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EFFECTS OF FLY ASH AND RICE HUSK ASH MIXING WITH BANJARMASIN SOFT CLAY SOIL ON CBR, SWELLING AND SHEAR STRENGTH VALUE

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ABSTRACT

Soil stabilization using admixture is one way to improve the mechanical properties of soil. Several studies have shown that the use of fly ash and rice husk ash can have an effect to increasing the CBR value and suppressing the expansion of soil volume (swelling), as well as increasing the shear strength value. However, the researches cannot explain the effectiveness of mixing fly ash and rice husk ash as a soft clay soil stabilizer, especially soft clay soil in Banjarmasin, South Kalimantan Province.

The fly ash used comes from the Asam-asam PLTU, while the rice husk ash is taken from the Cempaka sub-district. The percentage of fly ash used in the mixture is 15%, 20% and 25% of the dry weight of the original soil, while the percentage of the rice husk ash used is 5% and 10% of the dry weight of the original soil. Each sample that has been compacted is cured for 3, and 7 days before performing the CBR test. On the samples that will be subjected to the immersion CBR test, a numerical analysis will be performed on shear strenght. Samples that have been tested for immersion CBR will be molded using a ring for testing direct shear. The maximum CBR value resulting from this research was in soil conditions mixed with 25% fly ash and 5% rice husk ash. When the curing time reached 7 days, the CBR changed to be 1,72%. The cohesion and friction angle of the soil also change depending on the percentage of admixture used. However, chemical stabilization uses fly ash and rice husk ash requires water on the process of stabilization so that the water content in the sample keep decrease during of curing time.

Keywords: Fly Ash, Rice Husk Ash, Stabilization, Soft Clay Soil.

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1. INTRODUCTION

Banjarmasin contains surface soil types that included to the soft soil category, with organic clay or silty clay predominating. The mapping of the different types of surface soil layers examined using 45 sondir test sites and 37 N-SPT test points demonstrates that the average value of these two parameters, which is 5, is rather low. Because Banjarmasin City is elevated below sea level, nearly the whole city was inundated during high tide, which resulted in the surface soil being softer [1].

This kind of soil shrinkage happens readily, therefore it will affect bearing capacity, which is determined by mechanical parameters and CBR. This property's propensity for rapid expansion and contraction can typically result in a variety of construction-related issues, particularly when building roads. Utilizing fly ash and rice husk ash in varying proportions for stabilization is one technique to improve the stability of this kind of soil. This is also done to ensure that the land satisfies technical requirements. Asam-asam PLTU fly ash is relatively safe for used as construction material. Results of the Asam-asam PLTU fly ash potential toxicity test has good potential to be exploited [2]. In addition, it was decided to use fly ash and rice husk ash as industrial waste stabilizing materials that have a marketable value.

Several references say that stabilization using fly ash can change the CBR soaked value of the immersion from 4.3% to 11%, while rice husk ash increases the CBR soaked value to 9.5% [3]. Other researchers also revealed that the use of fly ash can change the parameter value of CBR unsoaked, which was initially 1.52% to 1.98% at a percentage of added materials of 15%, while rice husk ash provides an increase until the CBR unsoaked value 2.56 % at a percentage of added ingredients of 10% [4]. This means that fly ash and rice husk ash have quite an influence on the soil stabilization process using additional materials.

Generally, another problem that occurs in soft clay soil is low shear strength. By adding admixture, the shear strength parameters will generally increase. Meanwhile, the influence of added materials on soil development can increase the CBR value along with the length of the stabilization period. This means that the added material is able to improve the physical and mechanical properties of clay soil.

Even though the chemical content of fly ash and rice husk ash tends to be the same, there are differences in the grain shape of the two materials. Fly ash usually has a round granular shape or a solid micro ball. Meanwhile, rice husk ash has irregular grain shapes and some resemble the shape of rice husks. By mixing these two stabilizing materials which have different physical properties, through this research we will see whether mixing these two industrial waste materials will be effective in stabilizing soft clay soil.

2. MATERIALS AND METHOD

The field work carried out was taking soil samples. Soil samples taken were disturbed soil and undisturbed soil. However, in this research it is sufficient to take samples using disturbed soil, namely soft soil in the ULM Campus Area, Banjarmasin City, South Kalimantan. Soil is taken at one point at the sampling location.

