**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 this 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, 3D swelling.

**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. This type of soil is clay soil containing many minerals with high swelling potential. Soil with this 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. This study aims to compare the effect of stabilization using bagasse ash on the strength of the soil to be used as a backfill for road subgrade. 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.

[8], [9] 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. 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. [10], [11], 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. 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. [12], [13] 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. 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. [14]–[16] 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. The choice of using bagasse ash mixed with asphalt treated base is because this mixture is specially formulated.

# **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. Moisture content is defined as the ratio between the weight of water and solid grains.

**Specific Gravity Test**

The specific gravity of soil is the specific gravity of the soil grains without including the water and air contained in the soil.

**Proctor Test**

This test was carried out to determine the optimum moisture content and dry density of the original soil, in this study was carried out with the help of the Standard Proctor test; this experiment refers to ASTM D 698.

# **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. This 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 behaviour for use in selecting foundation types and making design decisions. Knowledge of soil suction and shrinkage groundwater flow helps predict the possible behaviour 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, this study evaluates the differences in the behaviour 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.

# **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 1 water content of a mixture of expansive clay and ceramic waste

Figure 1 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%.

**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%. This can be seen in Figure 2.

Figure 2 Graph of the relationship between soil density and ceramic waste mixture.

**Unconfined Stress**

Figure 3 Unconfined Stress

Figure 3 shows that the soil stress that occurs decreases with stabilizing material. The original Jombang soil has a value of 1,287 kg/cm2, and then the original soil is mixed with ceramic waste as much as 5% and the soil stress value increases to 1,589 kg/cm2. Then for the 10% composition of the original soil and a mixture of soil stress values again increased to 1,461 kg/cm2. Then in the mixed soil composition of 15%, the soil stress value also increases to 1.342 kg/cm2. Moreover, in the last mixture, 20% soil stress composition increased to 1,333 kg/cm2.

**Soil Shrinkage (Swelling 3D)**

Figure 4 Volume swelling of Mixture soil and ceramic waste

Figure 4 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.

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**

1. The results of the research on ceramic handicraft industry waste as a stabilizing agent for expansive clay showed 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.

2. The study results of 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 and J. C. Armstrong, “Stabilization of expansive clay soils,” *Transp. Res. Rec.*, no. 1219, pp. 103–112, 1989.

[4] “Stabilization of Expansive Soil Using,” 2019.

[5] G. Landlin, B. Sharmila, and S. Bhuvaneshwari, “Comparative Evaluation of Lime and Biopolymer Amended Expansive Soil,” *Lect. Notes Civ. Eng.*, 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,” *Civ. Eng. Archit.*, 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 Fr. 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 Reg. Sci. Technol.*, 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 J.*, 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,” *Int. J. Eng. Appl. Sci.*, 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,” *Int. J. Eng. Innov. Technol.*, vol. 2, no. 11, pp. 181–184, 2013.

[13] . S. S. G. P., “Stabilization of Pavement Subgrade By Using Fly Ash Reinforced With Geotextile,” *Int. J. Res. Eng. Technol.*, 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 Conf. Ser. Mater. Sci. Eng.*, 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 J. Civ. Eng.*, vol. 10, no. 01, pp. 55–68, 2020, doi: 10.4236/ojce.2020.101006.