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THE EFFECT OF THE ADDITION OF BAMBOO LEAF ASH (BLA) AND LIME ON THE VALUE OF THE PLASTICITY INDEX ON THE STABILIZATION OF SOFT CLAY SOILS

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ABSTRACT

Indonesia as an archipelagic country has many areas dominated by soft clay soils, such as along the eastern to southern regions of Sumatra Island, the northern side of Java Island, Kalimantan, and several other islands. In general, soil stabilization for construction purposes such as highways still relies on synthetic materials such as geotextiles. Therefore, an alternative to soil stabilization that is more environmentally friendly and economical is needed. This study aims to analyze the effect of the addition of Bamboo Leaf Ash (BLA) and lime on the value of the Plasticity Index (IP) in silent clay type soft clay in the context of road construction. The methods used include testing the physical properties of the original soil as well as the soil mixed with BLA and lime with a certain percentage. The results showed that the addition of BLA and lime had an effect on decreasing or increasing the value of the plasticity index, depending on the percentage of the mixture used. The highest IP value was achieved in the original soil mixture with 20% BLA and 5% lime at 14.241%, while the lowest value occurred in the mixture of 10% BLA and 5% lime which was 12.090%. Thus, the combination of BLA and lime can be an alternative soft clay soil stabilizing material to support more sustainable road construction.

Keywords: *Soil Stabilization, Clay Soil, Bamboo Leaf Ash (BLA), Soil Properties Index, Plasticity Index*

1. INTRODUCTION

The effect of the addition of Bamboo Leaf Ash (BLA) and lime on the value of the plasticity index on the stabilization of soft clay soil for road construction is an important study in efforts to improve the quality of the basic soil that is often found in various regions in Indonesia. Soft clay soil has low plasticity and carrying capacity, so it risks causing premature damage to road structures. Therefore, effective, economical, and environmentally friendly soil stabilization techniques are needed.

Research by Amu et al. (2010) shows that bamboo leaf ash is able to improve the geotechnical characteristics of stabilized laterite soils, especially in lowering the value of the plasticity index. The results of a similar study by Iorliam et al. (2012) also stated that a mixture of BLA and cement can improve the mechanical properties of clay soils. In addition, Sutikno and Damianto (2009) stated that the addition of lime to expansive soil is effective in reducing plasticity and increasing soil carrying capacity. These findings reinforce the urgency of research exploring combinations of alternative materials such as BLA and chalk.

This study aims to determine the effect of the combination of Bamboo Leaf Ash (BLA) and lime on the plasticity index value of soft clay soils. The methods used include laboratory testing of native soil and soil that has been mixed with BLA and lime variations. The results of the discussion showed that the value of the plasticity index decreased or increased depending on the proportion of the mixture, with the best value achieved in a specific mixture. In conclusion, the combination of BLA and lime has the potential to be an alternative soil stabilization material that is suitable for application in road construction projects in Indonesia.

This study is also closely related to environmental and sustainability issues, considering that BLA is organic waste derived from abundant bamboo biomass in Indonesia. The use of BLA as a stabilizing material not only reduces dependence on synthetic materials, but also reduces organic waste that has the potential to pollute the environment. Thus, this research has a positive impact in supporting the development of green technology in the field of civil engineering and supporting the sustainable development agenda.

2. LIBRARY OVERVIEW

Bamboo leaf ash is known to have pozzolan properties due to its high silica content. The incorporation of BLA into clay soils can result in significant improvements in the engineering properties of the soil. Research shows that the addition of bamboo leaf ash can reduce the value of the clay soil plasticity index,

thereby increasing the workability and ability of the soil to withstand the loads that usually occur in road construction (Fathonah et al., 2021; Fathonah et al., 2022). In particular, Fathonah et al. reported that the value of the plasticity index decreased from 20.11% to 15.96% with the addition of BLA optimally, accompanied by an increase in the California Bearing Ratio (CBR) value from 3.4% to 13.31% at a higher percentage of BLA (Fathonah et al., 2022). Furthermore, studies conducted by Ameen support these findings, showing an increase in compaction characteristics when BLA is combined with lime, proving that the two materials can synergistically improve the mechanical properties of stabilized soils (Ameen, 2021).

