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The Effect of Addition of Stone Ash to Shear Strength of Clay Soil in Suruh Trenggalek

Fauzie Nursandah[1], Fianca Nimas Yamada Puteri[2], Agata Iwan Candra[3], Yosef Cahyo Setianto Poernomo[4], Muhammad Heri Nastotok[5]

[1,2,3,4,5]*Faculty of Engineering, Kadiri University*

Email : [1] fauzie_nursandah@unik-kediri.ac.id, [2]fianchaputeri@gmail.com,[3]iwan_candra@unik-kediri.ac.id, [4]yosef.cs@unik-kediri.ac.id , [5]heri_nastotok@unik-kediri.ac.id

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A B S T R A C T

The land is one of the places where a building is built, so the structure depends on the ground's strength. Clay soil is a type of has a low bearing capacity. Therefore it is necessary to conduct research that can increase soil bearing capacity. Rock ash is an artificial aggregate obtained from the by-products of a stone crusher or cement-factory. This study's purpose is, namely, alarm and shear control of clay with the addition of rock ash. The clay soil used comes from the Trenggalek area. The percentage of adding agate is 0%, 10%, 20%, and 30% of the weight of the clay. The results showed that obtained were at a percentage of 30% with Liquid Limit value of 39.00%, Plastic Limit 29.00%, and Plastic Index of 10.00%. In the Direct Strong Test, clay soil with the addition of 30% of the rock tested the maximum increase in shear stress of 0.486 with a shear angle of 40 ° and a decrease in the cohesion of 0.100 kg/cm². This shows that clay soil, which can be categorized as montmorillonite soil with the addition of rock ash, can increase the stability of the clay soil.

INTRODUCTION

Almost all civil buildings are connected to the land [1]. A Land is a place where a building is built, so the comfort and safety of the building that is standing on it depend on the strength of the land under it. Soil as foundation placement must be calculated appropriately [2][3]. Soil conditions need to be considered to maintain the quality of the construction to be built [4].

Every construction that will be carried out must first make observations or research regarding the condition of the soil structure that will be used as building placement. If this is

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not done, various problems will arise due to unstable soil conditions [5]. Stable soil is very necessary, considering the function of the soil itself, which is useful for supporting the building foundation [6][7]. One of the existing constructions is highway construction. Unstable soil conditions will cause problems. Namely, the road above it will experience deflection or damage [8].

Clay soil is a type of soil that contains fine particles with a high plasticity index. High water content in clay soils can affect soil strength and soil stability if it receives loads [9]. Technically, clay soil with a high plasticity index can cause low shear strength and this has a very bad effect as a construction laying [10].

Unsupportive soil conditions cannot be used as the basis for construction work because it will cause many problems[11]. Therefore a soil improvement method is needed. One method that can be done for soil improvement that functions to stabilize the soil is by mixing one soil with another. This is done in order to find the desired soil gradient. Another method that can be done is by mixing the soil with additives, one of which is rock ash, which is a chemical mixing material. This can cause chemical reactions that produce new material as a result of a chemical reaction between the soil and the mixing material.

Stone ash is material for crushed stone originating from a stone machine, a crusher with a size of 0 mm - 5 mm. Rock ash is a fine aggregate containing a size of 17% to 25% rock ash fraction [12][13].

In this research, there will be mixing rock ash with clay found in the Suruh area, Trenggalek Regency. The original soil obtained from Trenggalek is an unstable clay so that the road conditions above it are damaged and deflected so that it is necessary to repair the soil.

Based on previous research conducted by Sindy Natalia Polii, O.B.A. Sompie, Lanny D.K. Manaroinsong, regarding "Pengaruh Penambahan Abu Batu Bara Terhadap Kuat Geser Tanah Lempung" (2018) concluded that the addition of coal ash can increase the shear strength in clay soil [8]. The purpose of this study is to determine the consistency and shear strength of clay soil with the addition of rock ash with variations in the addition of 0%, 10%, 20% and 30%, where the research was conducted in the Kadiri University laboratory.

