Effect of Variations in Water Addition On Maximum Dry Weight in Clay Soil Compaction

Rina Dwi Fatika[1], Agata Iwan Candra[2*], Mahardi Kamalika Khusna Ali[3]

[1,2,3] *Civil Engineering Study Program, Faculty of Engineering, Kadiri University.*

Email : [1] rinafatika02@gmail.com. [2*] iwan_candra@unik-kediri.ac.id [3] mahardi@unik-kediri.ac.id

A R T I C L E   I N F O

A B S T R A C T

Soil is a crucial element in construction, serving as the foundation for structural support. Soil compaction is one of the primary methods to enhance soil stability, especially for clay soil, which expands and shrinks due to changes in moisture content. This study aims to analyze the effect of water content variation on the maximum dry unit weight in clay soil compaction. The experimental testing was conducted in the Civil Engineering Laboratory of Kadiri University using the TS-365 Automatic Standard Proctor machine. The water content variations used were 15%, 18%, 20%, 23%, and 26%. The results showed that the optimum moisture content for achieving the maximum dry unit weight was 23%, with a maximum dry unit weight of 1,743 g/cm³. Increasing water content up to the optimum point increases soil density, but excess water reduces the dry unit weight due to particle separation. This research contributes to optimizes clay soil compaction for more stable and sustainable construction. By determining the optimum moisture content, the compaction process can be conducted more efficiently, minimizing the risk of soil volume changes and improving soil-bearing capacity for long-term infrastructure development.

1.   Introduction

Soil is a fundamental element in every construction project as it is the natural foundation that supports the load of structures built upon it. The characteristics of soil vary significantly depending on its location and mineral composition [1]. Based on particle proportions, soil can be classified into several types, such as sandy soil, clay soil, and loamy soil [2]. Among these types, clay soil has distinctive characteristics that differentiate it from other soils, particularly in terms of plasticity and sensitivity to moisture content.

Clay soil exhibits unique properties that are highly influenced by changes in moisture content. When clay soil absorbs water, its volume expands, while during drying, it contracts.

This property, known as expansive behavior, can lead to significant volume changes [3]. This phenomenon directly impacts the stability of constructions built on such soil, posing risks such as structural cracks, reduced soil bearing capacity, and uneven ground settlement or movement [4]. Therefore, a thorough understanding of clay soil characteristics is essential in geotechnical engineering, particularly in efforts to enhance soil stability through effective soil improvement methods.

In many cases, construction projects situated on clay soil often face substantial challenges due to significant volume changes. For example, infrastructures such as highways, multi-story buildings, and bridges can suffer structural damage if adequate soil improvement measures are not implemented before construction begins. One of the initial steps in addressing this issue is to comprehend the technical properties of the soil and conduct optimal compaction to improve its bearing capacity.

One of the most common methods used to enhance soil bearing capacity is compaction. Soil compaction aims to reduce pore spaces between soil particles, increase density, and minimize movement potential due to moisture fluctuations [5]. By increasing soil density, stability also improves, allowing it to support construction loads more effectively. In practice, soil compaction is carried out through various methods, both mechanical and by adding stabilizing materials.

In soil compaction testing, one of the widely used methods is the Standard Proctor Test. This test aims to determine the optimum moisture content that yields the maximum dry unit weight. Moisture content plays a crucial role in the compaction process [6]. Water acts as a lubricant that helps soil particles arrange themselves more compactly. However, if the water content is excessive, it hinders compaction and reduces soil density. Therefore, determining the optimum moisture content in soil compaction is a crucial step in establishing an effective compaction strategy in the field.

The research was carried out at the Civil Engineering Laboratory of Universitas Kadiri, utilizing soil samples extracted from the backyard of Building J of Universitas Kadiri at an approximate depth of 1 meter. The soil is identified as clay, a type characterized by its high water absorption capacity. Given this property, compaction tests are required to assess the strength and stability characteristics of the soil at the study site.

