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Effect of Fly Ash Addition in West Jakarta Cengkareng Area Soil on CBR Value

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ABSTRACT: Jalan Raya Daan Mogot KM.14, Cengkareng, West Jakarta, has a type of clay soil where the soil is very sensitive to changes in water content; in dry conditions, it has a high carrying capacity, while in a saturated state, it has a low carrying capacity. This is characterized by road damage that occurs at the location when the rainy season arrives. One way to improve the base soil of the site is through the soil stabilization method with the addition of chemicals, namely fly ash. This study used fly ash as a stabilization material, namely by adding fly ash with a mixture variation of 5%, 10%, 15%, and 20% to the weight of soil samples with a watering period of 1, 7, and 14 days. The result of the CBR value without soaking (unsoaked) of the original soil of 2.933% of the land belongs to the very poor group because the value of CBR ranges from 0% to 3%. Then, it is necessary to improve the original soil with soil stabilization with variations in the rate and period of expansion. The results of the study of CBR value without soaking (unsoaked) with the addition of fly ash can increase the value of native soil CBR along with the addition of fly ash mix variation; however, variations of 15% and 20% decreased from day 7 to day 14 days. The maximum value occurs at a mixed variable rate of 20% with a 7-day watering age and a CBR value without soaking of 17.835%.

KEYWORDS: CBR; Fly ash; Soil stabilization; Subgrade soil

I. INTRODUCTION

Soil is one of the most important aspects of an infrastructure because its function is to receive and withstand the structural load above it. In addition, it is a very important basic material in the construction field because it is on this soil that a construction is rested [1]. However, not all soils are good to use in construction because there are several types of subgrade soils that are problematic both in terms of soil bearing capacity and in terms of soil deformation. For this reason, in planning during construction, an investigation must be carried out into the characteristics and strength of the soil, especially the soil properties that affect the bearing capacity of the soil in withstanding the construction load above it [2].

Clay soil is easy to swell in wet condition and will shrink if the soil is dry in the dry season. Swelling and shrinkage happens because water content in the soil changes the volume of soil [3].The subgrade as the foundation of a pavement has an important role because the subgrade has the traffic load above the pavement. Subgrade that has low strength will cause damage to the pavement. Therefore, pavements built on weak-strength subgrades will have a short service life. One of the causes of damage is the expanding and shrinking properties of soil types that have high palstistas [3]. Changes in subgrade moisture content can result in cracking or deformation. Drainage factors and moisture content in the basic compaction process determine the speed of damage that may occur [4].

One way to improve soil that can be done is through soil stabilization. Since soil is a material that varies Because soil is a material that varies (heterogeneous) between one location and another, it causes differences in the way stabilization is done [5]. Various stabilization efforts have been carried out both physically, mechanically, and chemically. Physical soil stabilization efforts involve mixing soil materials with other materials, such as husk ash, to increase the characteristics of the material [6]. Chemical soil stabilization is an effort to improve the bearing capacity of soil and mechanical stabilization by mixing synthetic fibers. Soil stabilization here is objectively intended to improve the bearing capacity of the soil, increase the resistance to load, increase the hardness of the layer, and increase the strength of the layer. to load, increase the hardness of the layer, reduce voids, and reduce the effects of expansion and shrinkage on the soil [7].

This study took soil samples at Jalan Raya Daan Mogot KM.14, Cengkareng, West Jakarta. The area has a type of clay soil where the soil is very sensitive to changes in water content; in a dry state, it has a high bearing capacity, while in a saturated state, it will have a low bearing capacity. This is characterized by road damage that occurs at that location when the rainy season arrives. Repairs made by the authorities so far at this location only repaired the top layer of the road but did not solve the problem because the damage continued to occur every year. The idea was to improve the subgrade using a soil stabilization method with the addition of chemicals [8]. The chemicals that will be used for soil stabilization are fly ash.