Review

The literature review used as a reference in this study is as follows:

a. Soil

Soil is a material consisting of a mixture of organic mineral grains or inorganic material. The grains can be separated easily by using a water whisk. The material comes from

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the weathering of rocks. Soil types are gravel, sand, silt, and loam. The soil has 3 components, namely air, water, and solid materials. The soil must be able to withstand the loads that will work on it. One type of soil that is less profitable is clay because of its low permeability so that the consolidation process occurs for a long time, the nature of swelling is high and very influences changes in water content[5]. Soil properties will differ depending on the type of soil, the formation of the soil itself. For example, clay and peat soils are somewhat different but have a fine grain size, have a high water content [14].

b. Clay soil

Clay soil is able to have plastic properties when mixed with water, this can happen because clay soil has mineral particles. Clay soils can be plastic if the water has moderate levels, while in dry conditions, the clay is very hard [15]. The content of clay soils not only consists of clay particles but is mixed with silt grains and sand and organic matter. Silt / clay is also cohesive (binding)[16].

Clay soil has a fairly large weakness value. During the rainy season, the clay will expand quite a lot, and in the dry season, the clay will shrink quite significantly as well. Moreover, if the movement and reduction of the construction is not evenly distributed throughout the construction building, it will result in a danger of cracks and the danger of collapse in the construction above the ground [17].

Soil that has high swelling and shrinkage properties when it experiences changes in water content. This can happen if the soil is dry and expands in wet conditions[18]. This is triggered by the large pore volume when the soil is dry. High water content when the soil is wet, and it is very difficult to get out to the surface due to the low level of soil permeability and has experienced a large decline but in a relatively long time [19]**.**

Fine-grained soils containing clay minerals are very sensitive to changes in water content [20]. Atterberg has determined certain points in the form of a liquid limit, a plastic limit, and a shrinkage limit[21]. Soil is a material consisting of fine grains that are not cemented or, in other words, not chemically bonded to one another and comes from the results of organic weathering accompanied by liquids or solids that fill the empty space between the particles. solid particles [22].

c. **Fly Ash**

Fly ash is a type of artificial aggregate with a particle size of <0.075 mm, which functions as a mineral filler. Stone ash can be obtained from the by-product of a stone crusher or cement factory. This material is needed as an asphalt mixture and can be used as a

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substitute for sand. This material is the main material for making pressed concrete blocks and culverts [23].

d. Soil Stability

In general, soil stabilization has the purpose of changing the technical properties of the soil itself, such as compressibility, ease of work, bearing capacity, permeability, sensitivity to moisture content [24]. Soil stabilization is also very much needed at project locations because the heavy equipment working on the project requires a work platform and roads that are strong enough to become the foundation[25]. So that the implementation of work can be more efficient. Stabilization using added materials or chemical stabilization is a method of stabilization using added materials processed in a certain ratio to improve technical soil properties, such as strength, texture, ease of work, and plasticine [26].

Soil stabilization is a method used to change or improve the properties of the subgrade so that it is hoped that the subgrade will be of better quality and can increase the carrying capacity of the subgrade for the construction to be built on it [27]. The stabilization that is commonly used in clay soils is by chemical means, namely by adding a mixture of materials that can react to clay soil. Soil consistency is the moisture content where the soil state passes through other states. If dry clay soil is added to water gradually, the soil will change its character [28].

e. Direct Shear Test

The direct shear test is the easiest and simplest test which is useful for testing soil shear strength parameters. The tools used can be round or rectangular. In this test, the normal force P da F. The normal force P is placed on top of the box while the F force is placed on the horizontal plane. The existence of vertical and horizontal loads on the tool can cause stress on the ground. These stresses are the major principal test and minor principal stress, which results in the occurrence of shear stress which is able to form an angle in the field of soil shear [29].

The shear strength test is stated in the formula:

$$S = c' + \sigma' tan\varphi \quad \text{.....} \quad (1)$$

In Eq:

S = soil shear strength

U = pore water pressure

σ = Total stress

σ '= Effective stress

υ '= Effective inner sliding angle

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c '= Cohesion

Source : [30]

METHODS

This study used experimental research methods wherein this research was carried out directly based on SNI references which were carried out in the Civil Engineering Laboratory of Kadiri University. In this study using clay soil with a mixture of rock ash with a large of 0%, 10%, 20%, 30% which will be tested with a direct shear strength test.