In this study, compaction testing is conducted using the TS-365 Automatic Standard Proctor apparatus by incorporating specific moisture content variations into the soil samples before compaction [7]. The objective is to determine the optimum moisture content that results in the maximum dry unit weight. By identifying this optimum moisture content, the compaction process can be carried out more efficiently, thereby improving soil stability and reducing the risk of structural damage caused by soil volume changes.

The significance of this study is also linked to geotechnical challenges in various construction projects involving clay soil. In the context of infrastructure development in tropical regions, clay soil often experiences drastic moisture content fluctuations due to seasonal variations between rainy and dry periods [8]. During the rainy season, the soil may become overly saturated and lose its bearing capacity, while in the dry season, it can become excessively dry and undergo extreme shrinkage [9]. Therefore, understanding the compaction characteristics of clay soil based on moisture variations is crucial in developing effective compaction strategies.

Additionally, this research can contribute to the development of more efficient and environmentally friendly soil stabilization techniques. In some cases, clay soil with low bearing capacity can be improved by mixing it with additives such as lime or cement [10]. However, this approach often incurs additional costs and has environmental implications. Hence, by determining the precise optimum moisture content for the compaction process,

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mechanical stabilization methods can be optimized without the excessive use of additional materials.

This research holds significant value in the field of civil engineering, particularly in infrastructure development in areas with clay soil characteristics. By understanding the relationship between moisture content and maximum dry unit weight, compaction techniques can be applied more effectively in construction projects [11]. Furthermore, the findings of this study can serve as a reference for developing more efficient soil improvement methods to enhance soil bearing capacity in various environmental conditions.

Therefore, this study aims to analyze the effect of moisture content variations on the maximum dry unit weight of clay soil. By determining the optimum moisture content, the compaction process can be conducted more effectively, thereby improving soil stability and ensuring the success of constructions built upon it.

2.   Research Method

This study aims to analyze the relationship between variations in water content and maximum density of clay soil using the Standard Proctor Test method. To facilitate understanding of the research workflow, the following is a flowchart of the research method that describes the stages simply and systematically.
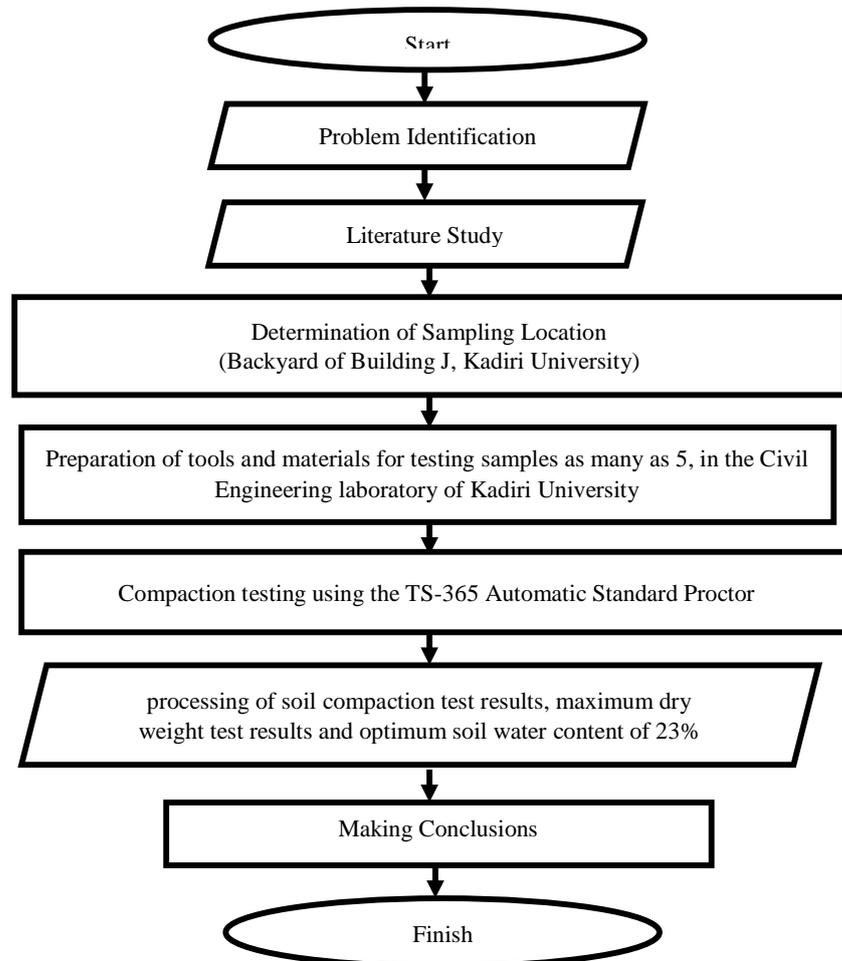

