STABILIZATION OF EXPANSIVE CLAY SOIL WITH FLY ASH AND GROUND GRANULATED BLAST FURNACE SLAG MATERIALS ON UCT VALUES (Case Study: Jalan Desa Sudimanik Kec.Sudimanik, Kab Pandeglang, Banten)

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ABSTRACT

Land is one of the important elements in construction projects and must have high bearing capacity to support the structure above it. Civil construction, whether roads, buildings, or other structures, will last a long time if one of the factors is supported by good subgrade. The location of the road in Sudimanik Village has soil that is classified as expansive clay, which has a high shrinkage capacity due to changes in water content. One way to improve unstable soil is to add additional materials such as Fly Ash and Ground Granulated Blast Furnace Slag (GGBFS).

The purpose of this study was to determine the characteristics of the soil based on the classification and physical properties of the soil using the Unified Soil Classification System method and to determine the characteristics of the soil and the effect of adding consistent variations of fly ash at 20% and variations in the percentage of GGBFS 0%, 10%, 20%, and 30% as additional material for soil stabilization against the unconfined compressive strength value with variations in curing time of 0, 7, 14 and 28 days.

The results of this study obtained soil classification according to the USCS classification including ML or inorganic silt and very fine sand, rock dust or fine silty or clayey sand. The plasticity index value after the study was 12.69%, in variation E, namely the addition of 20% fly ash and 30% GGBFS. The optimum qu value is in variation E with a curing time of 28 days, which is 2.287 kg / cm2. And experienced an increase in qu value of 295.918% from the original soil condition.

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1. INTRODUCTION

In civil engineering, soil is a collection of minerals, organic materials, and relatively loose deposits, located on bedrock. The terms sand, clay, silt, or mud are used to describe the particle size at a predetermined limit [1]. In the implementation of construction, a road is often found in poor soil conditions because the base soil has cohesive properties and has high shrinkage (plastic) which causes damage to the road structure which makes the road wavy or cracked. With the soil conditions in the Cibaliung road case study to be studied, the bearing capacity value of the soil taken through DCP testing has a bearing capacity of less than 3%, so the road is used as a case study in this study. Many materials can be used as soil stabilization materials. Some of them can use materials such as lime, cement, slag cement, fly ash, etc. In this study, it is planned to use stabilization materials derived from PT KSI waste in the form of Slag Cement (Figure 1.2), the use of Slag Cement as a soil stabilization material is a form of effort to utilize waste that is no longer useful to be more useful and valuable, in accordance with the vision and mission of the UNTIRTA Campus regarding the Smart & Green concept. In several previous studies, soil stabilization using Slag Cement using the CBR method at an optimum value for the addition of 15% slag cement for high plasticity clay soil obtained a CBR value of 15.25% with the addition of water on the wet side of the optimum water content [2]. Soil stabilization using Slag Cement on the CBR value on Jl Munjul with a curing time of 7 days was able to increase the CBR value from 2.4% to 16% with the addition of 10% Slag Cement [3]. Soft clay soil stabilized with Slag Cement has similar properties to cemented soil which effectively increases the bearing strength of soft clay soil [4].

The problem on the Sudimanik Village road, Cibaliung is the damaged road section which makes it difficult for vehicles to pass, especially during the rainy season, because the road base soil has cohesive and plastic properties which result in damaged road sections such as deflection and erosion of the road which only leaves stones and base soil. Based on the problems above, the author formulates:

a. What is the type of soil on the Cibaliung road based on the unified classification system?
b. How does the addition of constant Fly Ash (FA) at 20% and GGBFS as soil stabilization (with variations of 0%, 10%, 20%, and 30%) with a curing period of 0.7, 14, 28 days affect the Free Compressive Strength value.

1. To determine the type and physical properties of the soil to be tested.
2. To determine the value of soil bearing capacity against the addition of GGBFS and FA on the Sudimanik Village road, Cibaliung District, Pandeglang Regency with the Unconfined Compressive Strength (KTB) test.
3. To find the optimal percentage level with the addition of a GGBFS mixture to the soil bearing capacity.

This study is expected to provide knowledge in the field of civil engineering in the improvement of expansive soft soil, especially that GBBFS and FA can increase the value of soil bearing capacity on high plasticity clay soil for road base soil, houses, and other building construction. Slag cement is expected to be an alternative solution in efforts to improve the bearing capacity and high plasticity of problematic soil. From this study, variations and methods of soil improvement using GGBFS will be obtained and also to reduce and reuse waste from the KSI Factory and the Lontar Banten PLTU into products that can be used in the community. waste from the KSI Factory into products that can be used in the community.