This process will be carried out with the following approach, namely: Literature study, collecting primary and secondary data, as well as laboratory scale research.

Soil samples taken do not require any effort to be made to protect the properties of the soil. These soil samples are used to examine soil physical properties such as soil water content, grain size analysis, Atterberg boundaries (LL, PL and SL), and specific gravity. Tests are also carried out on the mechanical properties of the soil such as compaction tests, CBR (California bearing ratio) tests, swlling test and direct shear tests. On stabilized soil samples, curing is carried out with a stabilization age of 3 and 7 days before the mechanical properties are tested. Taking disturbed soil samples is enough to put them in a plastic sack. The fly ash samples were taken from the PLTU in South Kalimantan. Rice husk ash will be collected from the rice milling factory in Cempaka sub-district, Banjarbaru City.

Fly ash additives will be mixed into soft soil at a percentage of 15%, 20% and 25%. Meanwhile, the percentage of added rice husk ash used is 5% and 10%. These two types of materials will be combined for use in soil stabilization by applying 6 different types of mixture variations. From the results of tests on the physical and mechanical properties of the stabilized soil, it will be known how the added materials of fly ash and rice husk ash affect the soft clay soil of Banjarmasin.

3. RESULTS

The results of the soil physical properties test show that the soft soil used is included in the organic clay soil category which has a specific gravity value of 2.583. This is in accordance with the classification of the soil which is included in the organic clay (OH) soil category based on the plasticity index and liquid limit according to the Unified system classification as shown in Table 1. Based on the grain size distribution, the soil studied was dominated by 51.95% clay, which means that the clay grains in the soil are more than half of the soil grains other than clay.

Table 1. Value of Physical Properties of Soft Clay Soil Before Stabilization

No.	Physical Properties of Soft Soil		Value
1	Specific Gravity (Gs)	-	2,583
2	Water Content (Wc)	(%)	33.680
3	Grain Size		
	Gravel (>2 mm)	(%)	0.000
	Rough sand (0.6-2.0 mm)	(%)	0.002
	Medium sand (0.2-0.6 mm)	(%)	0.023
	Fine sand (0.05-0.2 mm)	(%)	0.112
	Silt and clay (0.002-0.05 mm)	(%)	0.324
	Clay (<0.002 mm)	(%)	0.520
4	Plasticity		
	Liquid Limit (LL)	(%)	52.532
	Plastic Limit (PL)	(%)	42.000
	Plasticity Index (PI)	(%)	10.531

0.109 kg/cm2 cohesion in the direct shear test shows that the consistency of the clay used is soft. If viewed based on the CBR value soaked of 0.34% and CBR without soaking of 1.4%, it can be seen that the soil is included in the bad criteria. Swelling in soaked samples occurred up to 12.3% when soaked for 4 days. The results of the compaction test explained that the soil was able to reach a dry volume weight of 1.56 at an optimum moisture content of 16.23% as shown in Table 2.

Table 2. Value of the Mechanical Properties of Soft Clay Soil Before Stabilization

No.	Mechanical Properties		Value
1	Cohesion (c)	kg/cm^2	0.109
2	Friction angle	°	8.36
3	Optimum Moisture Content (OMC)	%	16.23
4	Dry Density (γd)	kg/cm^3	1.56
5	CBR Unsoaked	%	1.40
6	CBR Soaked	%	0.34
7	Swelling	%	12.30

The immersion CBR test was carried out when the stabilization age reached 7 days. The water content of the soaked sample before stabilization was 24.79%. It can be seen in Fig. 1 that the water content is lower than in soil samples without stabilization materials. This shows that soil samples mixed with stabilization material have a greater intergranular density than soil without stabilization, which makes it more difficult for water to fill the pores in the soil. The difference in water content in each sample looks irregular, this means that the soil samples have a significant increase in stability at different ages.