Figure 1. Flowchart Research Method

This study uses an experimental method conducted at the Civil Engineering Laboratory of Kadiri University. The test is focused on the soil compaction process using the TS-365 Automatic Standard Proctor machine. The compaction test was carried out with variations in

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water content to determine the optimum water content that produces maximum dry volume weight. The results of this test are expected to be a reference in optimizing the soil compaction process in the field.

This study only used two main materials, namely clay and water. Clay is a plastic soil and has a diameter of less than 4 micrometers. Clay has very small pores, so it easily absorbs air. Clay contains silicon, oxygen, and aluminum elements. Clay is a soil that is sensitive to changes in water content [12]. Meanwhile, air is a chemical compound that is colorless, odorless, and tasteless, which is composed of the chemical element H_2O [13], which has an important role in the compaction process by acting as a lubricant between soil particles, allowing the particles to be arranged more tightly. The variation of water content in this study was used to determine the optimum air content that produces the maximum dry volume weight, so that it can be a reference in the compaction technique of clay soil in the field [12].

The compaction test flow begins with preparing the materials. Soil samples were taken from the backyard of Building J of Universitas Kadiri, then dried in an oven at 110°C for 24 hours to remove the natural water content contained in them. After drying, the soil was crushed until smooth and sieved using a 40-mesh sieve, so that a more uniform grain gradation was obtained. The selection of a uniform gradation aims to ensure that the compaction results are not affected by differences in soil grain size. A total of ±10 kg of soil was used in the compaction test, which was carried out using the TS-365 Automatic Standard Proctor and CBR (California Bearing Ratio) machines to measure the density and bearing capacity of the soil after compaction [14].

Next, a 2000 g soil sample was mixed with water according to the variation of water content of 15%, 18%, 20%, 23%, and 26%. Each mixture was stirred until evenly distributed to ensure homogeneous water distribution in the soil. The mixture of soil and water was then put into a mold that had been smeared with oil to prevent the soil from sticking to the mold during the compaction process. Compaction was carried out in three layers, with each layer given 25 impacts using a TS-365 Automatic Standard Proctor machine. After all layers had been compacted, the soil sample was removed from the mold, then weighed to determine the total weight of the wet soil. After measuring the wet weight, the soil sample was dried again in an oven at a temperature of 110°C for ±24 hours to determine its dry volume weight [15].

3.   Description and Technical

This study aims to analyze the relationship between variations in water content and maximum density of clay soil through the compaction process using the Standard Proctor Test method. The clay soil used as a population was taken from the backyard of Building J, Kadiri University, which was chosen because it represents the type of soil that is often found in construction in the area. To ensure sample homogeneity, the soil was dried in an oven at a temperature of 110°C for 24 hours to remove the natural water content contained in it. After that, the soil was crushed until smooth and sieved using a 40-mesh sieve to obtain a more uniform particle distribution [16].

