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THE ROLE OF ADDITIONAL CERAMIC WASTE ON EXPANSIVE CLAY STABILITY

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ABSTRACT

One of the construction problems is often due to poor technical properties of the soil, unstable soil, and poor soil bearing capacity is one of the causes of high shrinkage expansion. The purpose of The study was the use of ceramic waste as a stabilizing agent for expansive clay. Expansive clay samples were taken in undisturbed and disturbed conditions. Variations in addition of ceramic waste to clay are 0%, 5%, 10%, 15% and 20%. Physical properties were tested (moisture content, specific gravity, atterbeg and proctor limits) mechanical properties (free swelling). The results showed that the ceramic handicraft industry waste as a soil stabilizing agent showed that the results of the physical properties decreased in water content and specific gravity was quite consistent. In addition, the stress value increases after mixing ceramic waste are related to mechanical properties, and the longer the incubation day, the higher the swelling volume and the highest swelling volume in a mixture of 5% ceramic waste.

Keywords Ceramic waste, expansive clay, physical properties, mechanical properties.
Paper type Research paper

INTRODUCTION

Soft soils cause instability problems and long-term settlement, and they have low shear strength and high compressibility. Soft soil is divided into expansive clay soil and peat soil [1]. Civil engineering work cannot be separated from the most important aspect, namely land. One of the construction problems is often the result of poor soil technical properties, such as high soil moisture content, high comparability and low bearing capacity. Some of the soil types with these bad properties are soils that are easy to develop and shrink [2], [3]. Some types of soil that have the potential for large swelling and shrinkage are soils that can experience significant changes in volume along with changes in water content. The type of soil is clay soil containing many minerals with high swelling potential. Soil with The condition is often referred to as expansive clay [4], [5]. Polypropylene Polymer (PP) is usually used in improving soil stability, which is quite expensive. The cost of increasing the stability of the soil causes the price of construction to increase.

Many studies on the stabilization of clay soils have been carried out previously to improve soils with a mixture of various materials, including lime, cement, fly ash, red stone powder, bagasse ash, rice husk ash, and other materials. The results showed an improvement in the clay soil condition, both in its physical and mechanical properties [6], [7] the effect of bagasse as an embankment stabilizing agent for road subgrade. In the construction of a road subgrade, it is usually overcome by making the embankment layer as thick as possible for a subgrade with a low bearing capacity. The study aimis used of ceramic waste as a stabilizing agent for expansive clay. The test was carried out using the ASTM D 1883 – 87 method to determine the CBR value. The soil used was from Kuranji Padang. The stabilization was carried out chemically using 3% lime and 4% bagasse ash with a four day incubation period at optimum water content conditions. The tests carried out include physical and mechanical properties of the soil; from the results of testing the mechanical properties of the soil, the addition of stabilizing agents can increase the soaked and unsoaked CBR values and increase the value of free compressive strength. For unsoaked conditions, the highest CBR value was by using bagasse.

The physical properties and shear strength of soil stabilized with lime, with the results of the study showing that the stabilized soil, along with the increase in the percentage of addition of bagasse ash, the value of specific gravity, liquid limit value, plastic limit value, the plasticity index, and the percentage of soil grain percentage passing the No. 200 sieve tend to decrease, while the shrinkage limit value tends to increase [8], [9]. From the standard proctor test, the optimum water content tends to decrease, and the dry density increases. The value of shear strength with three days and seven days of treatment tends to increase along with the addition of bagasse ash. The highest cohesion values and friction angle values occurred in soil samples treated for seven days with the addition of bagasse ash. The expansive soil improvement using quicklime and bagasse ash, the results of the research showed an increase in strength, accompanied by a decrease in the water content of the soil sample [10], [11]. In addition to the swelling pressure test, a decrease in the swelling and shrinkage properties of the expansive soil was seen, especially with the addition of 8% lime and bagasse ash. The improvement of soft clay using quicklime (raw lime) and bagasse ash, from the results of the research conducted, showed an increase in strength accompanied by a decrease in the moisture content of the soil sample in the UCS Test, an increase in strength was observed [12], [13]. The largest was 82.28% due to the addition of 8% lime and 20% bagasse odour, with a curing time of 28 days. While in the CBR Test, the biggest increase in strength was 119.07% due to the addition of 8% lime and 20% bagasse ash with a curing time of 28 days. In the durability test, adding lime and bagasse can reduce the percentage of soil loss. uses bagasse ash as a mixed material for road works, among others, to increase the use-value of bagasse ash itself as an innovation regarding the use of bagasse ash as a pavement material other than as a pollutant material [14]–[16].