The role of lime in soil stabilization has also been widely documented. Lime not only serves as a filler, but it also reacts with clay minerals to form new compounds that can decrease plasticity. Ameen's research shows that the plasticity index and soil fluid limit have decreased significantly as the proportion of lime and BLA increases, indicating increased stability (Ameen, 2021). Similarly, several studies show that mixing lime with pozzolan material can improve the strength and durability of various soil types (Wijaya, 2021; Tang et al., 2023). For example, the combination of lime and BLA not only optimizes laterite soil compaction, but also significantly increases soil bearing capacity, which is critical for road construction applications

The interaction of these materials at the microstructural level is very important. When bamboo leaf ash is added to the soil, the pozzolan reaction that occurs during the binding process results in a denser and more cohesive matrix, thereby improving the soil's performance against deformation and plasticity problems (Ameen, 2021; Wijaya, 2021). This change in soil properties is mainly caused by the formation of a cohesive gel structure that strengthens the bonds between soil particles, thereby reducing plasticity and susceptibility to deformation (Ameen, 2021; Wijaya, 2021).

3. RESEARCH METHODOLOGY

The stages of research that will be carried out include: preparatory work, sampling, preparation of tools and materials, mixing of original soil samples, testing soil samples with mixed variations, and the last is the analysis of test results. This research process will be explained in the form of a flowchart as shown in Figure 1.

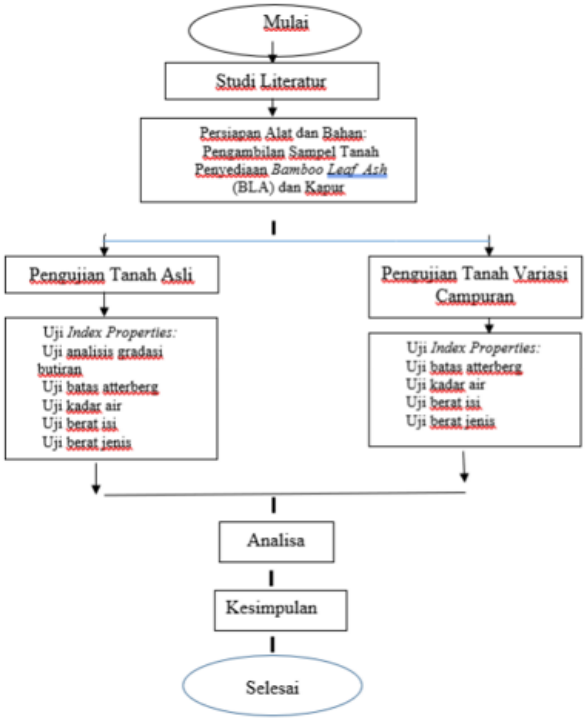

Figure 1. Flowchart

This research was carried out through a series of stages which include, (1) soil sampling from locations that have soft clay characteristics, (2) preparation of additional materials in the form of Bamboo Leaf Ash (BLA) that has been carbonized and sifted, as well as limestone, mixing native soil with a variety of BLA and lime mixtures in a certain percentage, laboratory testing of each sample to obtain soil index properties data (liquid limit, plastic limits, and plasticity index), analyze test results through comparison between variations to see the trend of changes in the plasticity index. The subject in this study is soft clay soil taken

from the top soil in areas that have a high cohesive soil structure. The object of the research was a mixture of clay soil with stabilizing materials, namely Bamboo Leaf Ash (BLA) and lime. Respondents were not involved in this study because it was laboratory experimental.

