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The Impact of Rice Husk Ash Waste Addition towards Landfill Stability

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Abstract. *Soil stability is an attempt of improvement carried out to increase soil carrying capacity in order to fulfill the needs of construction. The improvement method used in this study is mixing rice husk ash (RHA) with a certain percentage of clay soil. The tests carried out in this study include soil physical properties, compaction and CBR testing. Based on CBR testing, the results obtained were 11.65% on the variation of 0% RHA, 5% for RHA at 20.39%, 10% for RHA at 10.92% and for RHA 15% at 3.56%. The highest increase in CBR value occurred at the addition of RHA 5% which was 74.96% compared to the original soil of CBR. Based on the test results, it can be seen that the addition of waste rice husk ash with a level of 5% which is most effectively used in an effort to increase the landfill carrying capacity so that it can be functioned as a material for landfill stabilizer for subgrade roads*

Keywords: clay soil, rice husk ash, CBR, subgrade road.

Clay soil is soft and malleable which is often becomes a problem in doing construction. In addition, this soil has poor properties, such as high plasticity and low permeability that makes the water unable to come out of the ground. The properties make clay soil have a large shrinkage. Characteristics of clay soil are effected by two things; microscopic factors and macroscopic factors. Factors in this term mean factors in the soil that form clay soil from shrink swells. While macroscopic factors are physical soil properties, including plasticity and weight of soil.

(Bowles, 1984) suggests that when soil in an area is very vulnerable or may easily be suppressed or has an unstable consistency index, high permeability, or even has other properties that are unappropriate to be used for construction projects, then the soil needs to be stabilized. Clay soil is one type of soil that is usually carried out by the stabilization process. This is because clay soil has soft and cohesive properties when wet.

Husk is the hull of rice grain that is collected because of the grinding process. Husk ash is the result of the combustion process, which is carried out in the oven or in an open space. Silica is also the most dominant chemical and has the benefits for rice husk ash . Several studies using rice husk ash as stabilizing material for clay have been carried out by (Onyelowe et al., 2021; Ordoñez Muñoz et al., 2021; Verma et al., 2020). The increase in husk ash volume in the mixture would lower strength, but might be very effective to reduce the swells (Jain et al., 2020).

Previous research has shown that RHA has following characteristics: abundant pore, small specific gravity and large specific surface area (Meliyana et al., 2019). In particular, the presence of highly active amorphous silica in RHA is the reason RHA has a high activity similar to nanosilica (Rahmawati, Aprilia, Saidi, & Aulia, 2021). Therefore, many studies have investigated extensively on the basic characteristics and comprehensive utilization of RHA by reducing the use of limited natural resources such as cement, lime and other materials (Handayani et al., 2021; Rahmawati, Aprilia, Saidi, Aulia, et al., 2021).

The compaction effect of adding RHA to clays, especially to expansive soils, red clays, and soft soils has been studied and some promising results are obtained (Ordoñez Muñoz et al., 2021). RHA is mainly combined with solid materials such as cement, lime, industrial and agricultural wastes such as fly ash, carbide slag, steel slag or bagasse ash for soil improvement. The strengthening effect of RHA on soils was studied by performing Atterberglimit, compaction, UCS, CBR, direct shear and expansion tests, which showed that RHA has great application potential in soil improvement). In general, the addition of RHA can reduce the maximum dry density of the soil and increase the optimal soil moisture content (Taha et al., 2021). The addition of RHA can also increase the compressive strength, shear strength and CBR value of the soil, and effectively improve the strength of the soil. However, the optimal effect of RHA content is closely related to soil type, RHA content, and chemical composition.

MATERIALS AND METHODS

Materials

The materials used in this study were clay and rice husk ash waste. The clay soil was taken from the landfill area of Lamseunong Village, Kuta Baro Sub-District, Aceh Besar District. The samples were gained from this location because the location was close to the planned route of the Aceh toll road. The rice husk ash was the result of the processing of rice factory waste of PT. Kuta Breuh which was located in Ujong Blang Village, Kuta Baro Sub-District, Aceh Besar District.