METHOD

Expansive clay samples were taken directly in Babatang Village, Cankringrandu Village, Jombang Regency, East Java. The original state (undisturbed) or disturbed (disturbed). At the same time, the samples of Ceramic Handicraft Waste were taken from the Dinoyo Ceramics Factory, Dinoyo Village, Lowokwaru District, Malang City. The specifications for the expansive clay test object in Jombang Regency are undisturbed soil and disturbed soil. To mix the soil, the expansive clay soil is added to the composition of the mixture, as shown in Table 1.

TABLE 1. COMPOSITION OF THE MIXTURE IN EACH TREATMENT

Material	Weigth precentage				
Expansive Clay	100 %	95 %	90 %	85 %	80 %
Ceramic waste	0%	5 %	10 %	15 %	20%

PHYSICAL PROPERTIES

Moisture Test

Whenever conducting a soil test in the laboratory, the moisture content of the soil in question must be determined first. Soil moisture content is the ratio between the mass (weight) of water contained in the soil and the dry mass (weight) of the soil expressed in percent. Moisture content (w) is the ratio between the weight of water (ww) and the weight of the grains (ws) multiplied by 100%.

$$. W = \frac{W_w}{W_s} x100\% \quad (1)$$

$$= \frac{W_2 - W_3}{W_3 - W_1} x100\% \quad (2)$$

Where, W_1 is weight of the cup, W_2 is weight of cup + wet soil, and W_3 is weight of cup plus dry soil. The equipment used is a cup, digital scale, oven and container for the cup. Figure 3 shows the Moisture test equipment, including: Digital scale test, transparent container, oven, and cup.

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Specific Gravity Test

The specific gravity (*Gs*) of a soil is the specific gravity of the soil grains without including the water and air contained in the soil. The order of execution of the test to determine the specific gravity of the soil only applies to soils that pass sieve No. 4, whose grains are smaller than 4.75 mm in diameter. While the equipment used in the study were glass containers and digital scales.

Figure 3. Water Content Test Equipment

Proctor Test

The test was carried out to determine the optimum moisture content and dry density of the original soil, in The study was carried out with the help of the Standard Proctor test; The experiment refers to ASTM D 698. The test was conducted to determine the optimum moisture content and dry density of the original soil, in the study carried out with the help of the Standard Proctor test; The experiment refers to ASTM D 698. The test is to find the relationship between moisture content and volume weight, and evaluates the soil to meet the density requirements, it is necessary to carry out a compaction test. The research was carried out with the help of the Standard Proctor test and the soil passed the No. 4 sieve (4.75 mm).

Figure 4. Proctor Test Tool

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MECHANICAL PROPERTIES

Soil Shrinkage Test (Swelling 3D)

Soil shrinkage is defined as a swelling event due to water seeping into the soil pores Replacing air due to an additional load. The test aims to know how much the percentage of swelling and pressure is when the soil is loaded as a soil whose volume changes under the influence of the drying-wetting cycle, and associated suction problems and failures have been investigated in the field of construction as reported from many sources around the world. The soil suction test is one of the most effective ways to investigate soils' swelling and shrinkage behavior for use in selecting foundation types and making design decisions. Knowledge of soil suction and shrinkage groundwater flow helps predict the possible behavior of swelling pressure. The low moisture content and high soil suction result in a high increase in the swell ability of the soil under the wetting cycle. Therefore, The study evaluates the differences in the behavior of undisturbed swelling and shrinkage soils and formed soils on the drying-wetting cycle in the laboratory to examine the effect of the relationship between soil water absorption and swelling soil pressure. Figure 5 shows the equipment used in soil shrinkage testing.