Research Flow

The research flow starts from the stage of collecting and preparing materials and materials for the Direct Shear Strength Test. In the direct shear strength test, readings were made 21 times on each sample of the specimen and then the maximum shear stress was taken. With the test results of several specimens, the diameter (cm) is 6.3 cm, the sample height is 1.6 cm, the calibration tool is 0.89 and the area is 31.157 cm². The stages of the research flow that can be described in Figure 1 below:

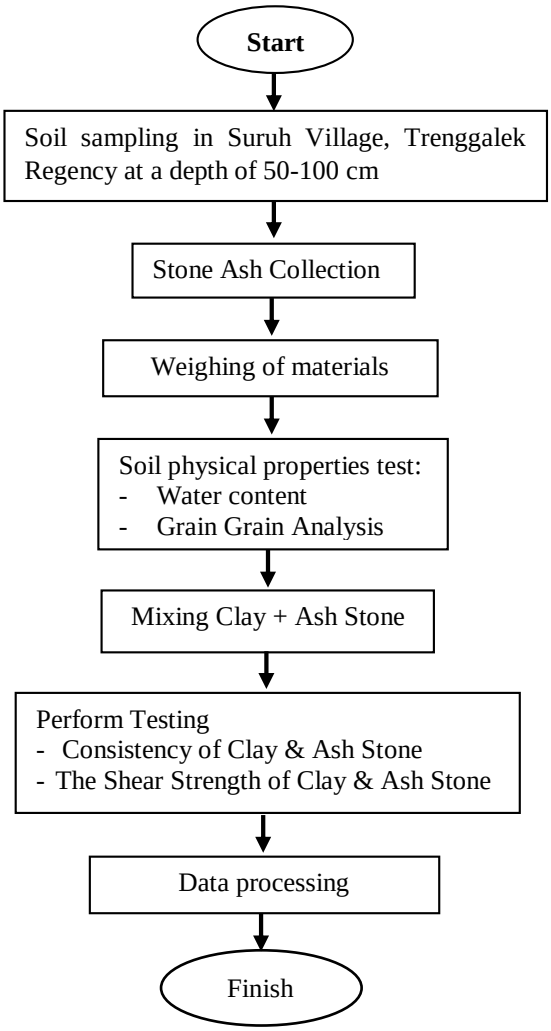

Figure 1. Research flow

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Results and Discussions

Gradation Analysis

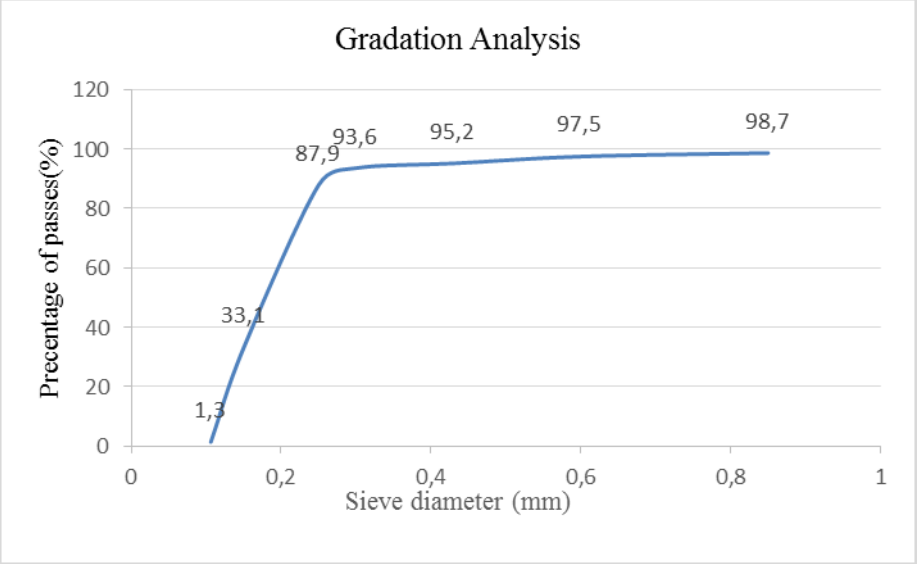
Grading analysis is carried out to analyze the grain structure of the original soil to determine the type of soil that will be carried out in the test. The results obtained from the gradation analysis test are presented in the following table:

Table 1. Grain grain analysis of original soil structure

Diameter (mm)	Restrained Amount (gr)	Percentage Withheld %	Percentage of Passes %
0,85	13	1,3	98,7
0,6	25	2,5	96,2
0,43	23	4,8	93,9
0,3	16	6,4	92,3
0,25	57	12,1	86,6
0,15	548	66,9	31,8
0,106	318	98,7	0
Total	1000		

Source: Research Data

Based on table 1, it can be seen that the results of the grading analysis show the results in accordance with the original soil sieve SNI test.