In this study, there are three types of variables determined, namely independent variables, dependent variables, and control variables. The independent variable is the variation in water content added to the soil with a percentage of 15%, 18%, 20%, 23%, and 26%, which aims to determine the optimum water content to achieve maximum dry volume weight. The dependent variable is the maximum dry volume weight obtained after the compaction process, which is the main parameter in determining the effectiveness of soil compaction [17]. Control variables include the compaction method using the TS-365 Automatic Standard Proctor, the number of impacts of 25 impacts per layer, and the initial condition of the soil that has been dried and screened before testing to ensure sample uniformity [18].

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To obtain accurate results, this study uses several main tools, namely the TS-365 Automatic Standard Proctor used for the soil compaction process [19], a 40-sized sieve to screen the soil to have a more uniform particle distribution, an oven at a temperature of 110 ° C to dry the soil before mixing with variations in water content, and a digital scale to measure the weight of the soil before and after the drying process. The use of these tools aims to maintain consistency in the testing procedure so that the results obtained are more valid and can be compared objectively.

The data obtained were analyzed using the Standard Proctor Test method, which includes calculating the wet volume weight and dry volume weight. The wet volume weight is calculated by dividing the total weight of the wet soil by the mold volume, while the dry volume weight is obtained from the comparison of the weight of the soil that has been dried in the oven with the mold volume [20]. The test results of the variation in water content are presented in the form of tables and graphs, so that the trend of changes in dry volume weight can be analyzed against the added water content.

The results of the analysis are used to determine the optimum water content, which is the highest point on the graph of the relationship between water content and dry volume weight. By knowing the optimum water content, the clay soil compaction technique can be optimized so that construction projects become more stable and efficient [21]. In addition, this study is expected to be a reference in determining clay soil compaction strategies in various field conditions, helping to improve infrastructure quality and minimizing the risk of decreasing soil bearing capacity due to changes in water content.

4.   Results and Discussions

The following are the results of laboratory tests showing the relationship between variations in water content and maximum dry volume weight in the process of compacting clay soil. The data obtained reflect changes in dry volume weight along with increasing water content until reaching the optimum point before experiencing a decrease due to excess water. The following is a picture of the results of the wet volume weight after the compaction test process was carried out on clay soil.

Source : image of research results (2025).
Figure 2. Image of wet soil weight after compaction test.

Details of the test results are presented in the following table.

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Table 1. Standard Proctor Test Results

TEST WEIGHT	Sample				
	15%	18%	20%	23%	26%
MOLD WEIGHT (g)	1678	1678	1678	1678	1678
WEIGHT OF WET SOIL+MOLD (g)	3240	3318	3496	3565	3510
WEIGHT OF WET SOIL (W) (g)	1562	1640	1791	1887	1832
OVEN DRY SOIL WEIGHT (Ws) (g)	1359	1395	1511	1538	1456
WEIGHT OF WATER (Ww)= W-Ws (g)	203	245	280	349	376
Water Content (Wc) = Ww/Ws*100 (%)	15%	18%	20%	23%	26%
MOLD VOLUME (V)= $\pi.r^2$. T (cm³)	882.48	882.48	882.48	882.48	882.48
WEIGHT VOLUME (γ) = W/V (cm³)	1.770	1.858	2.030	2.138	2.076
DRY VOLUME WEIGHT (γd) = Ws/V (g/cm3)	1.540	1.581	1.712	1.743	1.650

Source: laboratory research results (2025)

Based on the results of laboratory tests presented in Table 1, it can be seen that the dry volume weight of the soil increases with increasing water content until it reaches an optimum point at a water content of 23%, with a maximum dry volume weight of 1.743 g/cm³. This increase in dry volume weight indicates that water in the right amount can help arrange soil particles to be denser by reducing friction between particles, so that the soil reaches optimal compaction conditions. However, after passing the optimum point, there is a decrease in dry volume weight, indicating that excess water can have a negative impact on soil compaction.