Figure 5. The Equipment Used in Soil Shrinkage Testing.

Figure 5 shows the equipment used in the soil shrinkage test, consisting of a hammer, calipers, iron rods, punch guides, and iron rods. Soil samples for swelling 3D testing by determining the weight of the soil to be compacted in the mold by referring to the moisture content data (Woptimum) and standard proctor density (γdmax), the weighed soil is added with water according to the design moisture content and compacted in the mold then stored in a desiccator. The soil and carbide waste samples used must pass the No. 200 (0.0075 mm) sieve. The manufacture of free-swelling test specimens was carried out by mixing carbide waste and expansive clay into a plastic and then shaking it until the carbide and soil waste were evenly mixed, after which it was cured for 24 hours.

RESULTS AND DISCUSSION

The results showed that the potential for free expansion of expansive clay varies greatly, influenced by the type or classification of expansive soil, chemical and mineral elements, activity water content and plasticity index.

Soil Water Content

Figure 6 shows that the effect of the greater the percentage of a ceramic waste mixture, the water content value varies. For example, if the original soil is mixed with 5% ceramic waste, the water content of the soil decreases to 37.09%, then at the 10% mixture composition, the water content again decreases to 36.58%, in the 15% mixed composition, the water content decreases to 29.41%, then at the mixed composition of 20% % water content again decreased to 28.13%.

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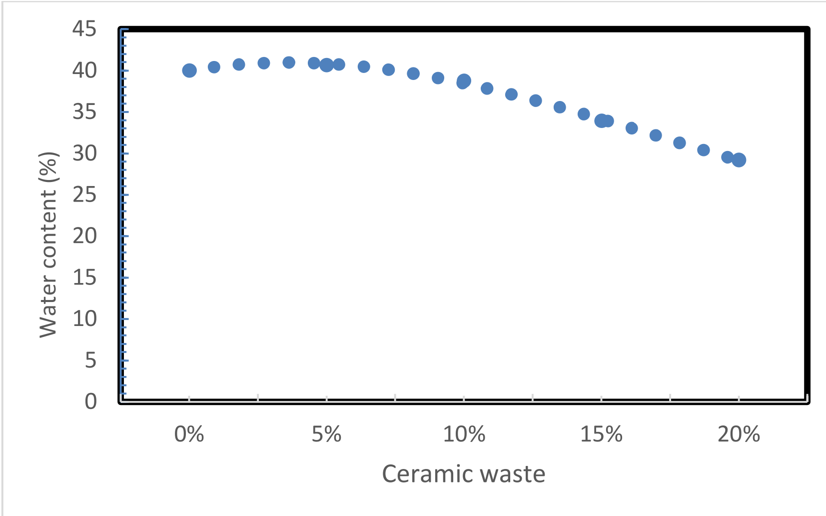

Figure 6. Water Content of a Mixture of Expansive Clay and Ceramic Waste

Specific gravity

The original soil was stabilized with 5% Ceramic Waste from a specific gravity value of 2.9%, and the stabilization value was increased to 10% Ceramic waste, the specific gravity was 3.1%, the stabilization value was increased to 15% Ceramic waste. The specific gravity value was 2,83%, the stabilization value is increased to 20% Ceramic Waste, then the specific gravity value is increased by 2.75%. The can be seen in Figure 7.

