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Utilization of SagoAsh Waste as Soil Stabilization Material

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ABSTRACT: *The production of waste occurring annually globally is increasing, and is expected to increase in the coming years, only a small part of this is disposed of safely and only a small part is recycled. Utilization of recycled waste with engineering purposes helps to overcome long-lasting problems and utilize waste effectively.This study examined the behavior of the physical properties and soil carrying capacity without stabilization and with stabilization of sago bagasse waste on fine-grained soil media with various test design configurations. Soil mechanical test + mixture of sago pulp ash waste (burnt at 450°) with variations of 0%, 2%, 4% 6%, 8% and 10%, on dry weight of soil: includes testing of natural soil moisture content), specific gravity (specific gravity), liquid limit (liquid limit), plastic limit (plastic limit), sieve analysis (sieve analysis): mechanical properties testing consists of direct shear testing, Unconfined Compression Strength, compaction testing and California Bearing Test.In stabilized soils, as the percentage of addition of sago pulp ash increased, soil property indexes: liquid limit value (LL), plastic limit value (PL), plasticity index (PI) tended to decrease. For mechanical testing, a significant effect on increasing the free compressive strength (UCT) of the soil in the 6% addition variation, the increase value of 54.63% and the California Bearing Ratio (CBR) value experienced an optimal increase in carrying capacity when adding sago pulp ashes. 6% with an increase of 28.57%. These things indicate that the characteristics of the soil property index and soil bearing capacity after stabilization are better. The chemical composition of the ash from burning sago pulp gives a good indication of its effectiveness in soil stabilization, the silica and alumina content in the soil can react with calcium hydroxide in the burning ash.Sago dregs to produce cementation. The formation of this cementation binds the particles together, by covering the soil grains and filling the inter-aggregate pores. Based on these results, it can be concluded that clay soil treated with the addition of Sago Pulp Burning Ash performs well as a stabilizing agent.*

Keywords: *Sago Dregs Ash, Soil Stabilization*

INTRODUCTION

Soil is a material that greatly influences the stability of building structures, highway pavements, tunnels, dams, and others. A structure will be stable if it is located on soil that has a high bearing capacity or soil with good stability. In the construction of highway pavements, each layer of pavement must meet predetermined requirements. The soil under the pavement must be stable or have a high bearing capacity. so that it can accept the working traffic load.Soil stabilization is one of the conventional methods used to improve the quality of road subgrade and pavement layers. This method makes it possible to improve the existing material properties at the project site and achieve the required specifications [1-3].

Stabilization can be done chemically, namely by mixing the soil with additives such as lime, cement, fly ash, asphalt (bitumen), rice husks and others in a certain ratio. Various additives that have high calcium ions or other compound elements that can bind soil particles together so that larger granules will form have been studied, including the use of sago pulp ash waste. Sago waste is a lignocellulosic waste which is rich in cellulose and starch, so that it can be utilized optimally as a carbon source. Sago waste in the form of pulp contains 65.7% starch and the remainder is in the form of crude fiber, crude protein, fat and ash. Based on these percentages, the pulp contains 21% lignin residue, while the cellulose content is 20% and the rest is extractive substances and ash. In addition, sago bark contains 57% cellulose and 38% more lignin than sago pulp [4]. 1.46 % Al_2O_3, 2.5 % MgO and 3.09% other elements (Energy dispersive X-ray fluorescence (XRF) product).Therefore, it is very necessary to have a soil improvement method that can be applied to overcome these problems. Several methods of handling fine grained soils including clay soils have been carried out, among others by changing the material or mixing the soil with Sago Pulp Burning Ash Waste.One effort to improve the properties of clay soil is soil stabilization. The additional material used in this study was ash from burning sago pulp fiber. The ash from burning sago pulp fiber was chosen because it physically has loose properties so that it can become a filler and reduce the cohesion of clay soil. In addition, the ash from burning sago pulp fiber contains Ca, Al, and Mg which contributepreventing the absorption of water by clay particles as well as SiO_2 and Al_2O_3 compounds which have the potential to produce pozzolanic properties when reacted with water and $Ca(OH)_2$.

