger than 0.5 mm, the wet sieving method is applied to particle size groups larger than 0.1 mm, and the hydrometer method is applied to particle size groups smaller than 0.1 mm [16]. Moisture content is the percentage of water in the soil compared to dry soil. Soil samples in natural state are weighed to determine the mass, dried for a specified time, then weighed again to determine the dry soil mass [17]. The plasticity index is determined through the liquid limit and plastic limit, determined by the Cansagrande method and the rolling method, respectively [18].

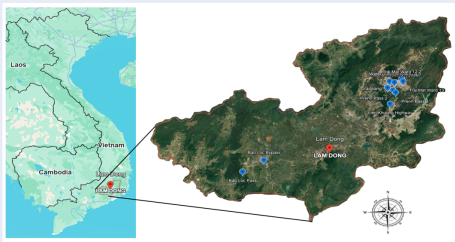

Figure 2: Research area and survey site locations (Source: The authors, developed using Google Earth imagery and map data)

In addition, slope stability is governed by many factors, including internal factors such as internal friction angle, cohesion, groundwater level and external factors such as load, weather, especially rainfall [3,8,19,20]. In this study, a numerical model was established to evaluate slope stability under certain geological and weather conditions. From the results of field surveys and laboratory experiments, a 2D Plaxis model was built using standard deformation boundaries (Xmin and Xmax normally fixed, Ymin fully fixed and Ymax free) and groundwater-flow boundaries (open at Xmin, Xmax and Ymax, closed at Ymin). A medium mesh was applied, and the simulation used a fully coupled flow – deformation analysis to consider the impact of rainfall on slope stability with rainfall data extracted during the period from May 14 to June 14, 2022 at Da Lat Station. The results show the correlation between rainfall and safety factor of the slope. Table 1 shows the physical and mechanical parameters used for slope stability calculations.

RESULTS

Physical parameters and geological structure

Figure 3 shows the distribution of 90 soil samples according to three main components: sand, clay and silt. The results show that the soil samples mainly belong to the groups of clay, clay loam, silty clay, sandy clay loam and sandy loam. Clay, clay loam and silty clay have high clay content (≥ 30%), are characterized by high cohesion, good water retention capacity but are also prone to swelling when soaked in water, increasing the risk of landslides. Meanwhile, silty clay and clay loam have a higher silt ratio, which helps improve porosity but still retains a lot of water, is prone to saturation and reduces strength when heavy rain lasts for a long time. The group of soils with high sand content, although able to drain faster, is less stable due to low cohesion, and is prone to strong erosion on steep slopes. The distribution of these soil types reflects the diversity of soil textures in different areas of Lam Dong province and shows that areas with high clay content are at higher risk of landslides, especially when the rainfall is prolonged. Therefore, soil structure assessment plays an important role in planning and proposing solutions to reduce landslide risks in these areas.

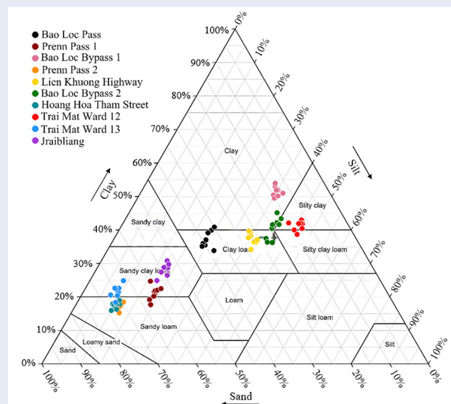

Figure 3: Soil texture triangle (Source: The authors)

Slope stability analysis

Figure 4 shows the relationship between cumulative rainfall and safety factor. In general, when the rainfall is prolonged, the cumulative rainfall increases, and the safety factor tends to decrease because the soil layers are mainly clay and clay loam, so they are easily swollen when heavy rain lasts for a long time, reducing the interparticle bonding and friction between soil particles, making the soil weaker. On the other hand, rainwater seeps into the soil, filling the voids, increasing the self-weight of the soil mass, and surface runoff easily causes surface erosion. Therefore, the larger the cumulative rainfall, the more unstable the slope becomes. However, in the early stage, the cumulative rainfall increases but the safety factor