At low water content, such as 15% and 18%, the resulting dry volume weights are 1.540 g/cm³ and 1.581 g/cm³, respectively. This value indicates that the soil is still in a less than optimal condition because the amount of water available is not enough to support the arrangement of soil particles optimally. The soil in this condition is still relatively dry, so that the soil particles cannot arrange themselves properly to achieve the highest density. As a result, the soil cannot reach a higher dry volume weight, indicating that there is still a large amount of empty space between the soil particles.

When the water content increases to 20%, the dry volume weight increases more significantly to 1.712 g/cm³. At this water content, water begins to act as a lubricant that helps increase the cohesion between soil particles, so that the arrangement of particles becomes denser. This mechanism is in accordance with the basic principle of soil compaction, where at optimal water content conditions, sufficient water will reduce the friction between particles, allowing soil particles to approach each other and produce greater density. This phenomenon also shows that at a water content of 20%, the soil begins to reach a better compaction condition compared to the previous water content.

At a water content of 23%, the maximum dry volume weight of 1.743 g/cm³ is achieved, indicating that at this point, the soil is in the most optimal density condition. At this condition, the amount of water in the soil is sufficient to fill some of the soil pores without causing excess water that can inhibit compaction. At this optimum point, the cohesion force between soil particles is at its most ideal level, so that the soil can be compacted with maximum efficiency. Therefore, a water content of 23% can be considered as the optimum water content for the soil tested in this study, because it provides the highest dry volume weight indicating maximum density.

However, when the water content increases to 26%, the dry volume weight actually decreases to 1,650 g/cm³. This decrease occurs because excess water fills the soil pores, causing soil particles to begin to lose optimal direct contact. As a result, soil particles begin to be pushed away from each other by excess water, which causes the dry volume weight to decrease. This phenomenon is in line with the concept of soil compaction, where at too high a water content, water begins to act as a separating agent that reduces friction and cohesion

between soil particles, so that the soil loses its density. In other words, excess water does not help increase soil density, but instead inhibits the compaction process.

In addition, this study confirms that the relationship between water content and dry unit weight is non-linear. Initially, increasing water content increases soil density by acting as a lubricant for soil particles. However, after the water content exceeds the optimum limit, excess water acts as a separator between soil particles, reducing compaction efficiency. Therefore, controlling water content in the compaction process is very important to ensure that the soil achieves maximum density and long-term stability. The results of this study can also be used as a reference in optimizing the use of resources in construction projects. By knowing the optimum water content, the compaction process can be carried out more efficiently, reducing the need for labor, work time, and excessive use of heavy equipment.

This not only reduces construction costs but also improves project sustainability by reducing environmental impacts due to unnecessary use of energy and additional materials. Therefore, this study makes an important contribution to the fields of geotechnical and civil engineering, especially in the planning and implementation of projects involving clay as a basic construction material.

