

**EFFECT OF ADDING WOOD POWDER ASH ON CBR VALUE IN STABILIZED HIGH PLASTICITY CLAY CEMENT AND LIME****Soewignjo Agus Nugroho<sup>1,\*</sup>, Ferry Fatnanta<sup>2</sup>, Muhammad Faizal Alridho<sup>1</sup>**<sup>1</sup>Departement of Civil Engineering, University of Riau, Pekanbaru, INDONESIA<sup>2</sup>Magister of Civil Engineering Study Program, University of Riau, Pekanbaru, INDONESIAE-mail: [nugroho.sa@eng.unri.ac.id](mailto:nugroho.sa@eng.unri.ac.id)**ABSTRACT**

Cement and lime are widely used as stabilizing agents for soft clays. Some pozzolanic materials have also been used as additives such as asphalt, geosta, fly ash (geopolymer), base ash, salt. Industrial waste such as rice husk ash, coal burning ash (geopolymer) is also used as an alternative for stabilization materials. This research aims to study the effect of sawdust ash, as wood waste, to replace cement and lime on the stabilization of high plasticity clay. The effectiveness of sawdust ash, in this study, was evaluated from the CBR value. The test samples were also reviewed under conditions with and without immersion and with and without curing. Based on the test results, lime is very effective as an additive because it increases the CBR value of more than 100 at a level of 10%. Wood husk ash also increases the CBR value by 100%. The use of cement, lime and wood husk ash requires curing time so that there is a strong bond between the clay and additives. The use of additives without curing did not increase the CBR value. In the stabilization of clay with 10% lime, replacement of lime with wood husk ash by 4%-6%, can be used as a road sub-grade with good quality.

**Keywords:** sawdust ash; CBR; lime; stabilization; cement.

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**INTRODUCTION**

The foundation functions to transmit the building load to the supporting soil layer. Soil is a support for the foundation of a building. Soil properties such as history of formation, gradation of grain size, ability to pass water, compressibility when given a load, shear strength, bearing capacity when receiving a load greatly affect the ability of the soil to support the load.

Soft soil has several properties, namely low shear strength, high swelling shrinkage, and seepage. Buildings erected on soft soil will face problems, namely bearing capacity collapse and settlement.

Soil stabilization aims to increase soil strength, reduce swelling-shrinkage properties, reduce permeability (seepage), reduce pore volume, and increase soil volume weight.

Mechanical, chemical and combined mechanical-chemical stabilization are examples of common stabilization methods. Pozzolanic additives that are widely used in soil mixtures include cement, lime, geosta, geopolymer, asphalt, salt. Research on additives, soil types, and optimal levels of chemicals has been carried out.

In 2019, Lembasi investigated the use of fly ash and bottom ash geopolymers to reduce swelling of high plasticity clays (Lembasi et al., 2019). In his research, Lembasi added 5% lime to a mixture of clay and geopolymer. The results of the study concluded that the smallest soil swelling potential value was obtained in samples by curing for 28 days. The largest laboratory CBR value also occurs in samples with a curing of 28 days (Lembasi et al., 2021)

A mixture of 5% lime in clay soil, if mixed with fly ash geopolymer with a content of 15% can be used as a good road subgrade material (Nugroho et al., 2020). Curing for 28 days, according to Nugroho, is needed to give the clay, lime, fly ash time to form a strong bond. Field compaction with moisture content close to OMC conditions will produce maximum carrying capacity. Changes in independent compressive strength values, with changes in the composition of fly ash and bottom

ash on high plasticity clay soils were also studied by Zulnasari (Zulnasari et al., 2021). In his research, Zulnasari also added 5% lime

Lime is effectively used for stabilization of expansive clay, high plasticity (Nugroho et al., 2021). According to Nugroho, the addition of 10% lime reduces the liquid limit by 6%, the plastic limit by 46%, and increases the free compressive strength by more than 300%.

The use of cement as a binding material in expansive clay mixtures was also carried out by (Takaendengan et al., 2013). Other researchers have also used cement in combination with other additives, such as with silica fume by Goodarzi et al. (Goodarzi et al., 2016), fly ash (Gunawan et al., 2018), rubber fibers. (Yadav & Tiwari, 2017). Some researchers also use more than 2 pozzolanic cement mixed in clay stabilization such as Vakili mixing with sodium silicate and slag (Vakili et al., 2016), Putra (Putra & Zaika, 2016) mixing rice husk ash and sugarcane.