II. RESEARCH METHOD

In general, every research project is carried out with a "research method" so that all processes that must be completed can be fulfilled as planned and the research can be concluded at the point of decision-making [9]. Direct observation, interviews, and survey applications were used as primary data collection methods [10, 11]. The preparation of the research has several stages of work or methodology presented in a flow chart, which can be seen in Figure 3.1 below [12, 13].

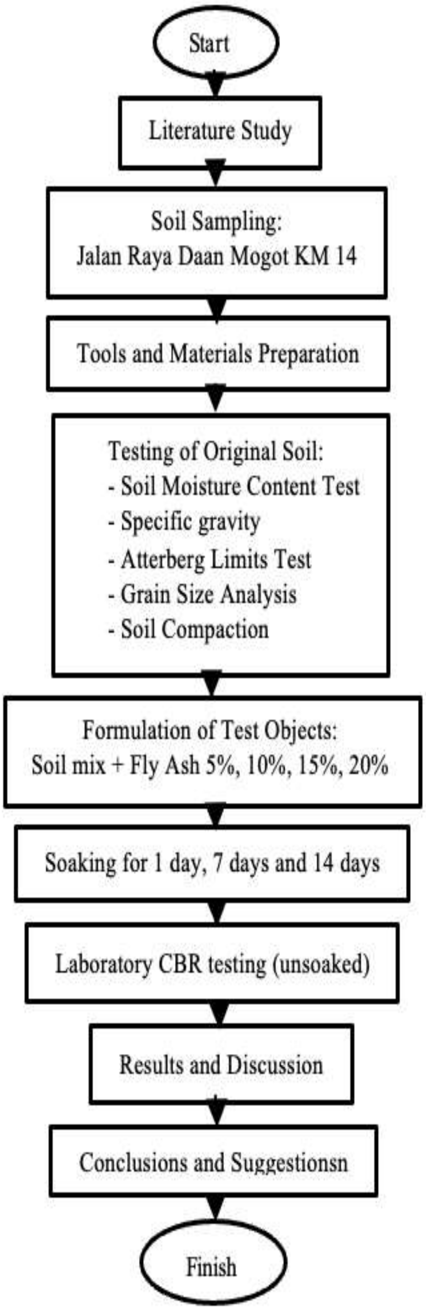

Figure 1. Research Flowchart

In this study, several stages were carried out, first testing the physical properties of soil consisting of testing water content, specific gravity, liquid limit, plastic limit, shrinkage limit, grain size analysis to determine soil type [14]. The second research, compaction testing to determine the optimum water content and dry weight. The third research, making CBR test objects with predetermined fly ash levels of 5%, 10%, 15%, and 20% with a curing period of 1 day, 7 days and 14 days. Then conduct the CBR test to get the value of the carrying capacity of the soil under study. The fourth research is to calculate and analyze the effect of fly ash waste on CBR value [15]. The soil sample in this study is at the location of Jalan Raya Daan Mogot KM.14 can be seen in Figure 2 below.

Figure 2. Research location

III.RESULT AND DISCUSSION

A. Testing of Soil Properties

The results of soil physical properties testing conducted on the original soil from Cengkareng, West Jakarta, can be seen in Table 1 below:

Table 1. Recapitulation of Laboratory Testing of Original Soil

No	Parameters	Unit	Value
1	Water content	%	37,221
2	Specific Weight		2,71
Atterberg limits			
1	Liquid Limit (LL)	%	66,32
2	Plasticity Limit (PL)	%	35,00
3	Shrinkage Limit (SL)	%	9,182
4	Plasticity Index (PI)	%	30,223
Sieve Analysis			
1	Cu		4,92
2	CC		0,99
Standard Compaction			
1	MDD	gr/cm3	1,294
2	OMC	%	33,333

B. CBR Testing of Original Soil

The CBR test carried out is by means of CBR without soaking (unsoaked) [16]. This test aims to determine the strength of the surface of the soil layer, which will generally be used as a construction base layer in the laboratory, at the optimum moisture content obtained from standard compaction. California Bearing Ratio (CBR) test results can be seen in the figure below:

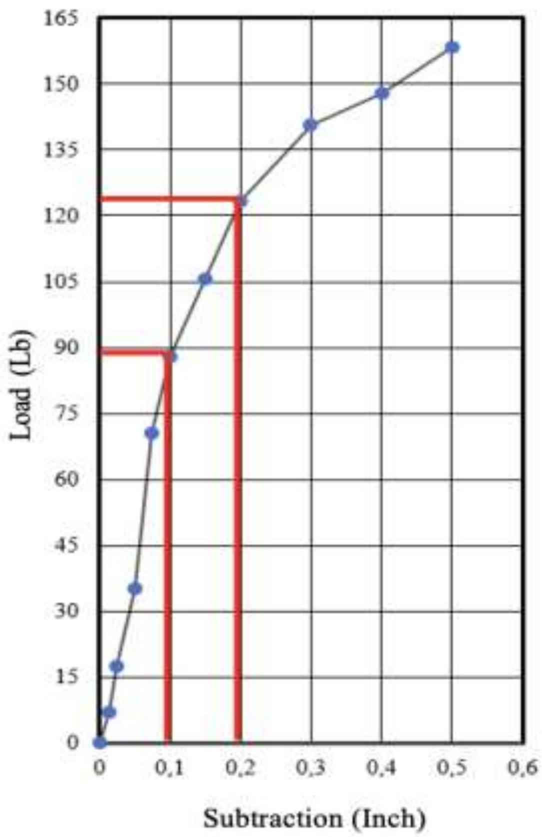

Figure 3. CBR Testing Graph of Original Soil

The CBR value of the original soil without soaking can be calculated using the following method:

CBR 0,1" = $\frac{88}{3 \times 1000} \times 100 = 2{,}933$ %

CBR 0,2" = $\frac{123{,}2}{3 \times 1500} \times 100 = 2{,}738$ %

From the calculations above, the CBR value of 0.1 "is 2.933% and the CBR value of 0.2" is 2.738%, so the CBR value used is the CBR value of 0.1 "which is 2, 933%. According to the Ministry of Public Works and Public Housing regarding the 2017 Road Pavement Design Manual, the minimum value of CBR that can be used is 6%. So, the soil from Jalan Raya Daan Mogot KM.14 Cengkareng, West Jakarta needs soil improvement with soil stabilization methods using additional materials or additives.

C. Soil Classification

The soil from Cengkareng, West Jakarta has the following characteristics:

Table 2. AASHTO Soil Classification for silt-clay soils

General Classification	Silt - cCay Soil (More than 35% of all soil samples pass the No.200 sieve			
Group Classification	A-4	A-5	A-6	A-7 A-7-5* A-7-6⁺
Sieve Analysis (% lolos) No. 10 No. 40 No. 200	Min 36	Min 36	Min 36	Min 36
Properties of the fraction that passes Sieve No. 40 Liquid limit (LL) Plasticity index	Max 40 Max 10	Max 41 Max 10	Mx 40 Max 11	Min 41 Min 11
Most dominant material type	Silty soil		Clayey soil	
Assessment as subgrade material	Fair to poor			

*For A-7-5, *PI* ≤ *LL* - 30

⁺For A-7-6, *PI* > *LL* - 30

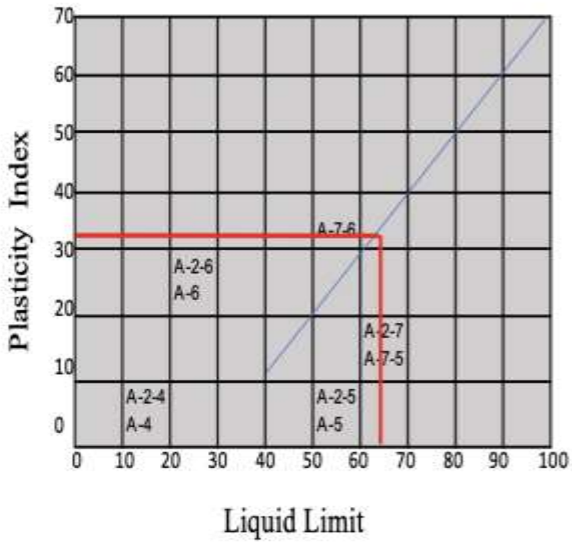

Figure 4. Liquid Limit Range and Plasticity Index Graph for Soil Grouping

Based on the test results of sieve analysis with a value of percent passing sieve no. 200 of 42.66%, liquid limit of 66.32%, plasticity index of 31.32% and GI value of 8.410%, the dominant type of material is clayey soil with an assessment as an ordinary to poor subgrade. Group classification based on liquid limit range graph and plasticity index including group A-7-5.