Data were obtained through laboratory testing using AASHTO (American Association of State Highway and Transportation Officials) standards, especially for liquid limit (AASHTO T89), plastic limit (AASHTO T90), and moisture content (AASHTO T265) tests. The mixing process is carried out evenly and homogeneously using a variation of BLA of 10%, 15%, and 20% combined with 5% lime. Data analysis was carried out quantitatively by comparing the results of the plasticity index values from original and mixed soils. The value of the plasticity index is obtained from the difference between the liquid limit and the plastic limit. Furthermore, data visualization is carried out in the form of a graph to see a downward trend or an increase in the value of plasticity.

The numerical data is then analyzed using data processing software, such as Microsoft Excel, to obtain regression equations and graphs of the relationship between the percentage of addition of stabilizing materials to the plasticity index. The results of these calculations were then reinterpreted in easy-to-understand language to demonstrate the effectiveness of the combination of BLA and lime in stabilizing soft clay soils.

4. RESULTS AND DISCUSSION

This study aims to determine the effect of the addition of Bamboo Leaf Ash (BLA) and lime on the value of the plasticity index (PI) in soft clay soils. The mixture variations used are 10%, 15%, and 20% BLA combined with 5% lime.

Table 1. Values of Plasticity Index (PI) on Various Soil Mix Variations

Sample Variations	Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)
Natural Land	31,44%	18,57%	12,87%
Soil + 10% BLA + 5% Lime	58,77%	46,67%	12,09%
Soil + 15% BLA + 5% Lime	64,73%	51,67%	12,99%
Soil + 20% BLA + 5% Lime	69,36%	55,12%	14,24%

The addition of 10% BLA and 5% lime lowered the PI value from 12.868% to 12.090%. However, at the addition of 15% and 20% of the BLA, the PI value increased to 12.990% and 14.241%, respectively.

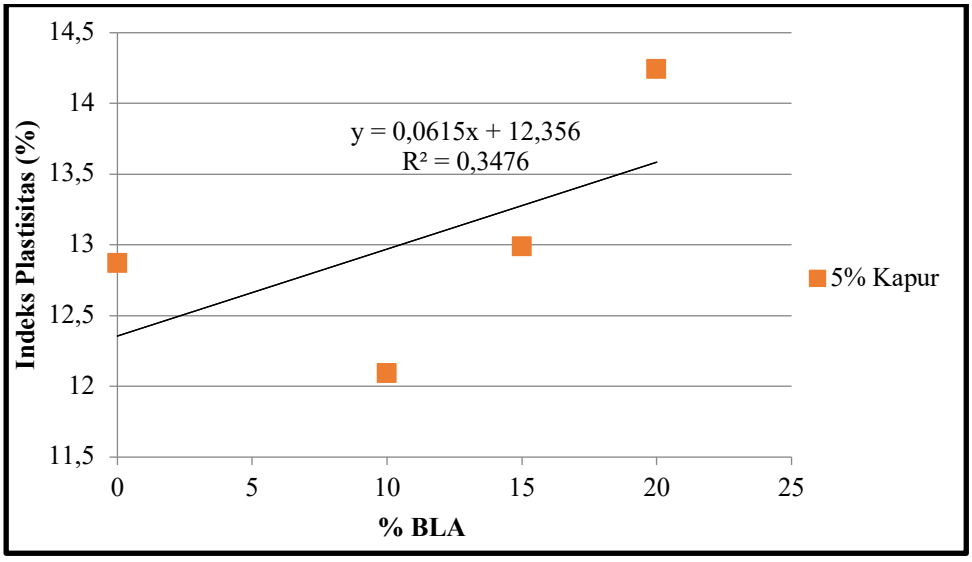

Figure 2. Graph of the Effect of BLA Addition on Plasticity Index

The results showed that the combination of BLA and lime was able to affect the value of the soil plasticity index. A decrease in the PI value in the first variation (10% BLA + 5% lime) indicates that the combination is effective in reducing the plastic properties of the soil. This is thought to be because the high silica content in BLA reacts with calcium from lime to form a pozzolan compound, which increases the bonds between soil particles and reduces plasticity.