The use of industrial wastes, apart from burning coal, has also been widely used. Apart from Putra et al., several other researchers have also succeeded in proving an increase in the shear strength and bearing capacity of clay. Adha et al., 2011 used rice husk ash waste (Adha, 2011), Yi in 2015 used slag.

The combination of high plasticity clay with cement mixed with rice husk ash has been carried out by Ihsan et al. (Ihsan et al., 2019). Ihsan et al. Obtaining the highest UCS and CBR values occurred in the composition of a mixture of clay with 5% cement and 10% rice husk ash. Lesmana et al. (Lesmana et al., 2016) also used cement up to 30% for stabilization of high plasticity clay. The more cement content in the mixture, the higher the CBR value of the sample, is the conclusion of Lesmana's research

There is very little research on the utilization of sawdust, after being burned to ashes (saw-dust ash). The use of saw ash is still rare, especially for soil improvement. Research tries to use saw ash waste as a substitute for other stabilizing materials (lime) in high plasticity clay mixed with 5% cement.

## **RESEARCH METHODS**

The original soil, in the form of clay, was taken from Muara Fajar District, Pekanbaru City, Riau.

Wood husk ash waste comes from the wood processing factory (Saws Mill) Teratak Buluh Village, Siak Hulu District, Kampar Regency. The cement used is Portland Composite Cement (PCC). Quick Lime or quicklime is used

Initial testing includes determination of Atterberg boundaries and Laboratory compaction. The original soil and all mixed variations were checked for consistency limits. The standard Proctor test aims to determine the optimum water content (OMC) where the soil bearing capacity (MDD) has the highest value.

The water content used when mixing clay with stabilizing materials (cement, lime, wood husk ash), is set the same as the water content in the original soil OMC condition so that it is uniform.

The main test is in the form of determining the value of Laboratory CBR on the original soil and mixed variations.

Mixed variations are selected by adding:

1. Cement (5%)
2. Lime (4%, 6%, 10%)
3. Wood husk ash (4%, 6%, 10%)
4. Cement and lime
5. Cement and wood husk ash
6. Cement, lime and wood husk ash

The variation of the stabilizing material is intended first to see the effectiveness of lime in increasing the bearing capacity; secondly, the effect of wood husk ash on the value of soil bearing capacity; the last is the use of wood husk ash, which is a processing waste, as a substitute for lime for stabilizing clay soils.

Prior to the Laboratory CBR testing, in soaked or unsoaked conditions, samples were treated by curing 0 days (non-curing) and 28 days (curing).

The steps for implementing the research can be seen in Figure 1.

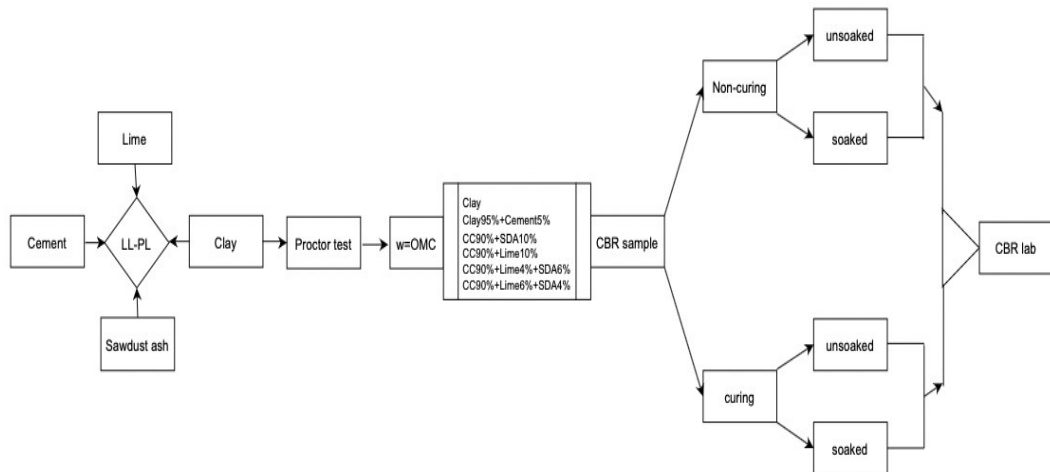


Figure 1. Graphical Abstract research

RESULTS AND DISCUSSION

Standard compaction tests of Proktor and Atterberg limits were carried out in the Laboratory. The original soil has a liquid limit value and a plasticity index of 69.15% and 36.50%, respectively. The test results if plotted on the Atterberg consistency graph are included in the high plasticity clay (CH) class. The optimum moisture content of the proctor test results is 29.00% and the maximum dry density is 13.70 kN/m3. The results of the consistency limits test are summarized in table 1 below.