2. METHODS

This study used soil samples obtained from Sudimanik Village Road, Cibaliung District, Pandelang Regency, Banten, with coordinates of -6.7520470, 105.7273263. Used with a mixture of fly ash material from Banten 3 Lontar PLTU which produces +13700 tons of fly ash every month, and Slag Cement obtained from PT. Krakatau Semen Indonesia (KSI).

(a) (b)

Figure 1. (a) Research Location Map; (b) Condition

The method of taking soil samples is done by digging the soil to a depth of approximately 10-20 cm from the surface of the soil. The soil that will be sampled is first cleaned from roots, garbage, and other objects, then the soil is put into a sack to be taken to the testing location, namely the Untirta Civil Engineering Laboratory.

Figure 2. Materials Used in Reasearch

Fly ash is the residue from coal combustion in power plants. Ground Granulated Blast Furnace Slag (Slag Cement) is cement produced from Grinding Blast Furnace metal processing mixed with gypsum limestone. Slag cement contains silica compounds (SiO_2) and has cementitious characteristics that can harden and increase strength if used as an additive.

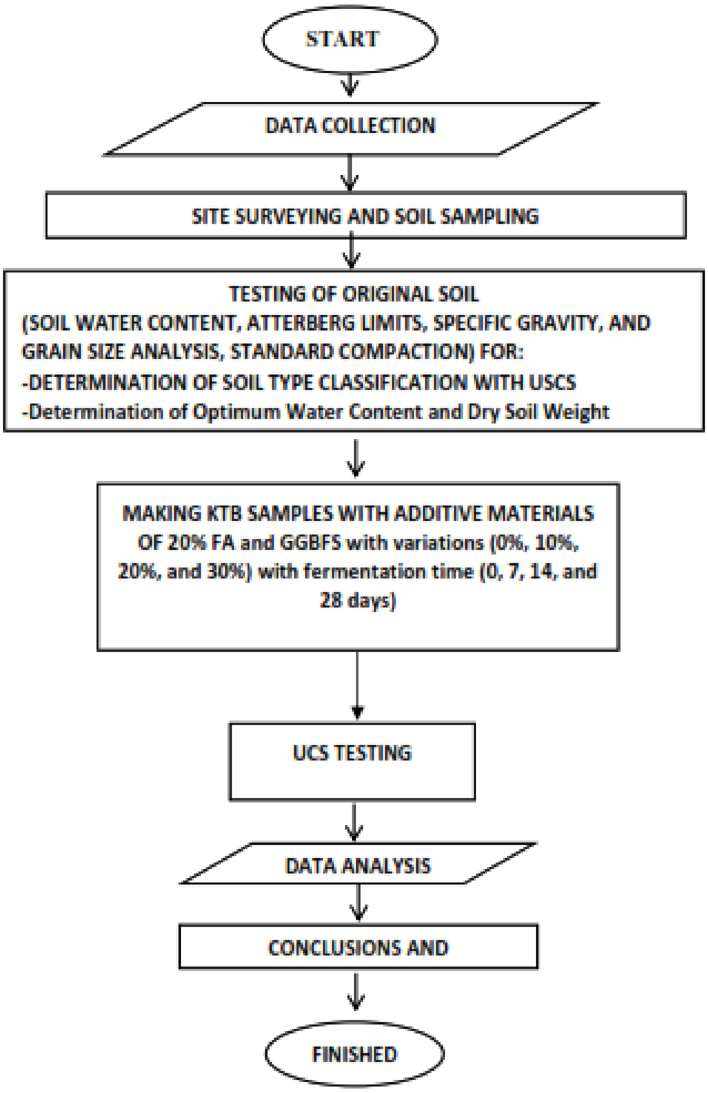

Figure 3. Flow Chart

3. RESULTS AND DISCUSSION

3.1 RESULTS OF PHYSICAL TESTING OF NATIVE SOIL AND MIXED SOIL VARIATIONS

Physical testing of soil in this study includes testing of grain size analysis, water content, grain specific gravity, liquid limit and plastic limit. This physical testing of soil is carried out to determine the physical properties of the soil that will be needed as data for the classification of research soil. All physical testing of soil is carried out at the UNTIRTA Civil Engineering Laboratory.

Table 3.1 Recapitulation of Original Soil Physical Properties Test Results

Compaction test	Value	Information
Grain Size Analysis	51,5%	Fine grained soil with percentage passing sieve No. 200
Water content	23,578%	
Content Weight	1,978 gr/cm^3	
Specific gravity	2,123	Organic Clay
Liquid Limit	45%	The liquid limit value of the original soil is included in the Intermediate Limit category.
Plastic Limit	32,85%	
Plasticity Index	12,15%	The Plasticity Index value is included in the moderate plasticity category.