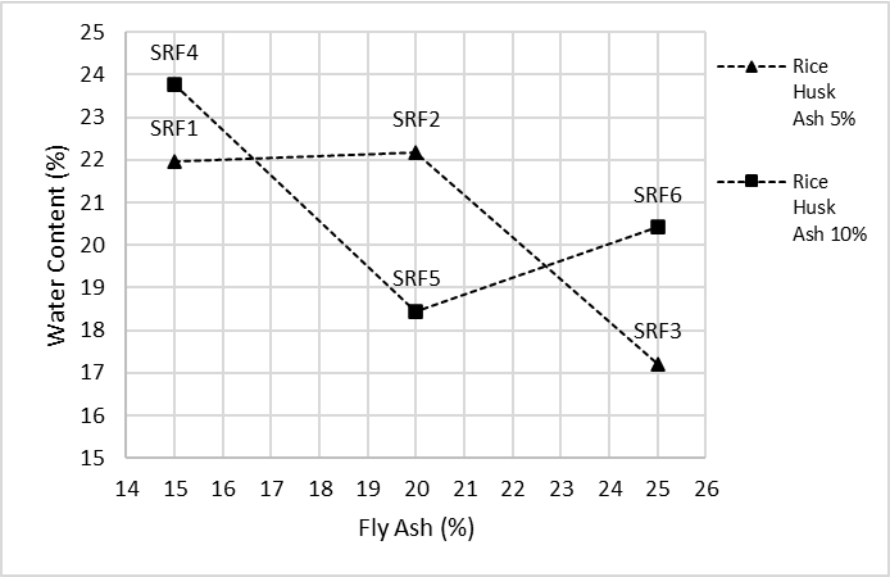

Figure 1. Comparison of Water Content of Each Type of Sample in Soaking Conditions

The initial cohesion value for the soil before stabilization was 0.109 kg/cm2. The addition of stabilization material with a percentage of up to 30% can increase soil cohesion by up to 255% of the cohesion value of soft clay soil. The difference in the influence provided by fly ash and rice husk stabilization materials cannot be found in the differences in cohesion parameters. This can be seen by comparing the differences in cohesion between SRF2 and SRF4 and comparing the differences in cohesion between SRF3 and SRF5. When comparing the cohesion values of SRF2 and SRF4, it appears that the rice husk ash stabilization material has a stronger effect than the fly ash stabilization material. However, a comparison of the cohesion values for SRF3 and SRF5 shows the opposite result as shown in Fig. 2.

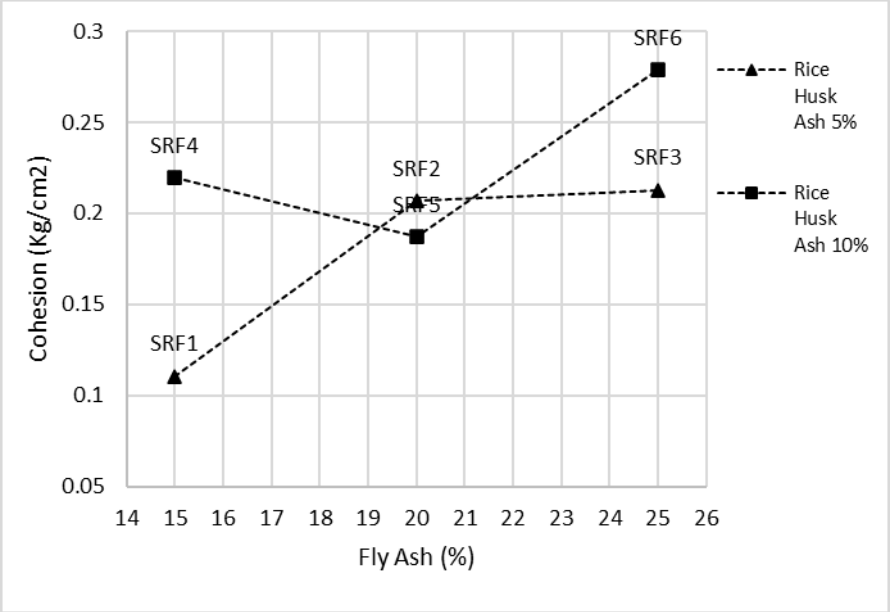

Figure 2. Stabilized Soil Cohesion Value

The initial friction angle value for the soil before stabilization was 8.36°. The research results show a tendency that the greater the percentage of stabilization material added, the value of the friction angle tends to increase. However, the fly ash stabilization material showed a stronger influence than the rice husk ash stabilization material. This means that increasing the rice husk ash stabilization material by more than 5% cannot increase the internal friction angle parameters. However, in general it can be concluded that adding fly ash and rice husk ash stabilization materials to soft clay soil can increase the soil friction angle parameters as shown in Fig. 3.