Table 1. Test Results of Consistency Limits of Sample Variations

No.	SAMPLES VARIATION	Atterberg Limits			USCS classification	Swelling potential
		LL (%)	PL (%)	IP (%)		
1.	Clay	69,15	32,65	36,50	CH	High
2.	Clay 95% + Cement 5%	63,15	37,92	25,23	MH	High
3.	Clay 96% + Lime 4%	65,38	43,53	21,85	MH	High
4.	Clay 94% + Lime 6%	62,51	42,17	20,34	MH	Medium
5.	Clay 90% + Lime 10%	57,86	41,00	16,86	MH	Medium
6.	Clay 90% + SDA 4%	60,13	43,03	17,10	MH	Medium
7.	Clay 94% + SDA 6%	58,36	41,07	17,29	MH	Medium
8.	Clay 90% + SDA 10%	55,98	36,78	19,20	MH	High
9.	CC (95% Clay+5%Cement) 90% + Lime 10%	63,26	51,01	12,25	MH	Low
10.	CC (95%Clay+5%Cement) 90% + SDA 10%	54,47	30,47	24,00	MH	Medium
11.	CC 90% + Lime 4% + SDA 6%	58,76	40,74	18,29	MH	Medium
12.	CC 90% + Lime 6% + SDA 4%	60,31	45,27	15,04	MH	Medium

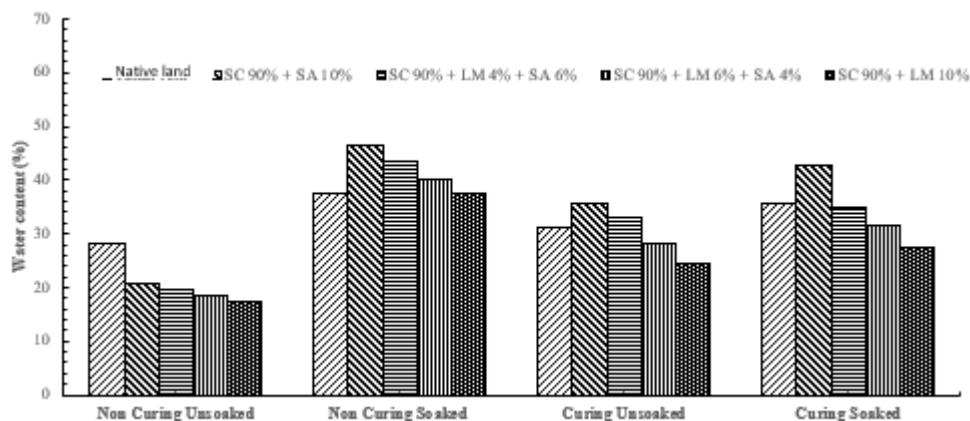
The addition of 5% cement succeeded in lowering the original soil liquid limit from 69.15% to 63.15% and increasing the plastic limit from 32.65% to 37.92%. The decrease in the liquid limit and the increase in the plastic limit reduce the value of the plasticity index and change the soil classification from clay (CH) to silt (MH). These changes also occur with the addition of lime or wood husk ash 4%-10% and 10% mixture of lime with wood husk ash (Table 1).

The properties of materials such as cement, lime, wood husk ash in absorbing water, when forming bonds with clay, are different. Making CBR samples at the optimum water content of the original soil, which is 29.00%, will change after 28 days of curing and change again after 4 (days) immersion. The measurement of water content is carried out after the implementation of the Laboratory CBR test. This is done to see the interaction of water with additives, namely cement, lime, wood husk ash or a combination of more than 1 (one) additive. Changes in water content during the process according to the conditions of the sample plan are shown in Table 2 and Figure 2.