Source: Analysis Results

Figure 2. Graph of Original Soil Sieve Gradation Analysis

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Based on the analysis of the gradation calculation and analysis of the original soil structure graph sieve shows the soil group that is included in the category of soil types developed by the American Association of State Ilighway and Transportation Official (AASHTO) which obtained results D60 = 0.21 mm, D30 = 0.15. mm, D10 = 0.11 mm and has a uniformity of Cu = 2.90 mm, Cc = 0.974 mm.

Consistency Limit Test

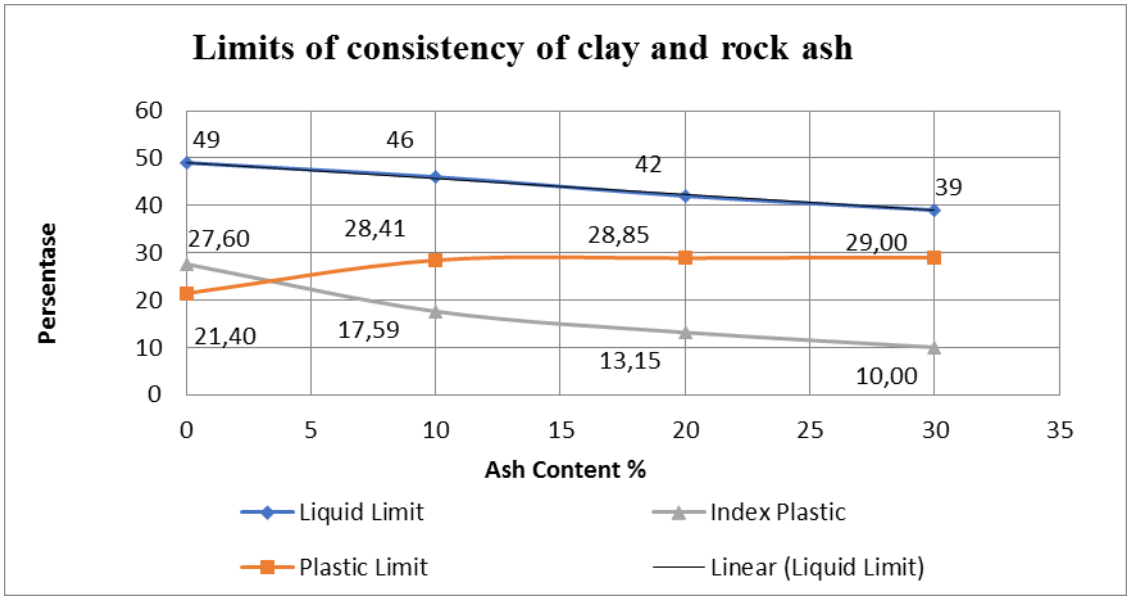
To determine the water content in a soil, consistency limit test is used with the liquid limit state and the maximum plastic level in the soil. Where the test results are obtained, the consistency limit test is presented in the table as follows:

Table 2. Boundaries of consistency of mixing clay and stone ash

Stone Ash Content (%)	Liquid Limit (%)	Plastic Limit (%)	Index Plastic
0	49	21,40	27,60
10	46	28,41	17,59
20	42	28,85	13,15
30	39	29,00	10,00

Source: Research Data

Table 2 shows the following graph:



Source: Analysis Results

Figure 3. Graphics Limits of consistency of clay and rock ash

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From the graph above, it can be seen that the plastic index decreases with the addition of rock ash. At the percentage of 0%, a plastic index of 27.60 is obtained, at a percentage of 10% it is 17.59, at a percentage of 20% it is 13.15 and 30% a plastic index of 10.00 is obtained. From this it can be concluded that the more the percentage of the addition of rock ash, the lower the plastic index.