Table 3. Unified Soil Classification (USCS)

<table>
<tr><th colspan="3">Main Division</th><th>Group Symbols</th><th>General Name</th></tr>
<tr><td rowspan="8">Coarse-grained soil More than 50% of the grains are retained on sieve No. 200</td><td rowspan="4">Gravel 50% or more of the coarse fraction retained on sieve No. 4</td><td rowspan="2">Clean gravel (gravel only)</td><td>GW</td><td>Well-graded gravel and gravel - sand mixtures, containing little or no fines.</td></tr>
<tr><td>GP</td><td>Poorly graded gravel and sand-gravel mixtures, containing little or no fine grains</td></tr>
<tr><td rowspan="2">Gravel with fine grain</td><td>GM</td><td>Silty gravel, Gravel - sand - silt mix</td></tr>
<tr><td>GC</td><td>Clayey gravel, Gravel - sand - clay mix</td></tr>
<tr><td rowspan="4">Sand more than 50% of the coarse fraction</td><td rowspan="2">Clean sand (sand only)</td><td>SW</td><td>Well-graded sand, gravelly sand, little or no fine grains</td></tr>
<tr><td>SP</td><td>Poorly graded sand and gravelly sand, little or no fine grains</td></tr>
<tr><td rowspan="2">Sand with fine grains</td><td>SM</td><td>Silty sand, sand - silt mixture</td></tr>
<tr><td>SC</td><td>Loamy sand, mixed sand - clay</td></tr>
</table>

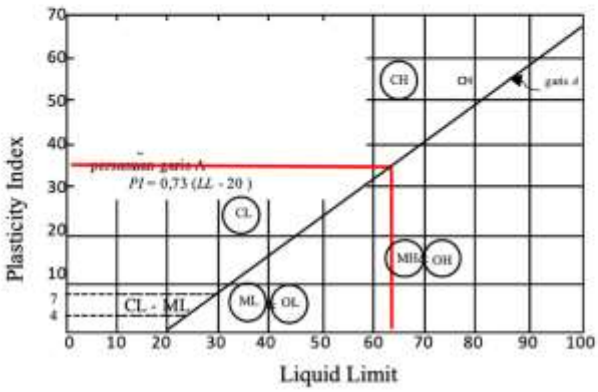

Figure 5. USCS Soil Classification Graph

Based on Figure 5, with a liquid limit (LL) value of 66.32% and a plasticity index (PI) of 31.32%, the soil belongs to a group with the OH symbol. The value of liquid limit (LL) > 50% and the OH symbol, the soil is included in the organic clay group with medium to high plasticity. Based on sieve analysis testing, the results of soil retained no.200 of 57.34% in the USCS classification system table is included in the group with the symbol SC, namely sand-clay mixed sand-clay.

D. California Bearing Ratio (CBR) Testing with Fly Ash Addition on Original Soil

This test aims to determine the CBR value of the pavement mixture and the level of mixture variation in soil mixed with fly ash. The test sample used is soil mixed with stabilization materials with varying levels of fly ash of 5%, 10%, 15%, and 20%, with a curing process for 1 day, 7 days, and 14 days after mixing. The curing process aims to determine the process of binding chemical compounds between cement and compounds in the soil.