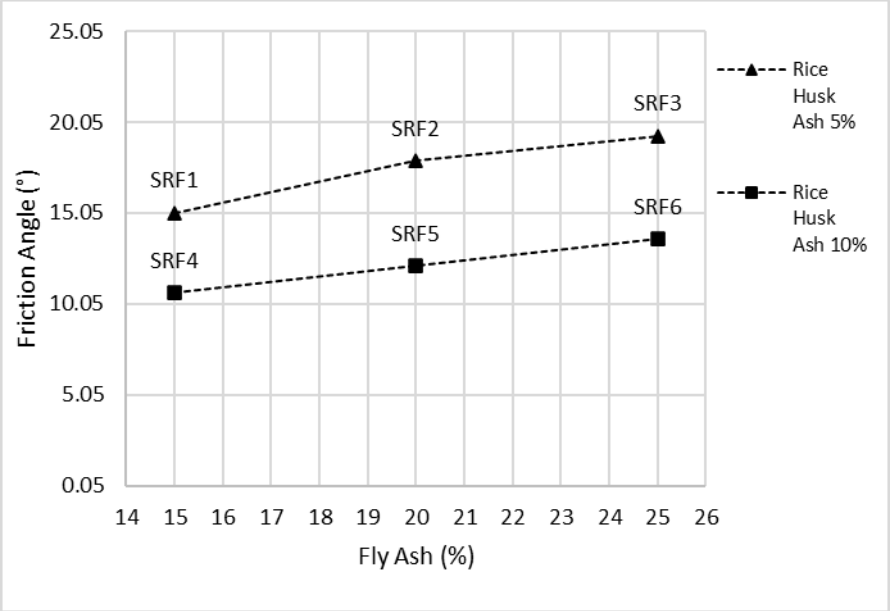

Figure 3. Friction Angle Values in Stabilized Soil

The shear strength of the soil increased from the initial condition before stabilization of 0.148 kg/cm2 to 0.345 kg/cm2 or an increase of 233% from the initial condition for the percentage of 25% fly ash stabilization material and 10% rice husk ash at a stabilization age of 7 days as shown in Table 3. Increasing the stabilization age also increases the shear strength value of the soil. Due to the influence of the stabilization age, the reaction to form the stabilization material continues and the gel becomes denser so that the shear strength increases. This is in line with research conducted by Ma'ruf [5].

Table 3. Comparison of the Increase in Shear Strength Values from Study Results with Previous Research

Shear Strenght (Kg/cm^2)		Increase in Shear Strength (%)	
Test result	Ma'ruf (2012)	Test result	Ma'ruf (2012)
Fly Ash 25% + Rice husk ash 10%	(Kapur + Abu Sekam Padi) 20%	Fly Ash 25% + Rice husk ash 10%	(Kapur + Abu Sekam Padi) 20%
7 days of stabilization	30 days of stabilization	7 days of stabilization	30 days of stabilization
0.345	0.329	233%	135%

The unsoaked CBR value of the soil before stabilization was 1.4%. The results of the unsoaked CBR test with curing prove that the CBR value increases as the percentage of stabilization material is added as shown in Fig. 4 and Fig. 5.

However, in samples that contain more rice husk ash at the same percentage of stabilizing material, the research results show that increasing the percentage of fly ash added is more effective than rice husk ash, which is in accordance with the results of research conducted by Prasetia [6]. Based on the research results, it can be seen that stabilization using fly ash and rice husk ash was able to increase the CBR value to 1.72% in the SRF3 sample at a stabilization age of 7 days.