Table 1: Input parameters for modeling (Source: The authors, extracted from project number B2024-20-20)

Parameter	Symbol	Unit	Layer				
			Layer 1	Layer 2	Layer 3	Layer 4	Layer 5
Behaviour					Drained		
					Mohr-Coulomb		
Natural unit weight	γ_{unsat}	kN/m^3	17.4	17.8	17.9	18.1	18.4
Saturated unit weight	γ_{sat}	kN/m^3	17.7	18.3	18.3	18.5	18.8
Poisson ratio	ν	-					
Elastic module	E	kPa	3379	4049	4150	4529	5045
Cohesion	c'	kPa	15	18	17.9	19.1	21.6
Internal friction angle	ϕ'	^{0}	14.03	16.45	16.49	17.03	17.41

still increases, which can be explained by "soil suction recovery" phenomenon: early rainfall slightly increases moisture in the upper desiccated layer, reducing matric suction but simultaneously enhancing apparent cohesion before full saturation occurs. Once the cumulative rainfall exceeds the infiltration threshold, pore pressure increases and FS begins to decrease.

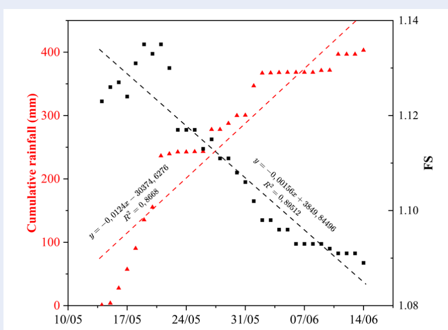

Figure 4: Effect of rainfall on slope stability (Source: The authors)

Figure 5 shows the deviatoric strain of the slope corresponding to the rain during the period from May 14 to 17, 2022. The results show that the greater the rainfall, the more obvious the failure surface is, on the 14th and 15th with the rainfall of only 0.8 mm/day and 3 mm/day, respectively, the deviatoric strain is relatively small, the affected zone is only formed at the foot of the slope. The rainfall intensity reaches 23.8 mm/day on the 16th, the deviatoric strain area spreads and reaches the maximum value at the foot of the slope, the failure surface has clearly formed, moreover, rain-induced surface loading becomes evident. As the rainfall intensity increases, the force due to rain acting on the surface becomes larger, by the 17th, this force is almost evenly distributed over the entire slope surface.

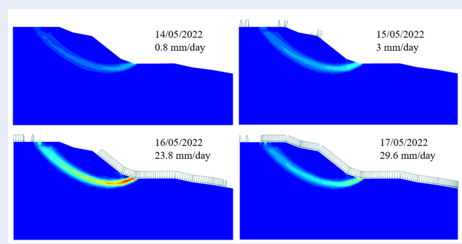

Figure 5: Changes in the failure surface of the slope from May 14 to 17, 2022 (Source: The authors)

DISCUSSION

Effect of rainfall on slope stability

Figure 6 presents the evolution of the factor of safety (FS) of a slope subjected to varying rainfall intensities ranging from 20 mm/day to 120 mm/day over a 30-day period. In the early stage (days 0 – 12), FS values remain relatively stable across all scenarios, suggesting a delayed response of slope stability to short-term rainfall.

However, a pronounced decline in FS is observed after this period, with the rate and magnitude of reduction strongly correlated with rainfall intensity. Under

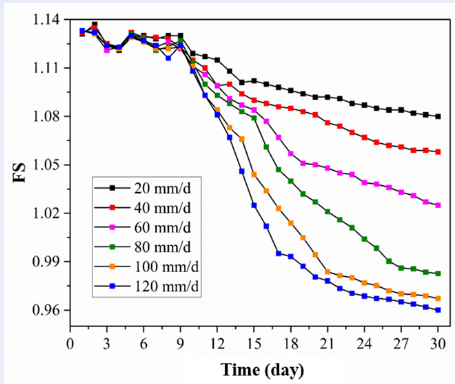

Figure 6: Relationship between rainfall intensity and slope stability (Source: The authors)