Methods

The implementation of soil sample testing was carried out in the Tests Laboratory including the properties of soil physical structures, compaction and CBR testing using the testing method of SNI 1743 Year 2008 and ASTM. In this research, RHA mixing was carried out with variations of 0%, 5%, 10% and 15% with tested samples amount of each was three samples.

RESULTS AND DISCUSSION

a. Soil Classification

Original soil, came from Lamseunong Village, had a liquid limit value and a high plasticity index of 51.49% and 25.56%. The results of the filter analysis showed that the soil that passed No.200

filter (Ø 0.074 mm) was 83.30%. Based on the liquid value and plasticity index and the percentage of pass filter No. 200, then based on the AASHTO classification the soil from Lamseunong village is clay soil included in group A-7-6. Whereas based on the USCS soil system this soil could be in the CH category which included as clay soil.

b. Chemical Elements of Rice Husk Ash Waste

The chemical composition of rice husk ash was obtained from the testing results carried out at Banda Aceh Industrial Research and Standardization Laboratory can be seen in Table 1 below.

Table 1 Composition of Chemical Elements of Rice Husk Ash Rice Waste

No.	Test Parameters	Results (%)
1	SiO_2	67,23
2	Al_2O_3	0,66
3	FE_2O_3	0,14
4	CaO	11,03
5	MgO	7,45
6	SO_3	0,11
7	Na_2O	0,22
8	K_2O	1,84

Based on Table 1, the results show that rice husk ash waste used in this study has high silica content at 67.3%. Silica contained in RHA can work as a binder on the soil and also fine grains of rice husk ash can be used as filler in the soil cavities.

c. Impact of RHA Addition to Atterberg Boundaries

The addition of RHA to the ratio can increase the liquid value and the plastic limit of the soil. Table 2 shows the liquid limit value and the plastic limit obtained from the test results. In the testing of original soil, the liquid limit obtained was 51.49% and 1.60% at 5% rice husk ash content. The biggest increase of liquid limit occurs in the addition of 15% husk ash, which increases by 5.95% from the original soil which is 57.44%.

Table 2. Recapitulation of the results of testing the Atterberg boundaries

No	Testing Parameter	RHA Mixture Percentage			
		0%	5%	10%	15%
1	Liquid Limit (LL) (%)	51.49	53.15	54.60	57.44
2	Plastic Limit (PL) (%)	25.51	26.88	27.14	28.01

The addition of RHA also causes an increase in the plastic limit value. At RHA levels of 0% obtained a plastic limit value of 25.51%. Then at rice RHA levels 5% plastic limit value increases from 1.37% to 26.88%. At levels of addition of RHA 10% and 15%, an increase in the plastic limit value repectively is 1.63% and 2.49% of the original soil. From the results of liquid limit testing and plastic limits, then the plasticity index value is obtained. Figure 1 shows the relationship of the percentage of RHA addition with the Plasticity Index.

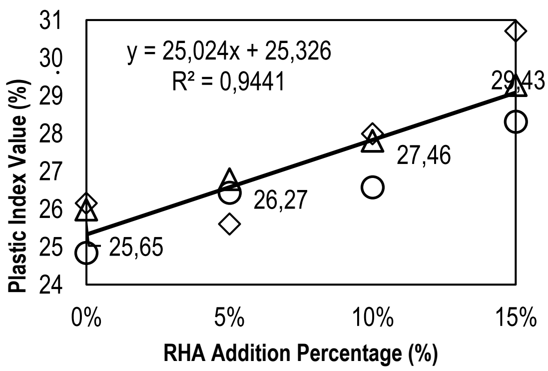

Figure 1. Percentage Relationship of RHA Addition with Plasticity Index

Laboratory test results show that the plasticity index due to the addition of rice husk ash is likely to increase. At the addition of 5%, the plasticity index value increases to 0.62%, which is 26.27% of the value of the plasticity index in the original soil, which is 25.65%. The higher the level of rice husk ash added, the plasticity index increases to 1.8% at level 10% and 3.78% at level of 15% husk ash content.