However, the increase in PI values at the 15% and 20% BLA variations indicates the presence of saturation points or excess BLA which actually increases the moisture content and causes the soil to return to more plastic. This is in line with the findings of Fathonah et al. (2022) who show that at certain levels, BLA can lower PI, but if it exceeds the optimal limit, it will increase the PI value again due to excess water absorption.

Ameen (2021) also stated that the combination of BLA and lime can improve the compaction characteristics and reduce plasticity if used in the right composition. In addition, the chemical reaction between BLA activated silica and lime produces CSH (Calcium Silicate Hydrate), which strengthens the microstructure of the soil.

Thus, this study confirms that there is an optimal composition in the addition of BLA and lime for the stabilization of soft clay soils. A composition of 10% BLA + 5% lime can be recommended for the purpose of lowering soil plasticity in road construction.

4.1 Comparison with previous researchers

The results of the test on native soil stabilized with Bamboo Leaf Ash (BLA) and lime produced values that could be compared with the results of previous research. The following is a comparison table showing the plasticity index figures.

Table 2. Comparison Of The Plasticity Index With Previous Research

Sample	(%)	LL (%)	PL (%)	PI (%)
Olubenga O Amu, et al. 2010	0% BLA	49,80	28,80	21,00
	2% BLA	44,60	30,36	14,24
	4% BLA	45,20	37,04	8,16
	6% BLA	48,60	30,83	17,77
	8% BLA	46,04	21,47	21,57
Olubenga O. Omu, et al. 2011	0% BLA	73,22	37,60	35,62
	6% BLA	54,16	40,20	13,96
	8% BLA	54,16	40,20	13,96
Amos Yala Iorlam. et al. 2012	20% + 0% cement	-	-	23,20
	20% + 2% cement	-	-	22,70
	20% + 4% cement	-	-	13,70
	20% + 6% cement	-	-	12,90
	20% + 8% cement	-	-	10,20
	20% + 10% cement	-	-	9,00
	20% + 12% cement	-	-	5,90
	20% + 14% cement	-	-	4,70
Sutikno and Budi Damianto, 2009	3% lime	39,08	31,89	12,61
	6% lime	46,50	32,50	16,50
	9% lime	75,56	28,96	18,04
	12% lime	89,30	28,57	18,43
This Research	0% BLA + 0% lime	31,44	18,57	12,87
	10% BLA + 5% Lime	58,77	46,67	12,09

	15% BLA + 5% lime	64,73	51,67	12,99
	20% BLA + 5% lime	69,36	55,12	14,24

5. CONCLUSION

Based on the results of the calculation of the liquid limit and plastic limit test on each soil mixture variation, the plasticity index value for variation 1 is 12.090%, the plasticity index for variation 2 is 12.990%, and variation 3 is 14.241%. These results show that there is a change in the plasticity index value of the original soil condition, which is 12.859%, which is caused by the considerable water absorption by the mixture of Bamboo Leaf Ash (BLA) and lime into the original soil. The value of the plasticity index (PI) decreased in the first variation, but increased along with the increase in the percentage of BLA and lime in the second and third variations.

This research proves that the addition of Bamboo Leaf Ash (BLA) and lime can be an effective alternative in efforts to stabilize soft clay soils, especially for road construction purposes. The main activities in this study are the development of environmentally friendly organic waste (BLA)-based stabilization material formulations, as well as the mixing and laboratory testing process using AASHTO standards. This process shows that practical and local approaches based on natural materials can be applied efficiently at the scale of civil engineering.

Although the test results showed that the plasticity index value decreased at the initial addition of BLA and increased slightly at higher levels, these findings reinforce the understanding that each stabilizing material has an optimal limit for its use. Thus, the main contribution of this research is not only to numerical results, but to the understanding of the process and limitations of soil material engineering as a whole.

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