

# Study of Alkali-Activated Coal Ash for Improving Soft Soil Subgrade

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## 1. Introduction

The increasing demand for coal is due to Indonesia's declaration of a 35,000 MW program to meet electricity needs throughout Indonesia, predicted to be complete in 2029. As constructing a power plant is the cheapest investment, coal has become the primary source of the national electricity supply. However, the Power plant has problems with waste from burning coal, namely Fly Ash and Bottom Ash. The utilization rate of coal ash in Indonesia is lower, especially outside Java Island. The total utilization of Fly Ash in Indonesia only reaches 10%, and the rest is piled up.

Various studies showed that Fly Ash and Bottom Ash as subgrade materials increase soil strength by increasing soil density and reducing plasticity index. Using Bottom Ash up to 12% can raise CBR Soaked value from 3.5% to 23%. While the addition of Fly Ash up to 12% only reached 4.5%. Utilizes Bottom Ash in a ratio of 3:7 to the soil, increasing CBR value and reducing swelling soil (Cadersa et al., 2014). Based on the study results, it is known that Fly Ash and Bottom Ash have significant potential as soil stabilization in subgrades.

Fly Ash includes non-self-cementing, so activators such as limestone or cement are needed. Mixing Fly Ash up to 6% in soil mixture with cement can reduce development in the soil to increase the value of CBR (Islam et al., 2019). Since the Coal Ash Yard is obtained from the Tanjung Jati B power plant, classified as class F, it requires an alkali activator. This proposed research uses NaOH, CaCO<sub>3</sub>, and portland cement to accelerate the pozzolanic reaction.

## 2. Methodology

This research was conducted in two stages. The first stage is research to find the composition of ACA, while the second stage is to find the characterization of ACA in soft soil. The proposed research activities would be finding the optimal composition of the Alkali-Activated Coal Ash (ACA) combination for soft soil subgrade and determining and

analyzing the effect of adding Alkali-Activated Coal Ash (ACA) on the performance of soft soil subgrade. The material is carried out by taking soft soil around Institut Teknologi Sepuluh Nopember at a depth of 0.5 m – 1 m for disturbed soil. Soft soil with disturbed soil conditions is carried out by preliminary laboratory testing to determine the initial characteristics of soft soil.

The initial test found that soft soil is not required as a road subgrade material, as shown in Table 1. The example of the requirements referred to is that the minimum soaked CBR value is 6%, while the soaked CBR value of soft soil is only 1.2%.

Table 1 Specification of soft soil tested

SOFT SOIL CHARACTERISTIC		Requirement
Unit Weight ( $\gamma_t$ )	1.471 g/cm <sup>3</sup>	
Specific Gravity (Gs)	2.57	
Plasticity Index (PI)	39 %	Max. 15%
CBR Soaked	1.2 %	Min. 6%
USCS	MH (Inorganic Silts)	
AASHTO	A-7-5 (Clay Soil)	

## 3. Results and Discussion

The characteristics of the Coal Ash yard can be viewed from several tests such as grain distribution testing, XRF testing, XRD, and SEM. The following are some of the results of tests that have been carried out to determine the characteristics of the Coal Ash yard of PLTU Tanjung Jati. From XRF test results identified that the Coal Ash yard, according to ASTM C618-19, is class F. This is evidenced by SiO<sub>2</sub> + Al<sub>2</sub>O<sub>3</sub> + Fe<sub>2</sub>O<sub>3</sub> is 77.72%, and the CaO composition is 5.8%. This study used an alkaline activator of 0.04 M NaOH because it accelerated the pozzolanic reaction in Coal Ash Yard. Based on the results, it is obtained that the Coal Ash Yard material has a smooth surface, seen from the aggregate surface. Most Coal Ash Yard granules are not evenly distributed; some are round and irregular. This indicates that the material is suitable for filler or a mixture of soft soil as a subgrade material.