The following is a recapitulation of the results of CBR testing without soaking for 1 day, 7 days and 14 days with variations in fly ash levels of 5%, 10%, 15% and 20% can be seen in the Table. 4 below:

Table 4. CBR Testing Result of Original Soil + Fly Ash

<table>
<tr><th rowspan="2">Soil and Mixture Types</th><th colspan="3">CBR Value T.A + FA, Optimum Water Content Condition</th></tr>
<tr><th>Soak 1 day (%)</th><th>Soak 7 day (%)</th><th>Soak 14 day (%)</th></tr>
<tr><td>Original Soil + FA 5%</td><td>3,520</td><td>4,459</td><td>5,515</td></tr>
<tr><td>Original Soil + FA 10%</td><td>5,280</td><td>5,749</td><td>11,499</td></tr>
<tr><td>Original Soil + FA 15%</td><td>11,733</td><td>14,080</td><td>12,907</td></tr>
<tr><td>Original Soil + FA 20%</td><td>14,080</td><td>17,835</td><td>15,840</td></tr>
</table>

Table 5. Percentage Increase in Unsoaked CBR Value

<table>
<tr><th rowspan="3">Soil and Mixture Types</th><th colspan="6">CBR Value T.A + FA, Optimum Moisture Content Condition T.A Description</th></tr>
<tr><th colspan="2">1 day (%)</th><th colspan="2">7 day (%)</th><th colspan="2">14 day (%)</th></tr>
<tr><th>CBR</th><th>(%)</th><th>CBR</th><th>(%)</th><th>CBR</th><th>(%)</th></tr>
<tr><td>Original Soil + FA 5%</td><td>3,52</td><td>20</td><td>4,46</td><td>52</td><td>5,51</td><td>88</td></tr>
<tr><td>Original Soil + FA 10%</td><td>5,28</td><td>80</td><td>5,75</td><td>96</td><td>11,50</td><td>292</td></tr>
<tr><td>Original Soil + FA 15%</td><td>11,73</td><td>300</td><td>14,08</td><td>380</td><td>12,91</td><td>340</td></tr>
<tr><td>Original Soil + FA 20%</td><td>14,08</td><td>380</td><td>17,83</td><td>508</td><td>15,84</td><td>440</td></tr>
</table>

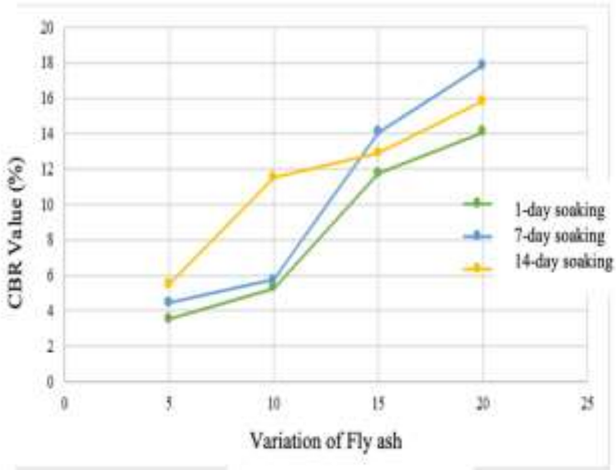

Figure 6. Comparison Graph of CBR Values with Fly Ash Variations without Soaking (Unsoaked)

Based on Figure 5 above, a comparison graph of unsoaked CBR values with fly ash variations is obtained, showing that the addition of fly ash can increase the CBR value along with the increase in the level of mixture variation. The maximum CBR value obtained is 17.835% at 20% fly ash mixture variation with 7 days of curing time. The lowest CBR value was 3.520% at 5% fly ash mixture variation with 1 day curing time.