Soil consists of a mixture of mineral grains with or without organic matter. Soil comes from rock weathering, which can be done physically or chemically. Soils can be classified by grain diameter into gravel, sand, silt, and clay. Soil calcification is useful for estimating soil properties in the field. There are two soil classification systems that are often used, namely the Unified Soil Classification System or USCS (Unified Soil Classification System) and AASHTO (American Association of State Highway and Transportation Officials).

Clay is defined as a class of particles that have a size of less than 0.002 mm (= 2 microns). This is due to a chemical process that changes the mineral composition of the original rock caused by water containing water or alkali, oxygen and carbon dioxide. The properties of clay soil are as follows [5]:

1. Fine grain size, less than 0.002 mm
2. Low permeability.
3. High capillary water rise.
4. It is highly cohesive.
5. High level of swelling and shrinkage.
6. The process of consolidation is slow.

Subgrade stabilization aims to change the soil structure or soil properties so that it can meet the requirements in increasing soil carrying capacity.Soil stabilization can be done in one of the following ways [6]:

1. Increase soil density.
2. Add effective materials so as to increase cohesion and or frictional resistance that arises.
3. Adding material to cause chemical and physical changes in the soil material.
4. Lowering the groundwater level (soil drainage).
5. Replacing bad soils.

The sago processing process can also produce associated waste in the form of bark around 17-25% and 75-83% sago pulp [7]. Sago pulp can be used as a mixture of biogas substrates because it contains a lot of organic matter, especially carbon [8].The ash from burning sago pulp fiber is a by-product of agricultural products, which is only considered as waste. However, when it is burned it has pozzolanic properties which have high silicate elements, the average SiO2 is 69.90%. This pozzolan contains cementation properties when mixed with water.

Bagasse fiber ash is the residue from burning sago pulp. Sago fiber pulp itself is the result of abundant waste from the sago processing process. The results of energy dispersive X-ray fluorescence analysis (XRF) showed that the content of silica oxide (SiO2) was 69.9% SiO2, 18.97% CaO, 4.08% Fe2O3, 1.46% Al2O3, 2.5% MgO and 3.09% other elements and tested by X-Ray Defractometry (XRD) to identify the shape of silica. This test shows that the silica oxide (SiO2) found in sago pulp ash is amorphous. So from these comparisons it can be concluded that sago pulp ash meets the requirements as a pozzolanic stabilizer. This pozzolan contains cementation properties when mixed with water.

Table 1. Chemical Composition of Sago Dregs Combustion Ash

No	Composition	Percentage (%)
1	Silicon Dioxide (SiO2)	69.90
2	Aluminum Oxide (Al2O3)	1.46
3	Iron Oxide (Fe2O3)	4.08
4	Sulfate (SO3)	3.12
5	Calcium Oxide (CaO)	18.97
6	Magnesium Oxide (MgO)	2.5
7	Sodium (Na2O)	9.04

This study aims to determine the effect of adding a mixture of sago pulp ash waste as a stabilizing agent on physical properties: including testing the original soil water content (natural moisture content), specific gravity (specific gravity), liquid limit (liquid limit), plastic limit (plastic limit), sieve analysis.: and mechanical properties and properties: direct shear test, Unconfined Compression Strength, compaction test and California Bearing Test. It is hoped that the use of sago pulp ash as a soil stabilizing agent will have a significant impact on the technical properties of the soil and thereby reduce the environmental impact caused by sago waste.