From the calculations in Table 1, a soil compaction graphic model is produced which can be seen in Figure 3.
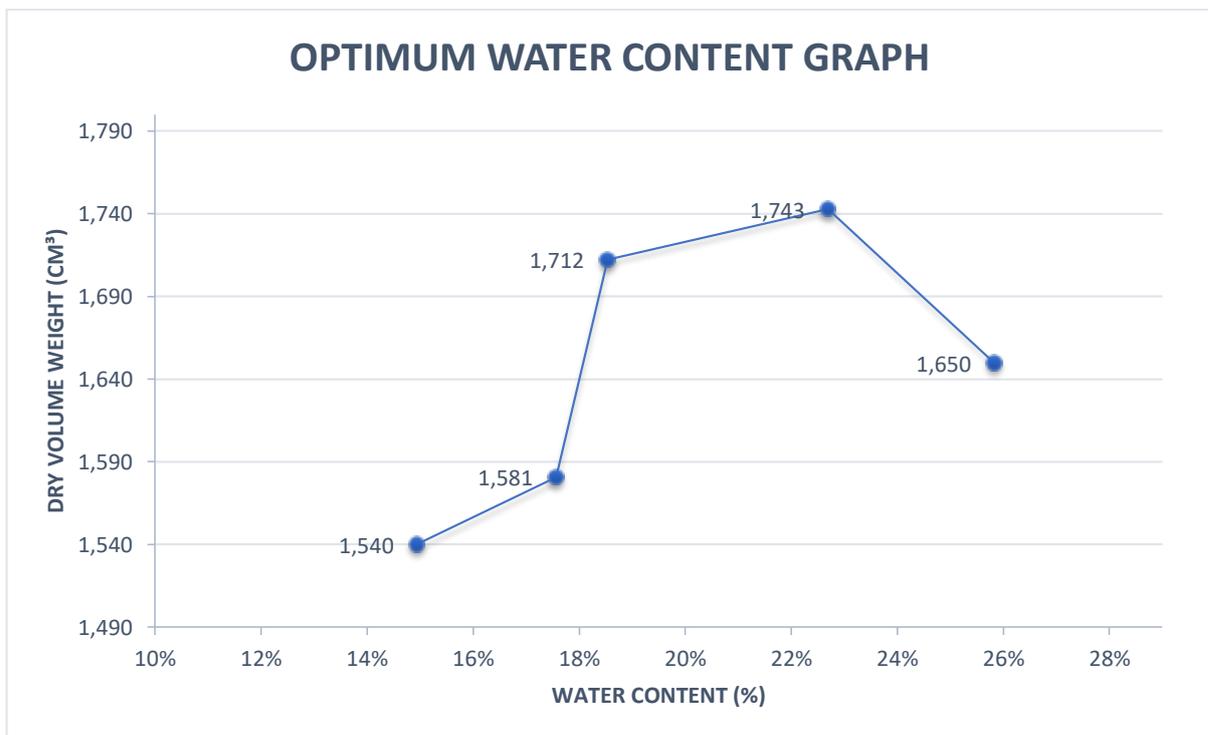
Source: laboratory research results

Figure 3. Graphic image of soil compaction test results

Based on the optimum water content graph, it can be seen that the dry volume weight of the soil increases with increasing water content until it reaches a maximum value at a water content of 22% with a dry volume weight of 1.743 g/cm³. After passing this point, the dry volume weight decreases at a water content of 26%, where the dry volume weight value drops to 1.650 g/cm³. This phenomenon indicates the existence of an optimum water content, which is the water content at which the soil reaches its maximum density before decreasing due to excess water which reduces the effectiveness of compaction.

The increase in dry volume weight at the beginning of the increase in water content is caused by the presence of water which functions as a lubricant between soil particles. This

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allows soil particles to be arranged more tightly and increases soil density. However, after passing the optimum water content, excess water actually fills the pore space in the soil, reducing contact between particles, and causing density to decrease. This is what causes the dry volume weight to decrease at higher water content.

The results of this study are in line with research conducted, which found that the optimum water content is in the range of 20–23%, with the maximum dry volume weight also experiencing a decreasing pattern after passing the optimum point. Explained that after the water content exceeds the optimum point, excess water causes the soil to become more susceptible to deformation, so that its density decreases. This is in accordance with the data obtained in this study, where the dry volume weight decreases after reaching a water content of 22% [7].

In terms of application, these results are very important in the field of civil engineering, especially in the process of soil compaction for infrastructure development. Knowing the optimum water content allows engineers to determine the right water content to achieve maximum density, thereby increasing the stability and bearing capacity of the soil. If the water content is too low, the soil has difficulty reaching maximum density, while if it is too high, the soil becomes saturated and loses its bearing capacity.

There are several implications that can be applied in the construction world to improve soil efficiency and stability. One of the main implications is improving the compaction process in the field, where by knowing the optimum water content, contractors can reduce the number of direct compaction trials and immediately apply the appropriate water content. This will save time and optimize labor in construction projects. In addition, controlling water content in road and foundation construction is an important factor in preventing soil deformation due to expansion and shrinkage. By adjusting the water content according to the research results, the risk of structural damage due to changes in soil volume can be minimized. Furthermore, this research also contributes to cost efficiency in large-scale construction, because by finding the optimum water content, the use of additional materials such as cement or stabilizers can be reduced, and the use of heavy equipment can be more efficient. Thus, the application of the results of this research will support the development of more stable, sustainable, and cost-effective infrastructure.