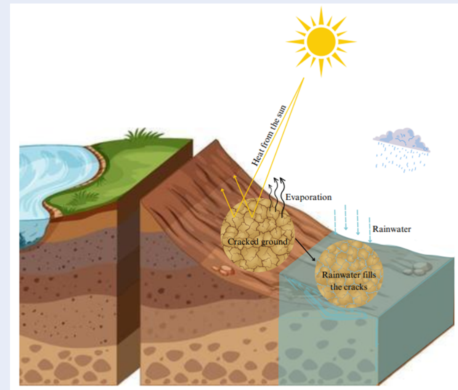

Figure 7: Soil response to the weather (Source: The authors)

extreme rainfall (120 mm/day), FS rapidly decreases and drops below the critical threshold of 1.00 around day 17, indicating potential slope failure. In contrast, FS under 20 mm/day remains consistently above 1.07 throughout the simulation, implying a minimal destabilizing effect. The results highlight that both the intensity and duration of rainfall are critical in governing the reduction in slope stability. These findings reaffirm that rainfall is a major triggering factor for slope failures, especially in regions with prolonged or high-intensity rainfall events. Therefore, incorporating rainfall thresholds and infiltration characteristics into slope stability assessments is essential for reliable landslide prediction and mitigation.

Slope stability is determined by physical properties

Figure 7 illustrates the behavior of basaltic soil with weather conditions. Shrinkage occurs in the dry season, it means when it is sunny, the temperature increases, the water in the soil evaporates, the groundwater level decreases, and cracks begin to develop on the surface. When a load is applied, the soil particles will rearrange and may cause subsidence. Conversely, when the rainy season comes, rainwater seeps down to fill the cracks, the soil particles absorb water and begin to swell, especially the clay mineral such as montmorillonite. This makes the soil weaker due to reduced shear strength. In addition, basaltic soil has poor water permeability, when the soil is saturated, rainwater cannot seep down and will flow over the surface, forming erosion channels. Therefore, prolonged heavy rain can easily destabilize the slope, leading to landslides.

Chemical reaction between basaltic soil and rainwater

Basaltic soil in Lam Dong province has similar characteristics to other provinces of the Central Highlands of Vietnam [21,22]. Statistics from some research results conducted in Di Linh - Bao Loc and Dak Lak are shown in Table 2.

The cation exchange capacity (CEC) of soil reflects the ability to retain and exchange cations such as Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}, CEC in soil samples in Di Linh - Bao Loc and Dak Lak is relatively high, indicating that the soil has good nutrient retention capacity [23,24]. However, high CEC also means that the soil has a high clay content (see Table 2), causing the soil to retain water and swell, making the soil easily weakened when it rains for a long time. When rainwater seeps into basaltic soil, the slightly acidic rainwater (due to CO_2 dissolved in the atmosphere forming H_2CO_3) reacts with basic oxides such as Fe_2O_3, CaO, MgO, Na_2O and under water saturation conditions to form bicarbonate. The dissolved ions will seep into deeper soil layers or flow into rivers and streams, creating voids in the soil (see Figure 8). In addition, the ion exchange process between H^{+} in rainwater and alkaline earth ions in the soil can cause the dispersion of clay particles, loss of cohesion and make the soil susceptible to landslides.

All these chemical reactions contribute to changes in soil structure, leading to reduced stability, especially on steep slopes or areas with high groundwater levels. During the rainy season, when the amount of water seeping into the soil increases, chemical reactions occur more strongly, combined with increased pore water pressure, basaltic soil is susceptible to saturation, reduced shear strength and landslides.

Table 2: Physical and chemical properties of red basaltic soil in some areas of the Central Highlands (Source: The authors, compiled from Nguyen TT & Luu TA (2017) [23] and Pham TT (2012) [24])

Location	Sand	Limon	Clay	Ca2+	Mg2+	CEC	Ref.
		%		meq/100g			
Di Linh	8.49 – 84.59	2.05 – 37.18	15.77 – 86.54	0.05 – 1.43	0.03 – 0.87	6.5 – 25.3	23
Dak Lak	15 – 25	16 – 20	55 – 69	3.7 – 5.5	0.5 – 0.8	14.45 – 17.55	24