MATERIALS AND METHODS

3.1 Materials and Equipment

The material used in this research is soil from Moncongloe Village, Maros Regency. Soil sampling was carried out in disturbed soil conditions. Fiber Waste Sago dregs comes from sago waste originating from North Luwu Regency. This sago fiber waste is burned at 450 degrees beforehand and tested for its chemical elements. The test results stated that 18.97%

contained calcium (CaO). The tests carried out consisted of testing the physical properties of the soil, compaction testing, Free Compressive Strength and CBR testing.
In laboratory testing, the methods used include:
1. Specific Gravity Check (ASTM 1989 D854-83)
2. Consistency Limit Check (ASTM1989 D 4318)
3. Free Compressive Strength Test (ASTM D-2166 -06)
4. Standard Proctor Testing (ASTM D-698 (Method B))
5. CBR Testing (ASTM D-1883)

The percentage of addition of ash from burning sago pulp fiber used included 0%, 2%, , 6%, and 10%, of the total weight of the soil. Examination of specific gravity and consistency limits is used to determine the physical properties of the original soil. Standard proctor testing is used to determine the optimum density and moisture content. The optimum water content obtained is used in CBR testing.

3.2 Unconfined Compression Test
This test was carried out with the aim of obtaining a shear strength value of
cohesive soil. Free compressive strength is the value of the maximum axial stress that a cylindrical specimen can withstand before it collapses.

3.3 CBR (California Bearing Ratio)
CBR (California Bearing Ratio) is the ratio of the penetration resistance force of the soil to the penetration of a continuously pressed piston with a similar penetration resistance force on a standard soil sample in the form of crushed stone in California. The ratio is taken from the penetration of 2.5 and 5.0 mm (0.1 and 0.2 in) provided that the highest number is used. This experiment is for

Assess the strength of subgrade compacted in the laboratory which will be used in pavement thickness planning with the CBR value (in %) which will later be used to determine pavement thickness. Subgrade in new road construction is original soil, stockpiled soil, or excavated soil that has been compacted to a density of 95% of the maximum density. Thus the bearing capacity of the subgrade is the value of the ability of the soil layer to carry the load after the soil is compacted. The higher the CBR value of the soil (subgrade), the thinner the pavement layer above it will be and the smaller the CBR value (low soil bearing capacity), the thicker the pavement layer above it will be according to the load it will carry.

RESULT AND DISCUSSION

3.1. Test Results of Soil Physical Properties and Soil Classification
According to the Unified Soil Classification System (USCS) soil classification system, based on the percentage value of grains that pass the No. sieve. 200 of 50.23% (greater than 50%), then based on the USCS soil classification table, soil samples were collected from MoncongloeMaros Regency is generally categorized in the fine grained (clay) soil group.

Table 1. Soil physical properties testing

No.	Paramater	Value
1	Moisture Content (%)	23.59
2	Fill Weight (γ)(gr/cm^3)	1.79
3	Specific Gravity (Gs)(gr/cm^3)	2.59
4	Atterberg limit	
	Liquid Limit (LL)	43.33
	Plastic Limit	30.17
	Plasticity Index	13.16
5	Grain Gradation	
	Coarse grained soil	49.77
	Fine grined soil	50.23
6	Soil Classification (unified method)	CH

Table 2 Specific Gravity of Soil Composition- Sago Dregs Ash

No	Code	Composition	Density
1	A0	Pure soil	2.59
2	A1	Soil + 2% sago dregs ash	2.72
3	A2	Soil + 4% sago dregs ash	2.59
4	A3	Soil + 6% sago dregs ash	2.47
5	A4	Soil + 8% sago dregs ash	2.27
6	A5	Soil + 10% sago dregs ash	2.25

Table 3. Results of the Atterberg Limit Test of Soil-Ash Sago Dregs

No	Code	Composition	Liquid Limit(LL)%	Plastic Limit(PL) (%)	Plastic Index (PI) (%)
1	A0	Pure soil	43.33	30.17	13.16
2	A1	Soil + 2% sago dregs ash	64.62	34.20	3.50
3	A2	Soil + 4% sago dregs ash	64.60	54.62	2.98
4	A3	Soil + 6% sago dregs ash	29.84	28.24	1.60
5	A4	Soil + 8% sago dregs ash	71.35	35.12	3.40
6	A5	Soil + 10% sago dregs ash	68.13	41.64	8.46