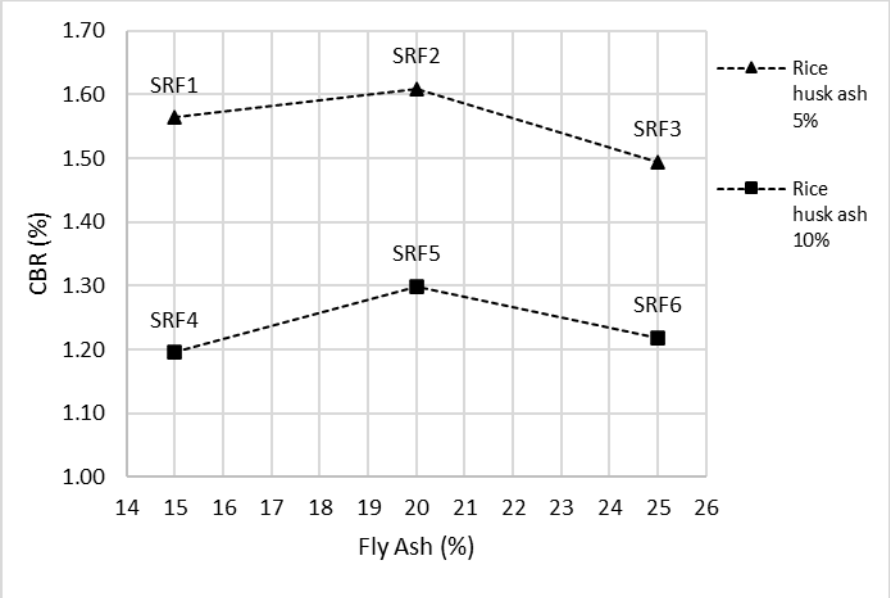

Figure 4. CBR Unsoaked Value at Stabilization Age for 3 Days

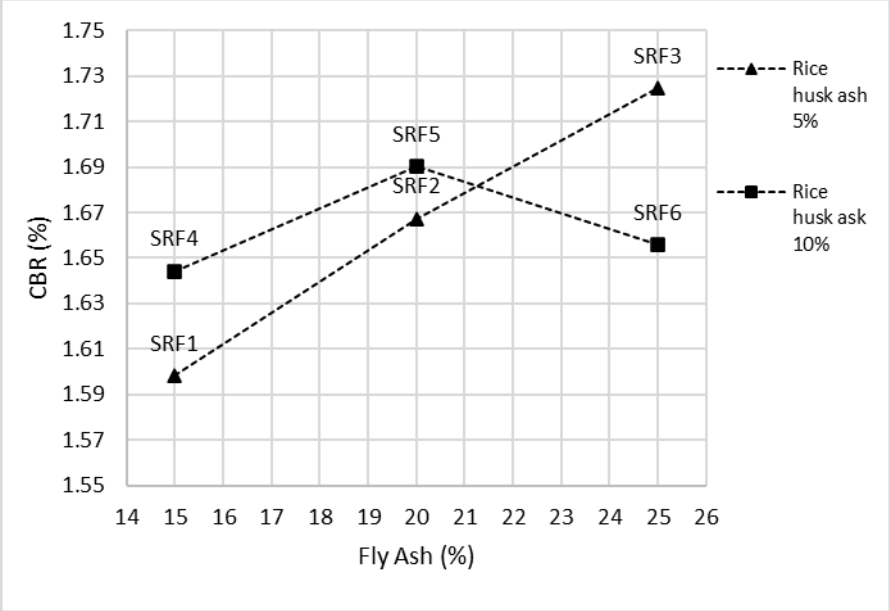

Figure 5. CBR Unsoaked Value at Stabilization Age for 7 Days

Fly ash and rice husk ash are not effective when used together at a stabilization age of 7 days so that the increase in CBR value is only 121% of the CBR value of soft clay soil before stabilization as shown in Table 4. The research results of Vattimala (2021) show that if only rice husk ash is used, the increase in CBR value can reach 168%. Meanwhile, the increase in Prasetia's CBR value (2023) reached 154% due to the influence of added lime with a percentage of 2.5%.