d. Effect of RHA Addition to Specific Weight

In testing the specific weight of the soil, RHA affects the results of its specific weight value, where the specific weight value decreases along with the level of addition of rice husk ash. In the original soil, the specific weight value obtained is 2.628 which is organic clay soil according to the table of specific soil weight, then decreased by 1.98% in the addition of rice husk ash 5% which is 2.576. At 10% addition level, the specific weight value obtained is 2.522 or decreased by 4.03% from the value of the specific weight of the original soil. The significant decrease occurs at the addition of 15% RHA which decreases at 5.94% from the original soil, which is 2.472. This specific weight loss is due to the specific weight of rice husk ash as a smaller mixture of the original soil. Figure 2 shows the relationship between RHA addition percentages with specific weight.

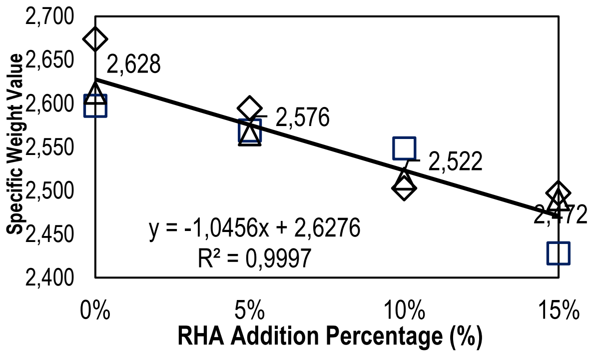

Figure 2. Relationship of percentage of RHA Addition with Specific Weight Tiang Bambu

e. The Effect of Rice Husk Ash Addition to the Optimum Value of Water Content

The level of soil density is measured by the weight of the dry volume. The greater the dry volume weight, the smaller the pore number and the higher degree of density. The effect of adding rice husk ash to soil density is shown in the following table and figure. Table 3 shows that the addition of rice husk ash tends to decrease the γd max.

Table 3. Compaction testing results (standard proctor)

Density Testing Parameter	RHA Percentage			
	0%	5%	10%	15%
Optimum Water Content (OMC)	24.55	26.73	27.15	29.79
Dry Weight Volume (gr/cm3)	1.451	1.430	1.394	1.377

The size of γd max in the original soil is 1.451 gram/cm^3 and has decreased to 1.377 gram/cm^3 in a variation of 15% RHA. This is because the value of γd max is directly proportional to the value of Gs, the more percentage of RHA addition, the more RHA replaces the fine grain of the original soil, thus, the specific weight of clay mixture and RHA decreases due to the specific weight of RHA is smaller than the specific weight clay. Therefore, the dry volume weight obtained in compaction of the original soil is greater than the weight of the dry volume of the soil after RHA is added.

Figure 3 shows that the addition of rice husk ash makes the optimum water content increase. The biggest increase occurred at 15% addition. In the original soil, the optimum water content produced was 24.55% and increased by 2.18% at the addition of 5% at 26.73%. At 10%, there was only a slight increase from the 5% level, which was 0.42%. The biggest increase occurred at the level of 15% which is 2.64% of the 10% RHA level and 5.24% of the OMC on the original soil. The increase in the optimum water content is due to a decrease that occurs at the maximum dry weight volume, so that it requires more water to get the optimum water content.