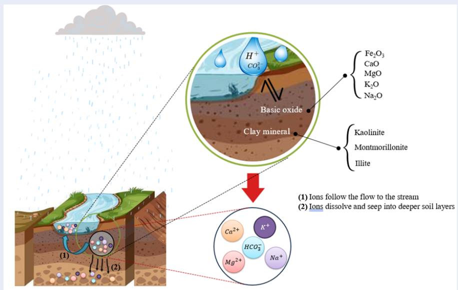

Figure 8: Rainwater changes the chemical composition of basaltic soil (Source: The authors)

CONCLUSION AND RECOMMENDATIONS

This study elucidates the relationship between the physicochemical properties of basaltic soil and the risk of instability in Lam Dong province, Vietnam. The main results include:

• Physical mechanism: Basaltic soil with high clay content increases water retention capacity but is easy to swell, reducing the interparticle bonding and friction between soil particles, leading to a decrease in shear strength when raining for a long time.

• Chemical mechanism: Acidic rainwater dissolves Fe_2O_3 and alkaline ions, creating voids and dispersing clay particles, further weakening the stability of the slope.

In addition, the results of the study will create a premise for forecasting and managing natural disasters under climate change conditions, with extreme rainfall characteristics, leading to the possibility of landslides in Lam Dong province and the Central Highlands region.

The main limitation of this study is the lack of direct determination of chemical properties, as some parameters were referenced from previous studies due to constraints in funding and time. Therefore, future research will focus on investigating the temporal and spatial variations in both the mechanical and chemical properties of basaltic soils to provide a more comprehensive understanding of their influence on landslide risk.

AUTHORS' CONTRIBUTIONS

Conceptualization, N.H.S. and H.T.T.; methodology, K.T.L., H.T.T., and N.H.S.; writing – original draft preparation, K.T.L. and H.T.T.; writing – review and editing, N.H.S.; visualization, N.H.S. and K.T.L.; supervision, N.H.S.; project administration, K.T.L. All authors have read and agreed to the published version of the manuscript.

COMPETING INTERESTS

The authors declare that they have no competing interests

ACKNOWLEDGEMENTS

This research is funded by Vietnam National University Ho Chi Minh City (VNU-HCM) under grant number: "B2024-20-20". We acknowledge Ho Chi Minh City University of Technology (HCMUT), VNU-HCM for supporting this study.

REFERENCES

1. Lewis AL, Sarkar B, Wade P, Kemp SJ, Hodson ME, Taylor LL, et al. Effects of mineralogy, chemistry and physical properties of basalts on carbon capture potential and plant-nutrient element release via enhanced weathering. Applied Geochemistry. 2021;132:132. Available from: https://doi.org/10.1016/j.apgeochem.2021.105023.
2. Anh LT, Thuy NT, Thanh ND, Nam HQ. Assessment of organic matter content in basalt soils under cultivation of major crops in Dak Lak province. Vietnam Journal of Earth Sciences. 2015;37(2). Available from: https://doi.org/10.15625/0866-7187/37/2/7366.
3. Zhang XW, Kong LW, Yin S, Chen C. Engineering geology of basaltic residual soil in Leiqiong, southern China. Engineering Geology. 2017;220:220. Available from: https://doi.org/10.1016/j.enggeo.2017.02.002.
4. Gutierrez NH, de Nóbrega MT, Vilar OM. Influence of the microstructure in the collapse of a residual clayey tropical soil. Bulletin of Engineering Geology and the Environment. 2009;68(1):107–16. Available from: https://doi.org/10.1007/s10064-008-0180-z.
5. Xia D, Zhao B, Liu D, Deng Y, Cheng H, Yan Y, et al. Effect of soil moisture on soil disintegration characteristics of different weathering profiles of collapsing gully in the hilly granitic region, South China. PLoS One. 2018;13(12). Available from: https://doi.org/10.1371/journal.pone.0209427.