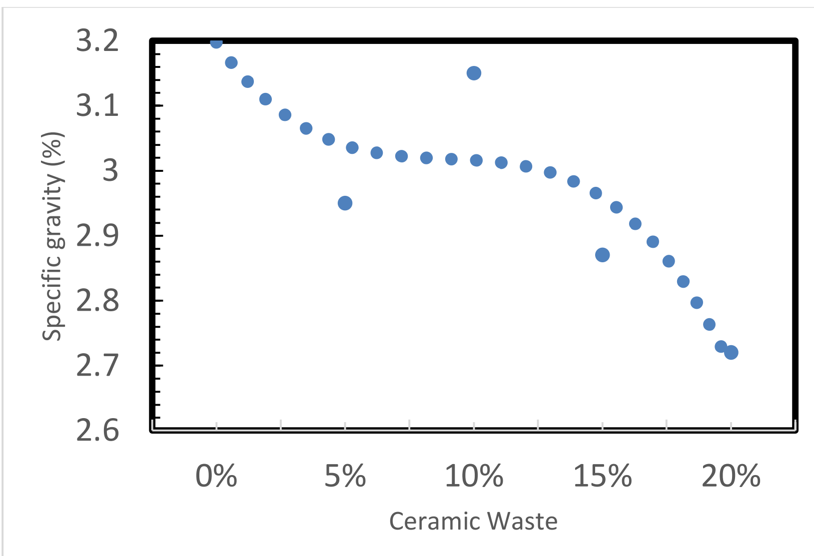

Figure 7. Graph of The Relationship Between Soil Density and Ceramic Waste Mixture.

Unconfined Stress

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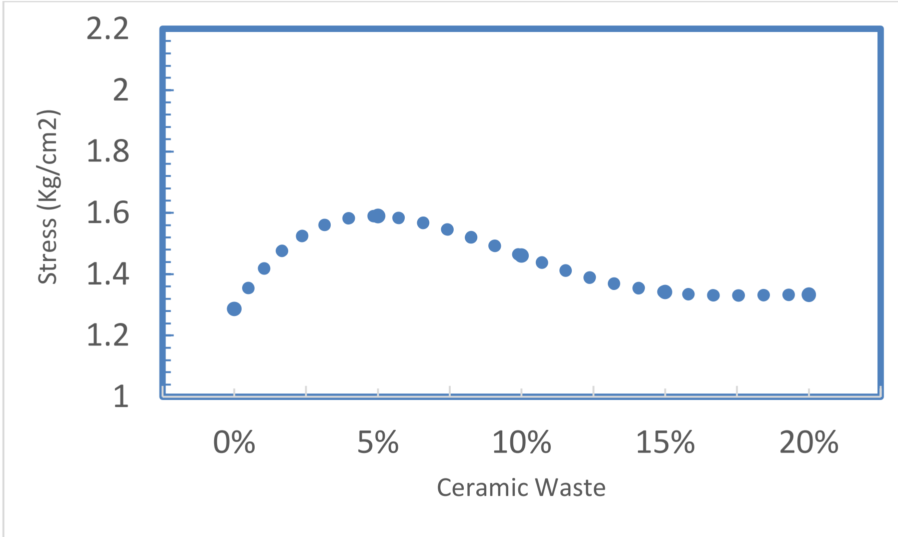

Figure 8. Unconfined Stress

Soil Shrinkage (Swelling 3D)