5. Conclusion and Suggestion
5.1 Conclusion

The results showed that water content has a significant effect on the density of clay soil. The dry volume weight increases with increasing water content until it reaches an optimum point at a water content of 23%, with a maximum dry volume weight of 1.743 g/cm³. At this water content, the soil reaches the best compaction condition because the amount of water available is sufficient to help arrange soil particles more tightly. However, after passing the optimum water content, the dry volume weight decreases due to excess water filling the soil pores, reducing interparticle cohesion, and inhibiting the compaction process.

This phenomenon is in accordance with the principle of soil compaction, where there is a parabolic relationship between water content and dry volume weight. If the water content is too low, the soil has difficulty reaching maximum density, while if it is too high, the soil becomes saturated and loses its bearing capacity. Therefore, in construction practice, controlling water content is very important to ensure that the soil reaches maximum density, increases bearing capacity, and maintains the stability and resilience of the structure above it. Choosing the right water content in the compaction process can also increase work efficiency and reduce the risk of soil subsidence and deformation in the future.

By implementing the results of this research, construction projects can improve the efficiency and resilience of infrastructure, support the principles of sustainable development, and reduce environmental impacts due to suboptimal soil compaction.

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5.2   Suggestion

For further research, it is recommended to test more variations of water content with a smaller range to obtain more accurate results regarding the optimum water content. In addition, the study can be expanded by testing other types of soil, such as sandy soil or laterite soil, to determine the differences in their compaction characteristics. Compaction tests should also be conducted under more varied field conditions to understand the influence of external factors such as compaction pressure and holding time on the final results. In addition, further analysis of soil stability after compaction for a certain period of time will be very useful in ensuring the effectiveness of compaction techniques for sustainable construction.

References

[1]   X. Gu and Y. Ling, "Characterization and properties of Chinese red clay for use as ceramic and construction materials," *Sci. Prog.*, vol. 107, no. 1, pp. 1–17, 2024.

[2]   F. Nursandah, F. N. Y. Puteri, A. I. Candra, Y. C. P. Setianto, and M. H. Nastotok, "The Effect of Addition of Stone Ash to Shear Strength of Clay Soil in Suruh Trenggalek," *Civilla J. Tek. Sipil Univ. Islam Lamongan*, vol. 6, no. 1, 2021.

[3]   I. Ardiansah, Zainuri, and M. Anggraini, "Experimental Study of Addition of Plastic Waste (PET) to the Shear Strength of Clay Soil," *Civilla J. Tek. Sipil Univ. Islam Lamongan*, vol. 7, no. 2, pp. 161–170, 2022.

[4]   B. Y. Akhafaji, R. J. Elkheralla, and A. S. Abdulhasan, "Application of Sewage Sludge and Its Impact on Soil Characteristics, Including Morphological and Biochemical Properties of Vigna radiata Plant," *Asian J. Water, Environ. Pollut.*, vol. 18, no. 4, 2021.

[5]   S. Perdana and Wawan, "Effect Of Compaction Of Peatland On The Physical Properties At The Two Different Locations," *JOM Faperta*, vol. 2, no. 2, 2020.

[6]   F. Susilowati, Z. F. Haza, and D. Sulistyorini, "Studi Eksperimental Pengujian Pemadatan Tanah Di Gunungkidul Dengan Metode Standard Proctor," *Renov. Rekayasa Dan Inov. Tek. Sipil*, vol. 4, no. 1, 2019.

[7]   Nurmaidah, "Uji Pemadatan Standar Dan Uji Pemadatan Modified Terhadap Tanah Yang Dicampur Kapur," *JCEBT (Journal Civ. Eng. Build. Transp.*, vol. 6, no. 1, pp. 1--12, 2022.