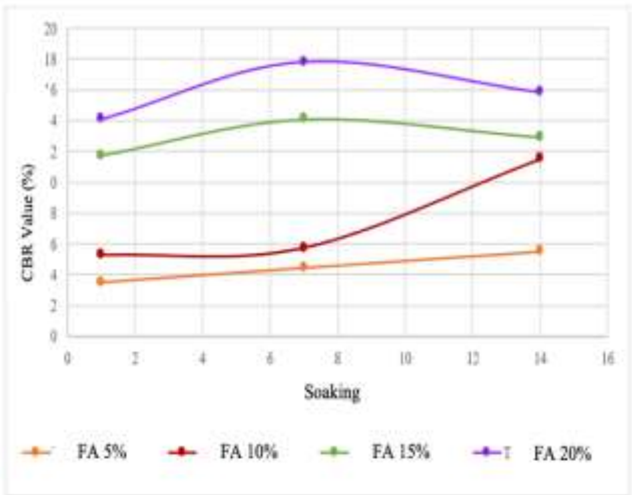

Figure 7. Comparison Chart of Unsoaked CBR Values with Fly Ash Variations on Soaking

Based on Figure 7 above, a comparison graph of the unsoaked CBR value with fly ash variations against burial is obtained, showing that in the 5% and 10% fly ash mixture variations, the CBR value increases along with the length of burial, while in the 15% and 20% fly ash variations it decreases from day 7 to day 14. The maximum unsoaked CBR value obtained was 17.835% at 7 days of curing.

IV. CONCLUSIONS

Based on the test results and discussion of mixing fly ash with variations of 5%, 10%, 15%, and 20% with the original soil of Jalan Raya Daan Mogot KM.14, Cengkareng, West Jakarta, it can be concluded as follows:

1. The characteristics of the original soil before mixing, based on the AASHTO system classification system, belong to the A-7-5 group, which has the most dominant material of clayey soil, with an assessment as an ordinary to poor subgrade. Meanwhile, according to the USCS classification system, fine-grained soils belong to the OH group, namely organic loamy soils with medium to high plasticity. According to the USCS classification system table, it belongs to a group with the symbol SC, namely sandy clayey sand-clay mixture.
2. The results of standard soil compaction show that the soil reaches an optimum moisture content (OMC) of 33.33% with a dry weight of 1.294 gr/cm3, which is then used in determining the unsoaked CBR value. The result of the unsoaked CBR test value from Jalan Raya Daan Mogot KM 14, Cengkareng, West Jakarta, is 2.933%. The CBR value without soaking (unsoaked) is included in the very poor group because the CBR value ranges from 0% - 3%. So, the soil from Jalan Raya Daan Mogot KM.14 Cengkareng, West Jakarta, needs soil improvement with the soil stabilization method using additives.

From the results of CBR testing without soaking (unsoaked) native soil mixed with fly ash variations of 5%, 10%, 15% and 20% for soil improvement as follows:

1. The results of the unsoaked CBR test above show that the addition of fly ash mixture variations can increase the original soil CBR value. The increase in CBR value continues to increase as the fly ash mixture variation increases, however, not with the age of the test sample burial at certain variation levels. The maximum value obtained in the CBR test of the mixture of native soil and fly ash is 17.835% at 15% fly ash mixture variation with 7 days of curing. The CBR value without soaking (unsoaked) is included in the fair group because the CBR value ranges between 7 and 20%. While the lowest value is found in the variation of a 5% fly ash mixture of 3.520% with 1 day of curing, The CBR value without soaking (unsoaked) is included in the poor-fair group because the CBR value ranges from 3-7%.
2. The unsoaked CBR value increased along with the increase in fly ash variation levels. With the addition of fly ash variation, the increase in unsoaked CBR value at 1 day of curing was 20%, 80%, 300%, and 380%, respectively. Then, after 7 days, curing was 52%, 96%, 380%, and 508%, respectively. And the 14 days of curing were 88%, 292%, 340%, and 440%, respectively.
3. The unsoaked CBR value does not increase with the length of curing at certain levels. At 5% and 10% fly ash variation levels, the unsoaked CBR value increases with the length of curing, with consecutive CBR values of 3.520%, 4.459%, and 5.515% at 5% fly ash levels and at 10% CBR

values of 5.280%, 5.749%, and 11.499, respectively. Whereas at 15% and 20% variation levels, the CBR value without soaking (unsoaked) decreased from day 7 to day 14. At 15% variation levels, the CBR value was 11.733%, 14.080%, and 12.907%; at 20% variation levels, the CBR value was 14.080%, 17.835%, and 15.840%, respectively.

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