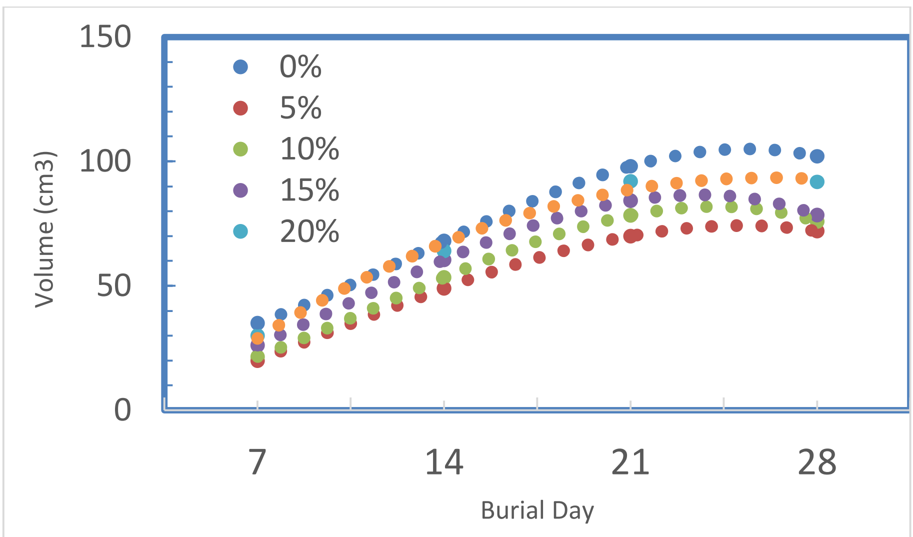

Figure 9. Volume swelling of Mixture soil and ceramic waste

Figure 9 shows that the overall clay mixture is expansive. On the 0% mixture on the 7th day, the percentage of development was 35%, then on the 14th day, the volume of expansion of the specimen increased from 35% to 68% then on the 21st day, the volume expansion experienced an increase of 98%, and for the 28th day of testing the swelling volume test object has not expanded the swelling volume of 102%.

For the 5% swelling volume value on the 7th day, the percentage of swelling was 20% then on the 14th day, the volume of test specimens increased from2 0% to 49% and then on the 21st day, the volume expansion experienced an increase of 70%, and for the 28th of testing the swelling volume test object was no longer a swelling volume developer or 72%. For the test data for the 10% swelling volume value of the mixture on the 7th day, the percentage of development was 21.6%, then on the 14th day, the volume of test object expansion increased from 21.6% to 53.4% and then on the 21st day the volume expansion experienced an increase of 78.3%, and for the 28th day of testing the swelling volume test object is no longer swelling volume developer.

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A mixture of 15% ceramic waste on the 7th day the the swelling volume value of the test object on the 7th day, the percentage of swelling was 26.2%, then on the 14th day, the swelling volume of the test object increased from 26.2% to 60.4%, then on the 28th day of testing the swelling volume was no longer expand swelling volume. In addition, the results of the 3D swelling test on the original Jombang soil with a mixture of 20% ceramic waste on the 7th day of the swelling volume value of the test object on the 7th day, the percentage of swelling was 30%, then on the 14th day, the swelling volume of the test object increased to 64% and then on the 21st day of testing the swelling volume of the specimen did not expand. The more days of damping, until the 21st day, the swallowing volume increases, but after that, it decreases. The 5% ceramic waste mixture showed the highest volume increase compared to other mixtures.

CONCLUSION

Based on the research results it can be concluded that the results of physical properties with the addition of a stabilizing agent composition of 5%, 10%, 15% 20% experienced a decrease in water content and specific gravity quite consistently, while mechanical properties showed that the stress value increased after the ceramic waste was mixed. In addition, the longer the incubation day, the higher the swelling volume increases, and the higher the swelling volume in a 5% mixture of ceramic waste.

REFERENCES

[1] V. Kumar, P. Praveen, S. Tomar, And D. Jaishwal, “A- Review ‘Stabilization of Expansive Soil Using Fly Ash And Iron Powder,’” Vol. 5, No. 1, Pp. 1–7, 2019.

[2] M. A. Sani, A. U. Chinade, A. Mamuda, A. Batari, And M. D. Abdullahi, “Effect of Gypsum In Proportion of Other Additives Used In Stabilizion of Deficient Soils: A Review,” Vol. 6, No. 6, Pp. 161–176, 2021, Doi: 10.11648/J.Jccee.20210606.11.