Changes in several physical properties of the stabilized soil such as plasticity index, moisture content, specific gravity, and dry weight are associated with an increase in strength. This increase in strength can be called a temporary increase. The increase in permanent strength is related to the long-term reactions, which are associated with the formation of various types of cementation compounds in the soil matrix. Causes agglomeration which glues between particles. Some of the pore cavities are partially surrounded by cementitious material which is harder and difficult for water to penetrate. The pore cavity isolated by the impermeable cementation layer will be measured as the grain volume thereby increasing the grain volume and decreasing the Gs value.

Table 4. Soil composition - Variation of ash resulting from burning sago pulp, undisturbed (qu) disturbed (qu) and sensitivity (St)

No	Code	Composition	Undisturbed Soil (qu)	Disturbed Soil (qu)	Sensitivity (St)
1	A0	Pure soil	0.1892	0.0818	1.9192
2	A1	Soil + 2% sago dregs ash	0.1017	0.0954	0.9472
3	A2	Soil + 4% sago dregs ash	0.2394	0.1312	0.9644
4	A3	Soil + 6% sago dregs ash	0.3136	0.1803	2.3992
5	A4	Soil + 8% sago dregs ash	0.2472	0.0414	1.9760
6	A5	Soil + 10% sago dregs ash	0.1297	0.000	1.9266

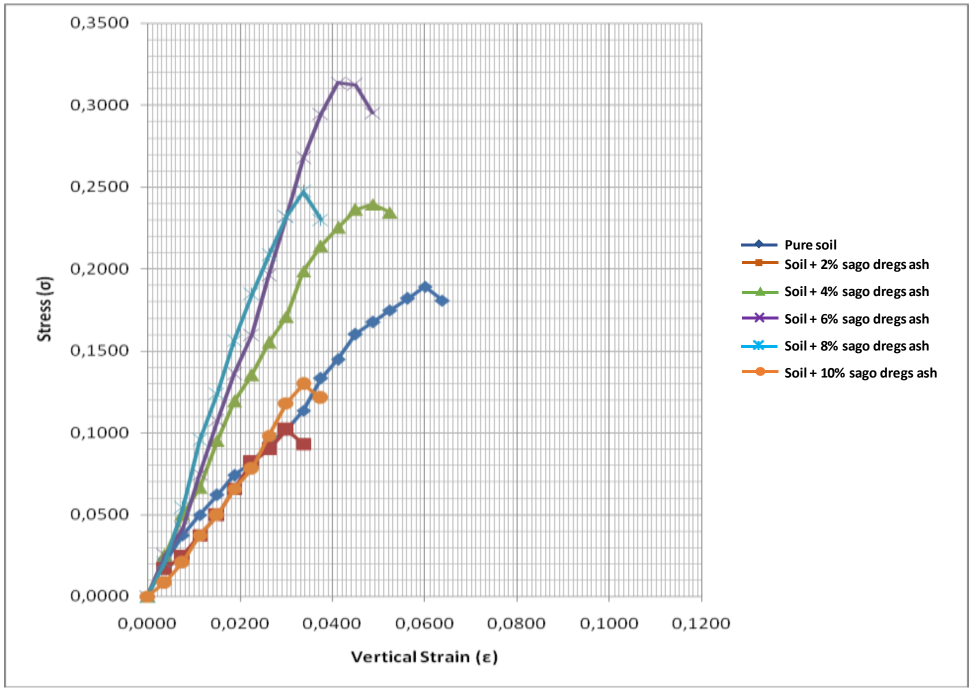

Figure 1. The relationship between stress and strain in the undisturbed soil with variations in the ash resulting from burning sago pulp

From Table 4 and Figure 1 it can be seen that the soil mixed with ash from burning sago pulp experienced the highest increase in stress at the addition of 6%, the change in compressive strength for undisturbed soil (qu) which was previously 0.1892 kg/cm2 experienced an increase of 0.1244 kg/cm2 or an increase of 39.66% to 0.3136 kg/cm2, while the lowest value occurred at the addition of 2% with a value of 0.1017 kg/cm2. This is caused by the addition of ash from combustion which fills the voids in the soil which makes the soil denser and affects the strong pressure on the soil.