**Table 2.** Moisture Content of Samples for CBR Lab test all conditions

No	Variasi Sample	Water content (%)			
		Non-Curing		Curing	
		Unsoaked	Soaked	Unsoaked	Soaked
1.	Clay 95% + Cement 5% (CC)	28,27	37,62	31,10	35,82
2.	CC (95%Clay+5%Cement) 90%+ LHA 10%	20,21	46,48	35,59	42,68
3.	CC (95%Clay+5%Cement) 90% + Lime 10%	17,42	37,66	24,44	27,41
4.	CC (95%Clay+5%Cement) 90% + Lime 4% + LHA 6%	19,73	43,53	32,90	35,03
5.	CC (95%+5%Cement) 90% + Lime 6% + LHA 4%	18,40	40,26	28,02	31,67

Making CBR samples with 5% cement content, reduced the water content from 29.00% to 28.27%. Cement requires water to form a bond with clay so that it absorbs free water. Like cement, lime and wood husk ash also need water to form a bond with clay. This can be seen in the variation of samples without curing and immersion.



**Figure 2.** Moisture Content of CBR . Samples

Curing was done by storing the sample at room temperature in a closed room for 28 days. During the ripening period, the process of forming bonds between the additives and the clay takes place. The bond formation process generates heat and absorbs water from the free air, so that the water content of the sample increases. The water content of the samples with and without curing is quite large.

Immersion is carried out after the sample is printed or after the curing process is complete. Samples were immersed in water for 4 days. During the soaking process, the water content increases due to the entry of water in the soil pores. The increase in water content in samples with curing was not too high compared to samples without curing after 4 days of immersion.

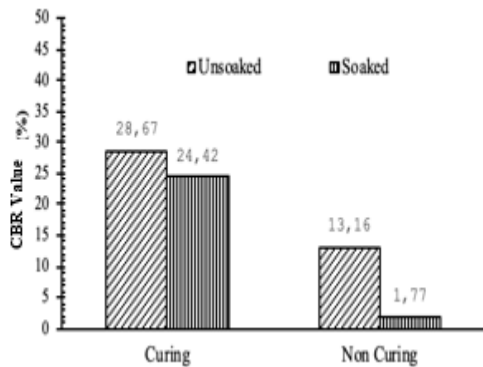


Figure 3. Variation of CC 90% + SDA 10%

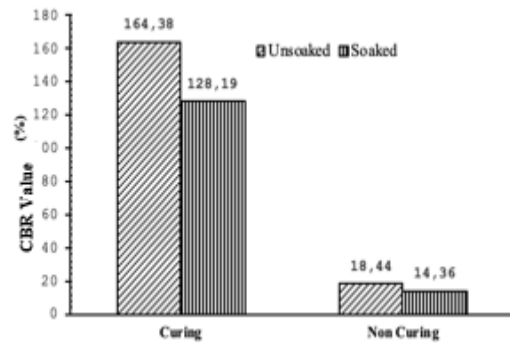


Figure 4. Variation of CC 90% + Lime 10%

Laboratory CBR Testing of original clay conditions without curing, soaking and not soaking, were 1.96% and 11.88%, respectively. The CBR value of the original soil with 28 days of soaked and unsoaked curing was 2.28% and 16.64%, respectively. There is no change in the CBR price on the original clay due to curing in 2 (two) conditions, namely the soaked condition and the unsoaked condition.

The addition of 10% SDA to a mixture of 95% clay with 5% cement, without curing, did not change the CBR value with or without immersion. (Figure 3)

Figure 3 also shows a significant difference between the samples in the treatment with 28 days of curing and without curing. The difference of 15.50% occurred in the unsoaked CBR value and 22.70% in the soaked CBR value. The addition of 10% SDA increased the CBR value up to 22% if soaked and 12.00% without soaking.

The addition of 10% lime (Figure 4), without curing, is common to increase the CBR value from 1.96% to 14.36% when soaked. Meanwhile, the CBR value without soaking increased from 11.88% to 18.44%. The curing process is very effective in increasing the value of the soaked CBR compared to the unsoaked CBR.

Under conditions of curing for 28 days (Figure 4), the increase in CBR value was very high, more than 100 different. The addition of 10% lime was effective in increasing the CBR value by giving the opportunity for a bond reaction between clay and lime to occur for 28 days.