Direct Shear Strength Test Results

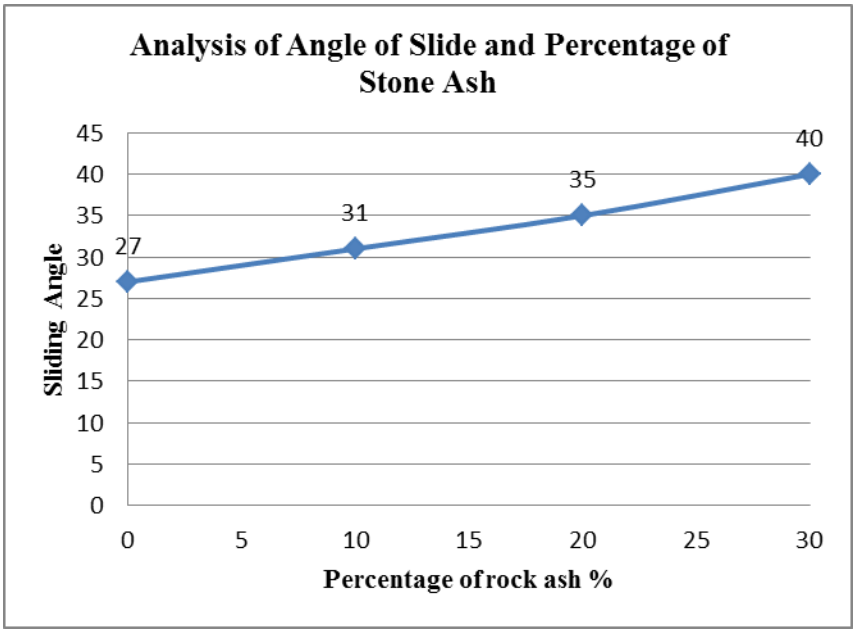
The direct shear strength test is carried out to measure the shear and drop strain on the specimen using tools such as the unconfined compression test (UCT) and the direct shear test apparatus.

Table 3. Direct shear strength test results

Mixed Variations	Cohesion (kg/cm^2)	Inner Slide Angle	Load Maximum Slide (kg/cm^2)
Original Soil + 0% Stone Ash	0,151	27°	0,371
Original Soil + 10% Stone Ash	0,143	31°	0,386
Original Soil + 20% Stone Ash	0,114	35°	0,414
Original Soil + 30% Stone Ash	0,100	40°	0,486

Source: Processed Data

From table 3 above, the following graph can be described:



Source: Analysis Results

Figure 4. Graph of relation between angle of slide and percentage of stone ash

In the picture above shows the increase in the angle of shear at each additional percentage of Stone Ash. In the original soil with the addition of rock ash by 0%, the shear

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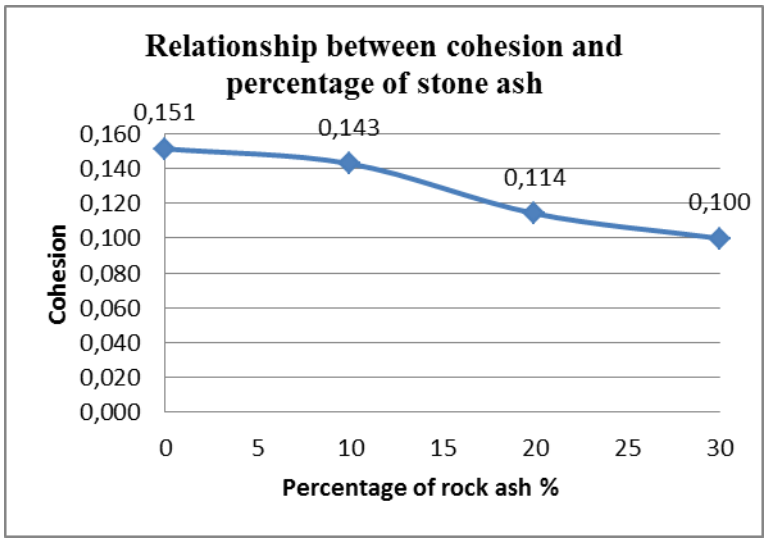
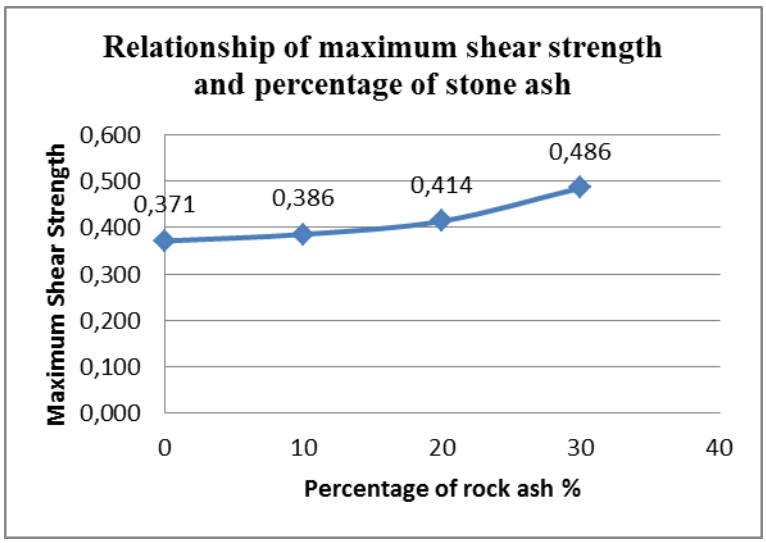
angle is 27 °, at 10% the addition of rock ash gets a shear angle value of 31 °, at 20% the addition of rock ash the value of the shear angle is 35 °, and the addition of rock ash is 30% of the value of the sliding angle is 40 °.