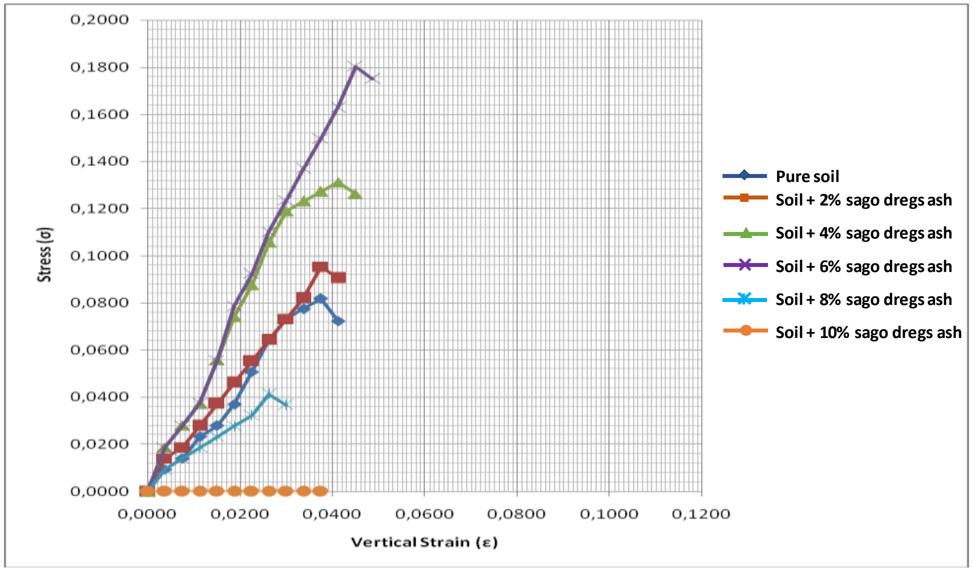

Figure 2. Graph of combined soil stress and strain disturbed by variations in ash resulting from burning sago pulp

Table 4. and Figure 2 can be seen that the soil mixed with ash from burning sago pulp experienced the highest increase in the 6% addition variation, the change in compressive strength for disturbed soil where previously the resistance value at compressive strength was 0.0638 kg/cm2 has increased of 0.0985 kg/cm2 or an increase of 54.63% to 0.1803 kg/cm2, while the lowest value occurred in the 10% addition variation with a Sensitivity (St) value of 2.3992. From these results this soil can be categorized as clay with moderate sensitivity.

The increase in the variation of the mixing of sago pulp burning ash had a significant effect on increasing the free compressive strength (UCT) of the soil at 6% addition variation, an increase value of 54.63% of the research sample. The increase in strength when sago pulp burning ash was added to the soil was mainly related to the potential of the Sago Pulp burning ash to absorb water from the soils tested. The presence of Sago Pulp Burning Ash in the soil mixture has a significant effect on reducing the natural moisture content, after which the strength increases

The addition of 8% mixing variation has a negative effect on decreasing compressive strength. The compressive strength decreased with increasing the mixing variation. This result is related to the fact that the ash from burning sago pulp has the same potential to expand and shrink between soil particles. This effect occurs due to the different chemical composition of the variations in the addition of ash from burning sago pulp. So, the variation of Sago Pulp Combustion Ash is added to the clay particles, a different chemical reaction takes place, and consequently gives a different level of strength.