3.1.1 Grain Size Analysis

The results of the grain size analysis on Jalan Desa Sudimanik Kec. Cibaliung, Kab. Pandeglang, Banten, are included in the category of silt and clay soil because the fine-grained soil or that passes the No. 200 sieve is more than 50% (0.075 mm). According to the USCS soil classification from the data obtained in the table below, the soil in this study is included in silt and clay soil with a percentage of passing the No. 200 sieve of 51.5%.

3.1.2 Specific Gravity

Specific Gravity testing is a comparison of the weight of soil particles and the weight of distilled water at the same volume and temperature. This test is carried out to determine the specific gravity of material grains which are the solid part of the soil. Based on SNI 1964:2008, the sample used is oven-dry soil that passes sieve No.4 and sieve No.10. Based on the results of tests that have been carried out on soil on Jalan Desa Sudimanik, Kec. Cibaliung, Kab. Pandeglang, Banten, has a soil specific gravity of 2.123. This Specific Gravity test is carried out on each mixture variation to determine the effect of adding fly ash and GGBFS waste on the soil specific gravity value. The results of the soil specific gravity test increased along with the increasing percentage of fly ash and GGBFS content in the soil mixture, and the Gs value was obtained as in Table 4.3.

Table 4.4 Specific Gravity Results for Original Soil and Additional Material Variations

Variation	Specific gravity
A (Fly Ash 0%, GGBFS 0%)	2,123
B (Fly Ash 20%, GGBFS 0%)	2,148
C (Fly Ash 20%, GGBFS 10%)	2,146
D (Fly Ash 20%, GGBFS 20%)	2,247
E (Fly Ash 20%, GGBFS 30%)	2,347

3.1.3 Liquid Limit

Liquid limit is a test to determine the water content of the soil at the transition limit from liquid to plastic. Based on the SNI 1967:2008 testing standard, the determination of the liquid limit is carried out using a cassagrande tool. This test uses soil that passes sieve No. 40 (0.425 mm) as much as 50 grams. Based on the results of the liquid limit test on soil from

Jalan Desa Sudimanik Kec. Cibaliung, Kab. Pandeglang, Banten, with variations in additional materials used, the following liquid limit values were obtained:

Table 4.5 Liquid Limit Analysis

Variation	Liquid Limt Value %	information
A (Fly Ash 0%, GGBFS 0%)	45,00%	
B (Fly Ash 20%, GGBFS 0%)	44,86%	*Intermediate Limit*
C (Fly Ash 20%, GGBFS 10%)	44,80%	*Intermediate Limit*
D (Fly Ash 20%, GGBFS 20%)	44,50%	*Intermediate Limit*
E (Fly Ash 20%, GGBFS 30%)	40,47%	*Intermediate Limit*

3.1.4 Plasticity Index

The plasticity index is the difference between the liquid limit and the plastic limit. In previous tests, the liquid limit and plastic limit values have been obtained. So the plasticity index value on Jalan Desa Sudimanik Kec. Cibaliung, Kab. Pandeglang, Banten, is as follows:

Table 4.7 Soil Plasticity Index

Variasi	Nilai
A (Fly Ash 0%, GGBFS 0%)	12,15%
B (Fly Ash 20%, GGBFS 0%)	12,95%
C (Fly Ash 20%, GGBFS 10%)	13,60%
D (Fly Ash 20%, GGBFS 20%)	15,71%
E (Fly Ash 20%, GGBFS 30%)	12,69%

3.1.5 USCS Soil Classification System

This study used the determination of soil classification based on the USCS (Unified Soil Classification System) system. Several tests required for USCS soil classification include grain size analysis, liquid limit and plastic limit tests. The results of previous tests were:
a. Grain size analysis
The amount of soil passing the No. 200 sieve is more than 50%, so it is included in fine-grained soil
b. Liquid limit (LL)
Liquid limit value (LL) = 45%
c. Plasticity index (IP)
Plasticity index value (IP) = 12.15%

3.1.6 Unconfined Compressive Strength Test Results

Unconfined Compression Test (UCT) is obtained from laboratory soil compaction testing of which samples are taken. Then removed with a soil unconfined compressive strength test specimen removal tool. Checking the unconfined compressive strength by controlling the strain. Measuring the length of the test specimen using a caliper with a balance accuracy of

0.1 cm. Then place the test specimen on the machine centrically, or by adjusting the machine so that the top plate touches the surface of the test specimen.