Source: Analysis Results

Figure 5. Graph of relationship between cohesion and percentage of stone ash

The graph above shows that the greater the addition of rock ash, the smaller the cohesion value. Original soil with 0% rock ash shows a cohesion value of 0.151 kg / cm², when adding rock ash by 10% the cohesion value becomes 0.143 kg / cm², when adding rock ash by 20% the cohesion value becomes 0.114 kg / cm², and in addition of rock ash by 30% the cohesion value drops to 0.100 kg / cm².



Source: Analysis Results

Figure 6. Graph of maximum shear strength relationship and percentage of rock ash

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In the graph above, there is a relationship between shear strength and the percentage of rock ash, indicating that the greater the addition of the percentage of rock ash, the greater the shear strength of the soil. In soil with the addition of 0%, the value of shear strength is 0.371 kg/cm², when the addition of rock ash is 10% the value of the shear strength becomes 0.386 kg/cm², the addition of rock ash is 20% the value of the shear strength becomes 0.414 kg/cm², and the addition of rock ash by 30% the value of the shear strength increased to 0.486 kg / cm².

CONCLUSIONS

Based on the results of the clay soil research with the addition of rock ash by 0%, 10%, 20% and 30%, which has been tested at the Civil Engineering Laboratory of Kadiri University by performing data analysis techniques obtained in the test, the following conclusions can be drawn:

1. From the results of the clay soil test taken in Suruh Village, Suruh Subdistrict, Trenggalek Regency, it is included in the soil mineral category of Montmorillonite activity.
2. In the structure of the test object which is added with rock ash by 30%, the Liquid Limit (LL) value decreases to 39%. Thus the addition of rock ash to the soil structure can minimize water absorption so that the difference in activity of soil structure shrinkage due to water absorption becomes more stable. The test value on the Plastic Limit (PL) increased to 29.00%, thus indicating that the clay specimen added with rock ash by 30% requires more water to reach a plastic state. The calculation results show that the Plastic Index (IP) value of the test object with 30% rock ash decreased to 10.00%.
3. In the direct shear strength test on clay soil with the addition of rock ash by 0%, the result is a shear angle of 27 °, and cohesion of 0.151 kg/cm², In the clay soil shear strength test with the addition of rock ash by 10%, the result is a shear angle of 31 °, and a cohesion of 0.143 kg/cm², In the clay soil shear strength test with the addition of rock ash by 20%, the result is a shear angle of 35 °, and a cohesion of 0.114 kg/cm², whereas in the clay soil shear strength test with the addition of rock ash by 30%, the result is a shear angle of 40 °, and a cohesion of 0.100 kg/cm²,

Recommendations

Based on the above conclusions, it is expected that in the following studies to overcome soil damage, it must pass several calculations and further classification of soil types, because

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at each location the soil structure has different field requirements. The consistency limit test does not continue the calculation of the addition of rock ash because it will affect the original properties of the soil itself. In this clay soil shear strength test, it is necessary to test the shear strength for comparison with other equipment, for example: Triaxial Test Equipment. This is based on previous journals that use the Triaxial Test Tool as a comparison so that the results obtained are more accurate.

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