6. Navarre-Sitchler A, Steefel CI, Yang L, Tomutsa L, Brantley SL. Evolution of porosity and diffusivity associated with chemical weathering of a basalt clast. Journal of Geophysical Research Earth Surface. 2009;114(2).
7. Eggleton RA, Foudoulis C, Varkevisser D. Weathering of Basalt: Changes in Rock Chemistry and Mineralogy. Clays and Clay Minerals. 1987;35(3):161–9. Available from: https://doi.org/10.1346/CCMN.1987.0350301.
8. Salem T, Hassan K, Mashhour M, AbuElella A. Assessment of Slope Stability Using FEM. In: The International Conference on Civil and Architecture Engineering. vol. 7 of 7; 2008.
9. A T. The effect of weathering on pore geometry and compressive strength of selected rock types from Turkey. Engineering Geology. 2004;75(3-4).
10. Nguyen QH, Egashira K. Clay Mineralogy of Ferralitic Soils Derived from Sedimentary and Metamorphic Rocks in Vietnam. Clay Science. 2007;13.
11. Kumar GS, Saini PK, Deoliya R, Mishra AK, Negi SK. Characterization of laterite soil and its use in construction applications: A review. Resources, Conservation and Recycling Advances. 2022;16:16. Available from: https://doi.org/10.1016/j.rcradv.2022.200120.
12. Nguyen LC, Do TN, Nguyen QD. Characteristics and Remedy Solutions for a New Mong Sen Deep-Seated Landslide. Vietnam: Sapa Town; 2023.
13. Tinh TT, Hai DN, Dung LB. Seasonal variation of phytoplankton in Tuyen Lam reservoir in Da Lat, Vietnam. Academia Journal of Biology. 2016;37(3).
14. Thanh DQ, Nguyen DH, Prakash I, Jaafari A, Nguyen VT, Van Phong T, et al. GIS based frequency ratio method for landslide susceptibility mapping at Da Lat City, Lam Dong Province, Vietnam. Vietnam Journal of Earth Sciences. 2020;42(1):55–66. Available from: https://doi.org/10.15625/0866-7187/42/1/14758.
15. Nguyen H, Khau T, Huynh T. Investigation of Natural and Human-Induced Landslides in Red Basaltic Soils. Water (Basel). 2025;17(17):1320. Available from: https://doi.org/10.3390/w17091320.
16. Vietnam Institute For Building Science And Technology. TCVN 4198:2014 - Soils - Laboratory methods for particle - size analysis.; 2014.
17. Vietnam Institute For Building Science And Technology. TCVN 4196:2012 - Soils - Laboratory methods for determination of moisture and hydroscopic water amount. ; 2012.
18. Vietnam Institute For Building Science And Technology. TCVN 4197:2012 - Soils - Laboratory methods for determination of plastic limit and liquid limit. 2012;.
19. Mburu JW, Li AJ, Lin HD, Lu CW. Investigations of Unsaturated Slopes Subjected to Rainfall Infiltration Using Numerical Approaches - A Parametric Study and Comparative Review. Sustainability (Basel). 2022;14(21):14465. Available from: https://doi.org/10.3390/su142114465.
20. Stewart BW, Capo RC, Chadwick OA. Effects of rainfall on weathering rate, base cation provenance, and Sr isotope composition of Hawaiian soils. Geochimica et Cosmochimica Acta. 2001;65(7):1087–99. Available from: https://doi.org/10.1016/S0016-7037(00)00614-1.
21. Nguyen TT, Luu TA. Assessment of Basalt Soil Quality under Different Land Use Types in Bao Loc - Di Linh Area, Lam Dong Province. Tạp chí Khoa học ĐHQGHN. 2017;33(3).
22. Liem NV, Bao DV, Bac DK, Hieu N, Hieu DT, Phong TV. Integrating Landsat 7 and 8 data to improve basalt formation classification: A case study at Buon Ma Thuot region, Central Highland, Vietnam. Open Geosciences. 2019;11(1).
23. Nguyen TT, Luu TA. . Assessment of Basalt Soil Quality under Different Land Use Types in Bao Loc - Di Linh Area, Lam Dong Province. . VNU Journal of Science. 2017;33(3).
24. Pham TT. Study of Land Use Characteristics Red Basalt (Ferralsols) Dak Lak Province. Vietnam Journal of Agricultural Sciences. 2012;10(7):1024–31.