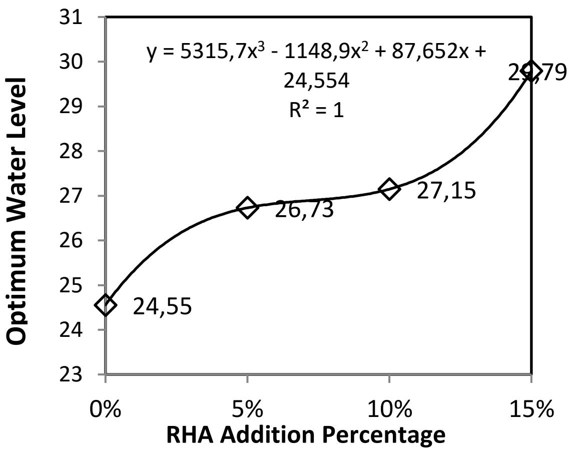

Figure 3. Relationship of percentage of RHA Addition with OMC

f. The Effect of Adding Rice Husk to CBR Value

Unsoaked CBR experiments in the laboratory are carried out in accordance with the standard proctor of water content. The purpose of CBM testing without immersion is to find out the strength of the soil. Figure 4 shows Relation of the percentage of rice husk ash to CBR.

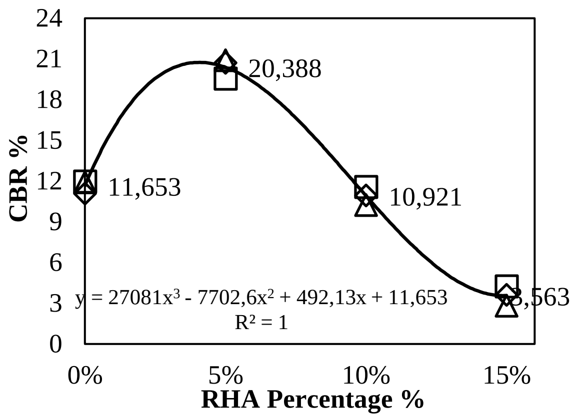

Figure 4. Relation of the percentage of rice husk ash to CBR

From the results of the graph above, it can be seen that the CBR value is greatly influenced by the addition of rice husk ash waste. The increase in CBR value occurs very large at 5% RHA addition rate, while at an additional level of 10% and 15% the CBR value decreases from the original soil CBR value. In the testing of original soil, the CBR value generated is 11.65% and increases to 74.96% at 5% RHA levels to 20.39%. While at the addition of RHA 10% and 15%, the CBR value decreases by 6.28% and 69.42% respectively from the original soil CBR value to 10.92% and 3.56%. This explains that the addition of rice husk ash with 5% levels is the most effective used as an effort to increase the carrying capacity of landfill.

CONCLUSIONS

Based on the results of data processing and discussion, a conclusion can be drawn as the final result of this study

1. The addition of rice husk ash causes an increase in the value of the Atteberg boundaries. In original soil, the obtained plasticity index was 25.65% and increased to 29.43% in addition variation 15% RHA.
2. Specific weight decreases with increasing rice husk ash. In original soil, the specific weight value obtained was 2,628. The biggest decrease occurred at 15% RHA addition level which decreases to 2.472.
3. Based on the results of testing the Atteberg boundaries, the soil from Lamseunong village is clayed soil which belongs to groups A-7-6 according to the AASHTO classification. Whereas based on the soil classification of the USCS system this soil is included in the CH category which means inorganic clay soil with high plasticity.
4. From the results of the compaction of the original soil with a standard proctor obtained dry volume weight of 1.451 gram/cm^3 with OMC of 24.55%. The addition of rice husk ash causes the dry volume weight to decrease so that the water content increases. At an addition rate of 15%, the dry volume weight decreases to 1,377 grams/cm^3 and OMC increases to 29.79%.
5. On testing the original soil, the CBR value generated is 11.65%. Furthermore, in testing with the addition of rice husk ash 5% the CBR value increased by 74.96% to 20,388%. At 10% RHA addition and 15% CBR value decreased.
6. The addition of rice husk ash with 5% content is the most effective used in an effort to increase the carrying capacity of landfill.

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