[3] T. M. Petry ond J. C. Armstrong, “Stabilization of Expansive Clay Soils,” *Transportation Research Record*, No. 1219, Pp. 103–112, 1989.

[4] Al-Baidhani, A., & Al-Taie, A. (2019). "Stabilization of Expansive Soils Using Stone Waste Materials: A Review". *Ijo-International Journal of Mechanical And Civil Engineering*, 2(07), 01-07.

[5] G. Landlin, B. Sharmila, And S. Bhuvaneshwari, “Comparative Evaluation of Lime and Biopolymer Amended Expansive Soil,” *Lecture Notes In Civil Engineering*, Vol. 164, No. January, Pp. 807–821, 2022, Doi: 10.1007/978-3-030-77230-7_62.

[6] A. A. Fondjo, E. Theron, And R. P. Ray, “Stabilization of Expansive Soils Using Mechanical and Chemical Methods: A Comprehensive Review,” *Civil Engineering And Architecture*, Vol. 9, No. 5, Pp. 1289–1294, 2021, Doi: 10.13189/Cea.2021.090503.

[7] A. A. Al-Rawas and M. F. A. Goosen, “Expansive Soils: Recent Advances in Characterization and Treatment,” *Taylor & Francis E-Library*, Vol. 53, No. 9, Pp. 1689–1699, 2006.

[8] M. Olgun, “The Effects and Optimization of Additives for Expansive Clays Under Freeze-Thaw Conditions,” *Cold Regions Science And Technology*, Vol. 93, Pp. 36–46, 2013, Doi: 10.1016/J.Coldregions.2013.06.001.

[9] A. Mahamedi And M. Khemissa, “Stabilization of an Expansive Overconsolidated Clay Using Hydraulic Binders,” *Hbrc Journal*, Vol. 11, No. 1, Pp. 82–90, 2015, Doi: 10.1016/J.Hbrcj.2014.03.001.

[10] G. P. Makusa, “Soil Stabilization Methods and Materials In Engineering Practice,” *J0urnal*, Vol. 1, Pp. 1–35, 2012.

[11] M. Anaokar and S. Mhaiskar, “Evaluation of Swelling Control Parameters For Stabilized Expansive Soil Buffer Layers Under Pavement Embankment,” *International Journal of Engineering and Applied Sciences (IJEAS)*, Vol. 5, No. 1, Pp. 79–85, 2018, Doi: 10.31873/Ijeas.5.1.33.

[12] M. Malhotra and S. Naval, “Stabilization of Expansive Soils Using Low-Cost Materials,” *International Journal of Engineering and Innovative Technology*, Vol. 2, No. 11, Pp. 181–184, 2013.

[13] Prasad, S. S. G., Ch, S. K., and Surisetty, R, “Stabilization of Pavement Subgrade by Using Fly Ash Reinforced with Geotextile,” *International Journal of Research in Engineering and Technology*, Vol. 03, No. 08, Pp. 255–259, 2014, Doi: 10.15623/Ijret.2014.0308040.

[14] K. Divya Krishnan and P. T. Ravichandran, "Investigation on Industrial Waste Material for Stabilizing the Expansive Soil," *IOP Conference Series: Materials Science and Engineering*, Vol. 912, No. 6, 2020, Doi: 10.1088/1757-899x/912/6/062062.

[15] M. R. Hakro *Et Al.*, "Compaction Characteristics and Permeability of Expansive Shale Stabilized with Locally Produced Waste Materials," Pp. 1–15, 2022.

[16] R. B. Kassa, T. Workie, A. Abdela, M. Fekade, M. Saleh, And Y. Dejene, "Soil Stabilization Using Waste Plastic Materials," *Open Journal of Civil Engineering*, Vol. 10, No. 01, Pp. 55–68, 2020, Doi: 10.4236/Ojce.2020.101006.