Based on the soil, it was then matched with the USCS soil classification system table, obtained Jalan Desa Sudimanik Kec. Cibaliung, Pandeglang Regency, Banten, as OL soil, namely organic silt and organic silty clay with moderate plasticity. Based on the test results above, it can be seen that the liquid limit ratio (LLR) value in the original soil in this study is 0.65, which is less than 0.75. So the research soil can be classified into OL or organic silt and organic silty clay with low plasticity.

Table 4.12 Recapitulation of q_u values for the addition of fly ash and GGBFS waste according to fermentation time

Variation/Days	A	B	C	D	E
0	0,5306	0,7428	0,79	0,66	0,578
7	0,36913	0,5424	0,92	1,097	1,545
14	0,50702	0,8725	1,167	1,368	1,745
28	0,6603	1,0494	1,403	1,58	2,287

From Table 4.10, it can be seen that the test results show that the addition of fly ash and GGBFS (slag cement) materials has an effect on the compressive strength value of the soil. For a curing period of 0 days, the optimum qu value increased in variations B and C, then decreased in variations D and E. While for curing for 7 days, 14 days, and 28 days, the optimum qu value increased along with the increasing GGBFS content in the soil.

Table 4.13 Results of qu values for variations in fly ash and GGBFS waste

Curing Time	Waste Variations	Qu value (kg/cm2)	Consistency
	A (Fly Ash 0%, GGBFS 0%)	0,5306019	Medium
	B (Fly Ash 20%, GGBFS 0%)	0,74284266	Medium
0 days	C (Fly Ash 20%, GGBFS 10%)	0,790007273	Medium
	D (Fly Ash 20%, GGBFS 20%)	0,660304586	Medium
	E (Fly Ash 20%, GGBFS 30%)	0,577766513	Medium
	A (Fly Ash 0%, GGBFS 0%)	0,369130655	Soft
	B (Fly Ash 20%, GGBFS 0%)	0,542393053	Medium
	C (Fly Ash 20%, GGBFS 10%)	0,91970996	Medium
	D (Fly Ash 20%, GGBFS 20%)	1,09657726	Stiff
7 days	E (Fly Ash 20%, GGBFS 30%)	1,544641086	Stiff
	A (Fly Ash 0%, GGBFS 0%)	0,507019593	Medium
	B (Fly Ash 20%, GGBFS 0%)	0,872545346	Medium
	C (Fly Ash 20%, GGBFS 10%)	1,16732418	Stiff
	D (Fly Ash 20%, GGBFS 20%)	1,367773786	Stiff
14 days	E (Fly Ash 20%, GGBFS 30%)	1,745090693	Stiff
	A (Fly Ash 0%, GGBFS 0%)	0,660304586	Medium
	B (Fly Ash 20%, GGBFS 0%)	1,049412646	Stiff
	C (Fly Ash 20%, GGBFS 10%)	1,403147246	Stiff
	D (Fly Ash 20%, GGBFS 20%)	1,580014546	Stiff
28 days	E (Fly Ash 20%, GGBFS 30%)	2,287483746	Very Stiff

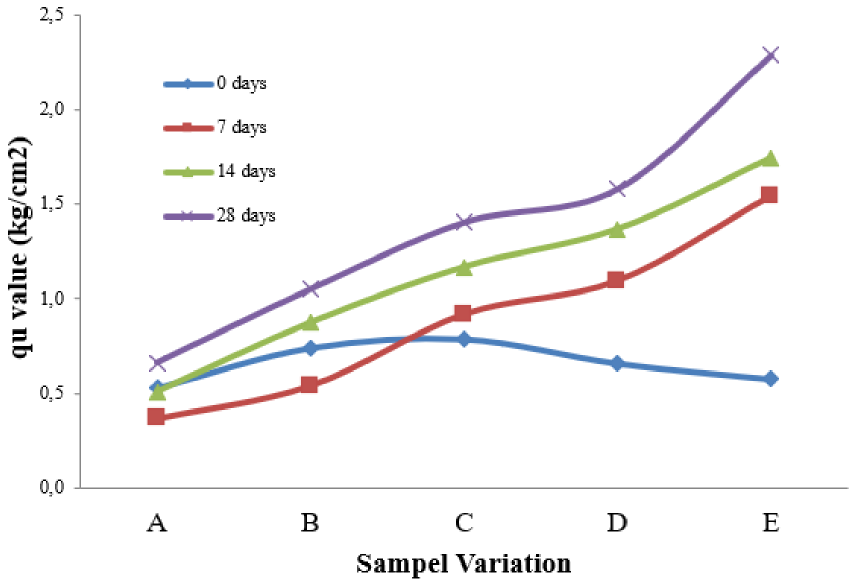

Figure 4. Graph of the Relationship between Value qu and Variation of FA and GGBFS Waste