The unconfined Compression Strength (UCS) Test determines the stress-strain relationship of cohesive soils without limiting stresses. The cohesive soil-free compressive strength test method determines the free compressive strength of soil samples with cohesion, both undisturbed and remolded compacted. In this study, the ACA material was compacted, and the specimens were stored using the moist curing method. UCS testing was carried out on 7, 14, 21, and 28 days of ACA specimens, summarized in Table 2. Based on Figure 1, the highest test results were obtained with a composition of 90% FAB A (Coal Ash) + 10% cement (90F), and the lowest was obtained with 95% FAB A + 5% cement. More cement content results in higher strength due to the cement pavement. Curing further improves the workability of the mixes. Much change occurs in the first 28 days; the rate slows considerably beyond this period.

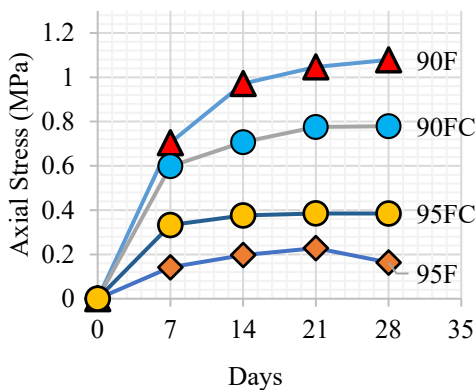


Figure 1 UCS Test Result

Table 2 Test cases and test results of UCS

Name	Coal Ash (%)	CaCO <sub>3</sub> (%)	UCS (MPa) for varying curing time (days)			
			7	14	21	28
90F	90	0	0.705	0.972	1.047	1.079
90FC	90	3	0.598	0.707	0.775	0.779
95F	95	0	0.142	0.197	0.229	0.164
95FC	95	3	0.333	0.376	0.385	0.385

In Figure 2, adding 3% CaCO<sub>3</sub> can increase the strength to 63% of the soaked CBR value. Adding ACA to the soft soil increased the CBR value of the immersion. This proves that Coal Ash yards can be used massively for subgrade materials. While on Figure 3 shows the result of adding ACA to soft soil, with the percentage of the weight of ACA. This proves that Coal Ash can lower the value of the Plasticity Index.

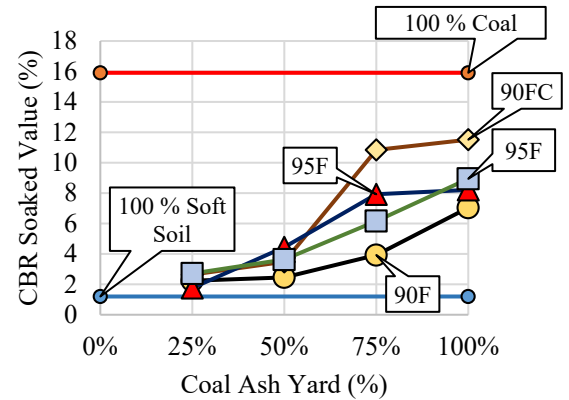


Figure 2 The Soaked CBR Value

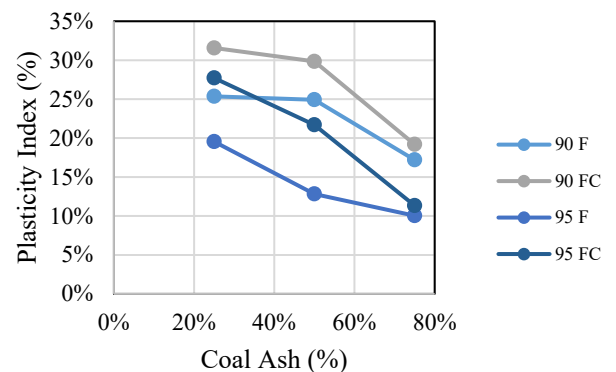


Figure 3 Plasticity Index Value

4. Conclusion

Based on the research conducted, it can be concluded that:

- 1) A mixture of coal ash of more than 90% can increase the value of CBR; and,
- 2) A mixture of coal ash of more than 90% can lower the value of the Plasticity Index.

References

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