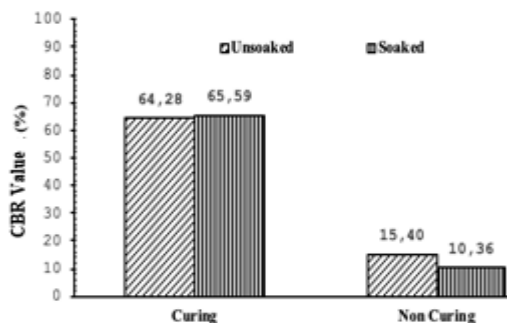


Figure 5. Variation of CC 90% + Lime 4% + SDA 6%

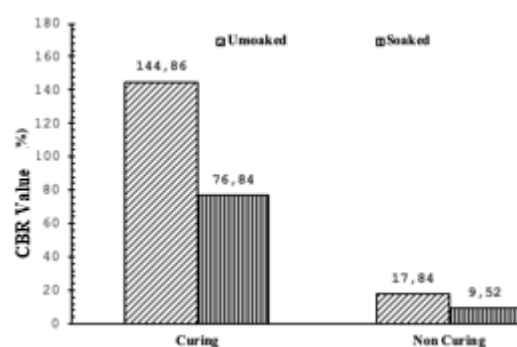


Figure 6. Variation of CC 90% + Lime 6% + SDA 4%

Wood husk ash, as a waste, has not been widely used to increase the bearing capacity of soft soil. Referring to the results of the CBR test in Figure 3, with the addition of a little cement, it is proven to increase the bearing capacity of the soil. The increase in CBR is very high with the use of lime, while the increase in CBR value is small when using natural resources. The combination of lime and SDA was carried out to see changes in the CBR value when some of the lime was replaced with wood husk ash. The results of the CBR test of a combination of pozzolanic materials in the form of lime and SDA are presented in Figure 5 and Figure 6.

Replacing lime with wood husk ash as much as 6% (Figure 5), curing for 28 days, reduced the soaked CBR value from 128.19% to 65.59% and the non-soaked CBR value from 164.38% to 64.28%. SDA as much as 4% as a substitute for lime reduces the CBR value to 76.84% in the condition of the sample being soaked and 144.86% without soaking.

**Table 3.** Mixed CBR values and CBR criteria for road sub-grade

Sample variation	Test conditions				CBR value (%)	Criteria Sub-grade
	Soaked		Unsoaked			
	Non-Curing	Curing	Non-Curing	Curing		
90% CC+10% SDA	1,77	24,42	13,16	28,67	20-30	Very good
90% CC+10% Lime	14,36	128,19	18,44	164,38	10-20	Well
90% CC+ 4% Lime +6 % SDA	10,36	65,59	64,28	15,40	5-10	Currently
90% CC+ 6% Lime+4% SDA	9,52	76,84	17,84	144,86	<5	Bad

Referring to Table 3, the clay mixture with a cement content of 5%, meets the criteria as a sub-grade by adding a mixture with additives with a content of 10%. Additives in the form of a mixture of lime and wood husk ash with a ratio that is close to the same.

### CONCLUSION

Laboratory CBR values for the original clay without curing were 1.96% for the bath and 11.88%. 28 days of curing increased the CBR value to 2.38% under immersion and 16.64% without immersion.

Stabilization of high plasticity clay with added cement, lime requires treatment with curing of at least 28 days to allow time for the additive to react, with the help of water, to form bonds with clay granules. Stabilization of high plasticity clay with cement, lime, and the combination of lime with wood husk ash.

Stabilization using lime is suitable for high plasticity clays because it can increase the CBR value up to 100%. Sawdust waste, in the form of ash, can be used as a clay stabilizing agent

The use of wood husk ash content of 4-6% is used as a mixture of high plasticity clay, can be used as a sub-grade of road pavement. The composition of a mixture of lime and rice husk ash is 10%.

Further research is needed to see the value of free compressive strength and swelling potential, stabilization decomposition with wood husk ash.

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### NOTATION LIST

- LM : lime
- SC : soil-cement=clay-cement
- CC : clay-cement
- SA : saw-dust ash=SDA

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