Table 5. Standard Compaction Test of Soil-ash resulting from burning sago pulp

No	Composition	Yd maks(gr/ cm^3)	Wopt(%)
1	Pure soil	13.27	28.771
2	Soil + 2% sago dregs ash	1.43	11.98
3	Soil + 4% sago dregs ash	1.49	12.42
4	Soil + 6% sago dregs ash	1.79	13.20
5	Soil + 8% sago dregs ash	0.64	13.70
6	Soil + 10% sago dregs ash	0.23	14.84

From Table 5, the addition of ash resulting from burning sago pulp with variations of 2%, 4%, 6%, 8%, 10% experienced various changes so that the maximum Ydry value and maximum optimum water content were obtained at the addition of 6%

with a value of 1.79 gr/cm3 with an optimum moisture content of 13.20%. With an initial maximum Ydry value of 13.277 gr/cm3 and an optimum water content value of 28.77%, while the minimum value for changes in Ydry occurs at the addition of 10% with a value of 0.23 gr/cm3. The change in maximum density is caused by the water that fills the pores being absorbed by the ash from burning sago pulp.

Table 6. California Bearing Ratio (CBR) Test Results

No	Composition	In	California Bearing Ratio Test Results (%)				
			1	2	3	4	5
1	Soil	0.1	14.969	17.147	19.052	8.165	4.627
		0.2	12.701	15.241	17.963	7.802	4.536
2	Soil + 2% ash	0.1	16.058	19.052	25.039	16.330	8.165
		0.2	14.878	16.511	23.951	15.423	7.984
3	Soil + 6% ash	0.1	18.507	26.128	26.672	19.596	17.147
		0.2	15.423	22.681	23.588	19.052	15.604
4	Soil + 10% ash	0.1	13.336	17.691	20.413	13.881	13.064
		0.2	15.423	16.330	20.322	15.060	15.967

After stabilization, the California Bearing Ratio (CBR) value increased according to the percentage variation of Sago Dregs Combustion Ash. The California Bearing Ratio value of the soil added with Sago Pulp Combustion Ash, is optimal at variations in the addition of 6% APAS with a penetration of 0.1. The reason behind the higher California Bearing Ratio is the additional resistance to penetration that occurs due to the tensile strength of the crushed surface [9].Ratio (CBR), this is an indicator for increasing soil carrying capacity. The addition of 6% Sago Pulp Combustion Ash showed an increase of 28.57% from the soil without the addition of Sago Pulp Combustion Ash.This increase can be attributed to the reaction between the soil and the Sago Dregs Burning Ash, forming cementation. The formation of this cementation binds the particles together, by covering the soil grains and filling the pores between the aggregates [10]. The addition of Sago Pulp Burning Ash reduced soil development by increasing the percentage of APAS. Development potential increases when the percentage of addition is more than 6% APA. The use of Sago Pulp Burning Ash as a stabilizer has also shown a change in an increase in the California Bearing Ratio (CBR).

CONCLUSION

The addition of the percentage of sago pulp ash soil property index: liquid limit value (LL), plastic limit value (PL), plasticity index (PI) tends to decrease. For mechanical testing, a significant effect on increasing the free compressive strength (UCT) of the soil in the 6% addition variation, the increase in value of 54.63% and the California Bearing Ratio (CBR) value experienced an optimal increase in carrying capacity when adding sago pulp ashes. 6% with an increase of 28.57%. This shows that the characteristics of the soil property index and soil bearing capacity after stabilization are better. The chemical composition of sago pulp burning ash gives a good indication of its effectiveness in soil stabilization, the silica and alumina content present in the soil can react with calcium hydroxide in the Sago pulp burning ash to produce cementation. The formation of this cementation binds the particles together, by covering the soil grains and filling the inter-aggregate pores. Based on these results, the clay treated with the addition of Sago Pulp Burning Ash performed well as a stabilizing agent.

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