Table 4. Comparison of the increase in CBR unsoaked values with previous research

Test result	Increase in CBR Unsoaked Value		
	Prasetia et al (2023)	Vattimala et al (2021)	Vattimala et al (2021)
FA:20%, RHA:10% 7 days of stabilization	FA:20%, RHA:10%, L:2,5% 7 days of stabilization	FA:20%	RHA:10%
121%	154%	127%	168%

The CBR value for immersion in soil that has not been stabilized is 0.34%. The CBR test was also carried out on soaked samples that had reached a stabilization age of 7 days. After the stabilization age of 7 days is reached, the sample to be tested for CBR will first be soaked for 4 days. The results obtained show that stabilization materials can increase the CBR value of soil under soaking conditions, but are not effective enough to be used on soft clay soils. This is also because at a stabilization age of 7 days, the stabilized soil has not shown a significant increase in the CBR value as shown in Fig. 6. From the results of the soaked CBR test it can also be seen that SRF 6 which has the most stabilization material has a lower CBR value than SRF 3 and SRF 5, this can explain that the more stabilization material added, the longer the stabilization life required to increase the stability of soft clay soil.

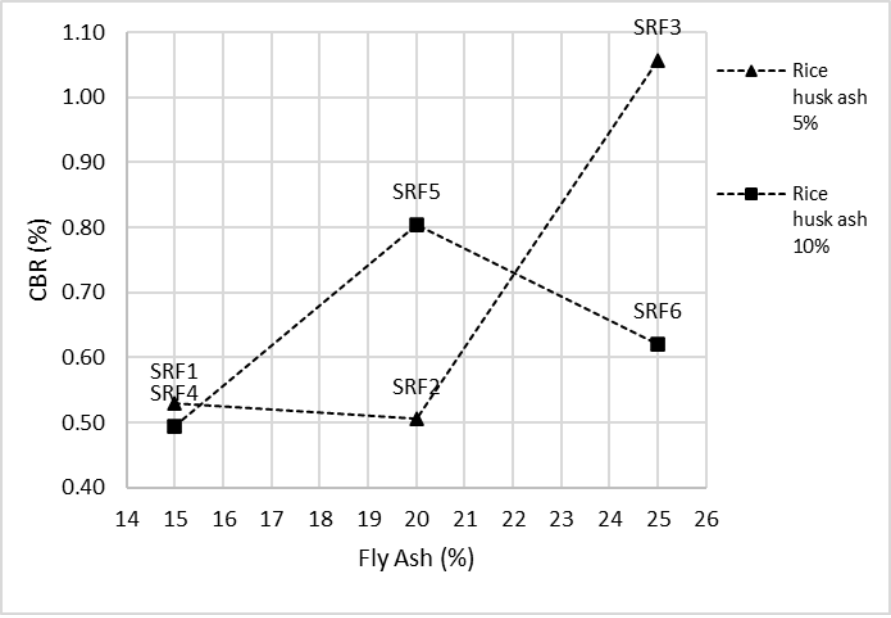

Figure 6. CBR Soaked Value at Stabilization Age for 7 Days

From the comparison in Table 5, it can be seen that the increase in the soaked CBR value is greatly influenced by the value of the initial soil condition. The increase in the CBR value of Ali's immersion (2019) reached 214% at a percentage of fly ash stabilization material of 15% because the CBR value before being stabilized by Ali (2019) was 4.3%.

Meanwhile, the increase in the immersion CBR value from the study results only reached 156% at a stabilization age of 7 days. This means that the initial characteristics of the original soil used greatly influence the increase in the CBR value. The increase in Prasetia's CBR value (2023) which was only 123% was due to the influence of added lime with a percentage of 2.5% [6].

Table 5. Comparison of the Increase in CBR Soaked Values with Previous Research

Increase in CBR Soaked value			
Test result	Prasetia et al (2023)	Ali et al (2019)	Ali et al (2019)
FA:15%, RHA:5%	FA:15%, RHA:5%, L:2,5%	FA:15%	RHA:5%
7 days of stabilization	7 days of stabilization	-	-
156%	123%	214%	142%

During soaking of the soaked CBR test samples, the influence provided by the addition of stabilization material was also observed on the swelling rate within 4 days. From the research results, it is known that the composition of the stabilization material that most suppresses the swelling rate is the SRF 3 sample. Based on Fig. 7, it is known that the greater the percentage of fly ash added, the greater the reduction in the swelling rate. On the other hand, if more rice husk ash is added, the reduction in swelling rate is not very significant. The highest swelling rate in stabilized soil was shown by the SRF4 sample, namely 8.89%, this indicates that the greater the percentage of rice husk ash stabilization material added, the less effective it is at reducing the rate of soil swelling. However, in general, fly ash and rice husk ash stabilization materials had an effect in the form of reducing the swelling rate in each test sample.