[8]   V. W. Susilo, D. Christian, D. Tjandra, and P. S. Wulandari, "Variasi Kuat Kokoh Tanah Lempung Ekspansif Akibat Perubahan Musim," *J. Dimens. Pratama Tek. Sipil*, vol. 5, no. 2, 2016.

[9]   E. Armanto and E. Wildayana, *Keunikan Dan Kemampuan Lahan Gambut*. Palembang: Unsri Press, 2023.

[10]   Y. Zhao, L. Wu, and X. Li, "NMR-based pore water distribution characteristics of silty clay during the soil compaction, saturation, and drying processes," *J. Hydrol.*, vol. 636, 2024.

[11]   A. Julianto, L. Afriani, Iswan, and A. D. Putra, "Pengujian Permeabilitas Tanah Yang Dipadatkan Dengan Metode Modified Proctor Cubic Permeameter," *JRSDD*, vol. 9, no. 4, pp. 910–920, 2021.

[12]   W. Liu, X. Huang, X. Feng, and Z. Xie, "Compaction and bearing characteristics of untreated and treated lateritic soils with varying moisture content," *Constr. Build. Mater.*, vol. 392, 2023.

[13]   Susana, "Air Sebagai Sumber Kehidupan," *J. Oseana*, vol. 17, no. 3, pp. 17–25, 2023.

[14]   M. Mumayyizah *et al.*, "Menentukan Klasifikasi Dan Karakteristik Tanah Daerah Bendiljati, Sumbergempol Tulungagung Menggunakan Uji Laboratorium," *Rang Tek. J.*, vol. 7, no. 1, pp. 18–30, 2024.

[15]   J. R. Oluremi and K. Ishola, "Compaction and strength characteristics of lead contaminated lateritic soil treated with eco-friendly biopolymer for use as road foundation material," *Hybrid Adv.*, vol. 5, pp. 1–12, 2024.

[16] R. Okalebo, K. W. Gathua, and P. L. Woomer, *LABORATORY METHODS OF SOIL AND PLANT ANALYSIS: A Working Manual*, The Second. Nairobi, Kenya: Sacred Africa, 2022.

[17] W. Diana, E. Hartono, A. S. Muntohar, and K. Wulandary, "Evaluasi Pemadatan Tanah pada Proyek Pembangunan Gedung," *Media Komun. Tek. Sipil*, vol. 28, no. 1, pp. 1–8, 2022.

[18] N. A. Fatkunada, A. Iwan, and D. Setiawan, "Experimental Study of Soil Compaction with Proctor Standard Test Equipment," *CIVED*, vol. 11, no. 2, pp. 495–502, 2024.

[19] A. N. Mahajana, A. Salim, and I. N. Di. P. Putra, "Kepadatan Tanah Timbunan Menggunakan Metode Sand cone Pada Proyek Pembangunan Jalan Lintas Selatan (JLS) Lot 2 Bululawang – Sidomulyo – Tambakrejo," *J. Talent. Sipil*, vol. 8, no. 1, p. 367, 2025.

[20] W. Utami, Setyanto, and R. Sulistyorini, "Korelasi Uji Pemadatan Standard Proctor Method Terhadap Pengujian CBR Laboratorium Berdasarkan Alat Uji Tekan Modifikasi di Laboratorium Untuk Pemadatan Tanah di Lapangan," *JRSDD*, vol. 7, no. 1, pp. 113–122, 2019.

[21] A. K. Khotima, "Stabilitas Tanah Lempung Dengan Menggunakan Pasir Monpera Balikpapan dan Pengaruhnya terhadap Nilai Daya Dukung Tanah (Studi Kasus Pada Km.8 Arah Stt Migas Menuju Tembusan Pantai Manggar)," *J. Tugas Akhir Tek. Sipil*, vol. 5, no. 2, p. 13, 2021.

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