VNUHCM Journal of Engineering and Technology 2026, 9(2):2872-2879

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Bài nghiên cứu

Nghiên cứu cơ chế trượt lở trên đất bazan tỉnh Lâm Đồng, Việt Nam

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TÓM TẮT

Nghiên cứu này tập trung làm rõ các đặc tính vật lý và hóa học của đất bazan tại tỉnh Lâm Đồng, Việt Nam, đồng thời đánh giá ảnh hưởng của các đặc tính này đến độ ổn định mái dốc trong điều kiện khí hậu gió mùa nhiệt đới đặc trưng của khu vực. Phương pháp nghiên cứu kết hợp giữa khảo sát thực địa, lấy mẫu tại các khu vực mái dốc đã, đang và có nguy cơ trượt lở, thí nghiệm trong phòng và mô hình hoá. Tổng cộng 90 mẫu đất đã được thu thập và tiến hành các thí nghiệm nhằm xác định các chỉ tiêu vật lý và cơ học quan trọng, bao gồm độ ẩm tự nhiên, giới hạn Atterberg (giới hạn chảy, giới hạn dẻo và chỉ số dẻo), khối lượng riêng và thành phần cấp hạt. Độ ổn định mái dốc được mô phỏng dưới các kịch bản mưa khác nhau bằng phương pháp phần tử hữu hạn, sử dụng phần mềm Plaxis 2D. Kết quả thí nghiệm cho thấy đất tại khu vực nghiên cứu có hàm lượng hạt sét cao ($\geq$ 30%), đặc trưng bởi các khoáng sét montmorillonit, điều này thúc đẩy các chu kỳ trương nở – co ngót mạnh theo sự biến đổi ẩm theo mùa, hình thành các khe nứt trong đất, từ đó tạo điều kiện cho nước mưa thấm sâu vào khối đất. Kết quả mô hình hóa chỉ ra rằng cường độ và thời gian mưa làm suy giảm nghiêm trọng sức kháng cắt của đất thông qua việc gia tăng đáng kể áp lực nước lỗ rỗng và giảm ứng suất hữu hiệu trong đất. Đồng thời, quá trình phong hóa hóa học, đặc biệt là sự hòa tan và biến đổi các chất liên kết oxit sắt (Fe_2O_3) dưới tác động của nước mưa có tính axit, góp phần làm suy yếu cấu trúc đất và gia tăng sự mất ổn định mái dốc. Hơn nữa, kết quả mô hình cũng đã định lượng rõ ràng tác động bất lợi của mưa, thể hiện qua sự suy giảm đáng kể hệ số ổn định của mái dốc trong các kịch bản mô phỏng. Nghiên cứu này làm sáng tỏ các cơ chế tương tác thủy – cơ và hóa học chi phối quá trình trượt lở trong điều kiện đất đỏ bazan nhiệt đới, nơi các yếu tố phong hóa mạnh, hàm lượng sét cao và chế độ thủy văn gió mùa cùng tác động. Các kết quả nghiên cứu góp phần quan trọng vào việc nâng cao hiểu biết về cơ chế phá hoại của đất bazan, đồng thời cung cấp cơ sở khoa học cho việc lựa chọn và thiết kế các giải pháp ổn định mái dốc, thoát nước và quy hoạch sử dụng đất phù hợp. Nghiên cứu có ý nghĩa thiết thực trong việc quản lý địa kỹ thuật – thủy văn nhằm giảm thiểu rủi ro trượt lở đất không chỉ tại tỉnh Lâm Đồng mà còn cho các khu vực có điều kiện địa hình – địa chất tương tự ở Tây Nguyên, qua đó góp phần nâng cao khả năng chống chịu và phòng tránh thiên tai.

Từ khoá: Đất bazan, ổn định mái dốc, phong hoá, trượt lở

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Lịch sử

- Ngày nhận: 25-09-2025
- Ngày sửa đổi: 26-12-2026
- Ngày chấp nhận: 16-03-2026
- Ngày đăng: 02-06-2026

DOI :
https://doi.org/10.32508/vnuhcmj-et.v9i2.1545

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Trích dẫn bài báo này: Sơn N H, Ly K T, Tín H T. **Nghiên cứu cơ chế trượt lở trên đất bazan tỉnh Lâm Đồng, Việt Nam** . *VNUHCM J. Eng. Technol. 2026; 9(2):2872-2879.*