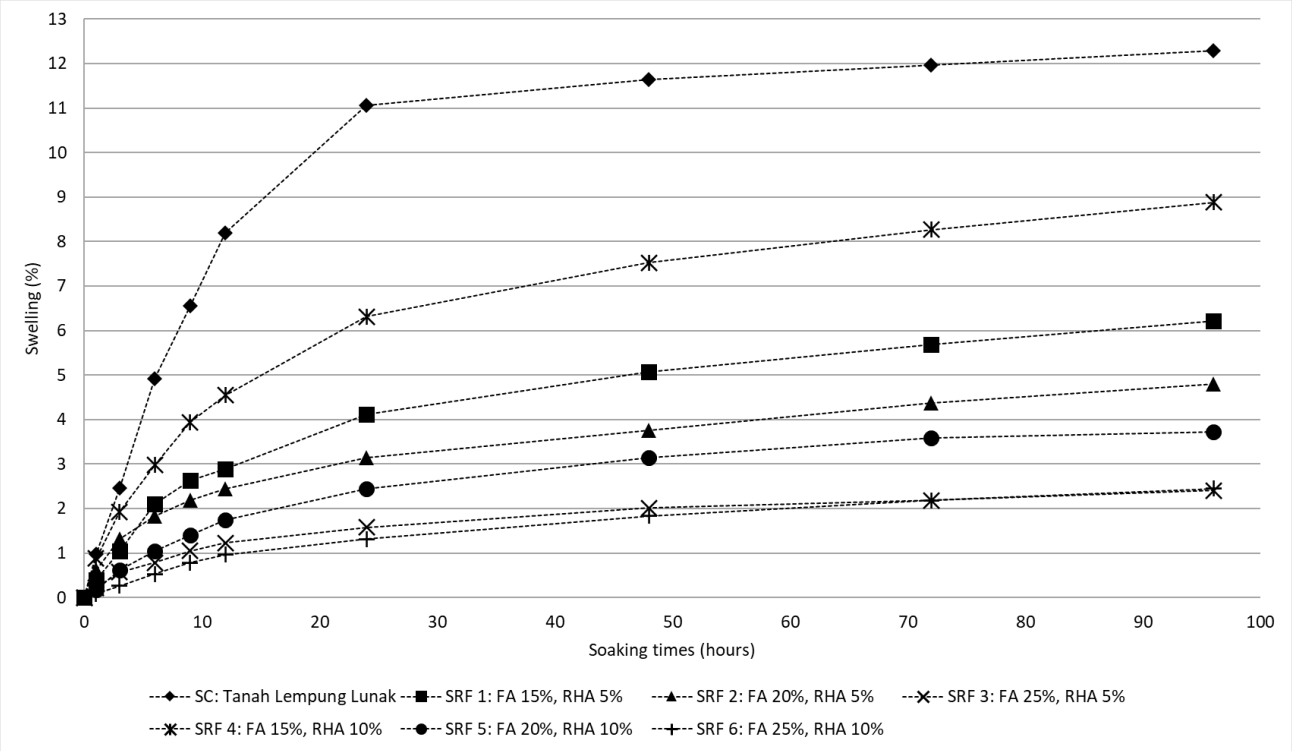

Figure 6. Relationship between Soaking Time and Swelling Rate

4. CONCLUSION

As explained previously, the addition of stabilizing materials in different percentages increases the behavior of the mechanical properties of soft clay soils also differently. From the previous description it can also be concluded that the addition of 25% fly ash admixture and 5% rice husk ash (from the dry weight of soft clay soil) provides very significant changes in the parameter values of soft clay soil. The stabilization age also greatly influences the increase in soil parameter values. Based on the CBR test results, it can be concluded that the most optimum percentage of stabilization material is 25% fly ash and 5% rice husk ash.

From the research results, it can be seen that increasing the percentage of fly ash to increase soil stability is more effective than increasing the percentage of rice husk ash. From the research results, it is also known that the addition of fly ash and rice husk ash admixtures has not been able to achieve a CBR figure of 6% in accordance with the guidelines of Road Pavement Design Manual No. 02/M/BM/2017, so it is highly recommended that similar research be carried out on clay soils whose initial CBR value is not too low.

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