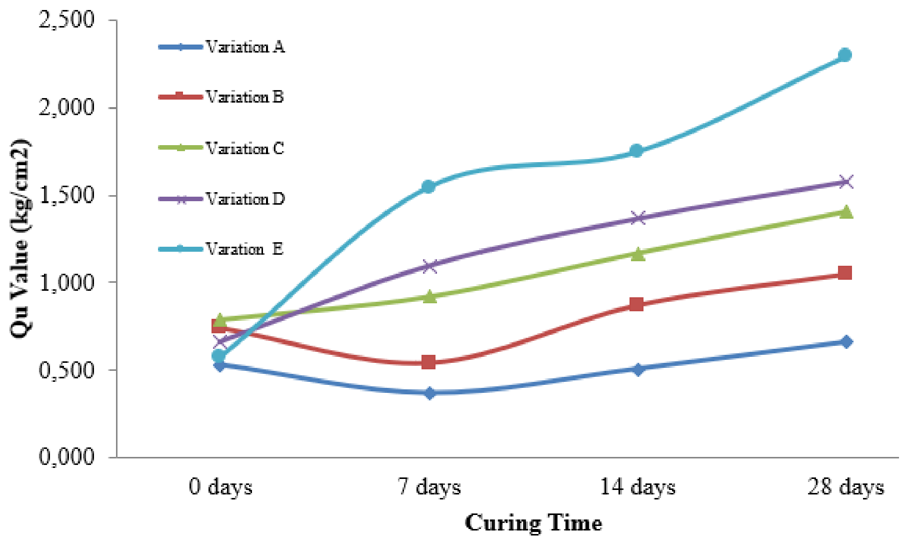

Figure 5. Graph of the Relationship between Value qu and Incubation Time

Based on Table 4.18, the qu value always increases in variations C, D, and E. While in variations A and B, it decreases during the 7-day curing period, and increases again during the 14-day and 28-day curing periods. In all variations of the addition of fly ash and GGBFS materials, the 28-day time has the largest value, which means that it can be concluded that the qu value of the soil increases due to the pozzolanic properties of fly ash and GGBFS waste materials, so that when mixed with water, the soil will become harder as the curing time increases. From the previous recapitulation of qu values, it can be concluded that both the addition of fly ash and GGBFS waste given or the curing time of both will affect the qu value. This influence is in the form of an increase in the qu value (soil strength).

4. CONCLUSION

Based on the research and testing that has been done, it can be concluded that soil stabilization using fly ash and GGBFS/slag cement materials on the soil on Jalan Desa Sudimanik Kec. Cibaliung, Pandeglang Regency, Banten, is as follows: 1. In testing the physical properties of the original soil according to the USCS soil classification, this soil is classified as OL or organic silt and organic silty clay with low plasticity, with a plasticity index value of 12.15%. In this study, fly ash and GGBFS/slag cement materials can affect the unconfined compressive strength value but cannot change the physical properties of clay soil. After the study, the plasticity index value became 12.69% in variation E, namely with a percentage of additional material of 20% fly ash and 30% GGBFS. The results of variation E decreased after previously increasing in variations B (20% fly ash + 0% GGBFS), C (20% fly ash + 10% GGBFS), and variation D (20% fly ash + 20% GGBFS). In this study, after testing variations A, B, C, D, and E, all five can be used as subgrades, because all five variations have plasticity index values <15%. 2. In the unconfined compressive strength test, fly ash and GGBFS/slag cement materials can increase the qu value which was originally in the original soil condition by 0.531 kg/cm2 at a curing time of 0 days and by 0.660 kg/cm2 at a curing time of 28 days and is classified as medium consistency. In variation B with a curing time of 28 days, the qu value increased to 1.049 kg/cm2 and is classified as stiff consistency. In variation C, with 28 days of curing, a value of 1.403 kg/cm2 was obtained which is also classified as stiff consistency, in variation D with 28 days of curing, a qu value of 1.580 kg/cm2 was obtained which is also classified as stiff consistency. Then in variation E with a curing time of 28 days, a qu value of 2.287 kg/cm2 was obtained which is included in very stiff consistency, and is the optimum qu value in this study with an increase in qu value of 295.918%.

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