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CHARACTERISTICS OF SOIL TEST SEDIMENTS STABILIZED WITH PORTLAND CEMENT AND FLY ASH

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ABSTRACT

The study aims to determine the bearing capacity of the soil stabilized with Portland cement and fly ash as well as obtaining the mixing percentage of stabilizing agent to increase the bearing capacity of the soil. Soil testing sediment of dredging at Bili-Bili DAM is conducted with several characteristics properties, they are: testing the water content, bulk density, density, limits of Atterberg, sieving and testing of minerals and chemicals, while density testing is used for fly ash and Portland cement, then the process of stabilization or mixing. The variations of the mix: Soil sediments, cement (5%, 10%, 20%), fly ash (2.5%, 5%, 10%), then mechanical testing which consists of compaction, CBR, and unconfined compressive strength. The results of properties testing of water content, bulk density, specific gravity, are 97.13%, 1.61 g / cm3, and 2,51gr / cm3. In addition to the mineral and chemical content testing is to determine the content of the soil sediment, fly ash, and the mix between them. The test results of CBR and Unconfined Compressive Strength show that the variations in soil sediments (native) compared with the variation of mixture with the addition of Portland cement and fly ash have higher value than the soil sediment (original) and keep increasing up to a variation of a mixture of 20% Portland Cement + 10% fly ash. From these results, it can be concluded that the value of the soil bearing capacity of sediment dredged at DAM Bili-bili without stabilization Portland Cement and Fly Ash obtained CBR value and Unconfined compressive strength (UCS) are quite low, but with the stabilization of Portland cement and fly ash CBR value and Free Compressive Strength (UCS) have increased continuously with the addition of the composition of the Portland cement and fly ash. Where the greatest value of CBR and Unconfined Compressive Strength Portland Cement stabilization are at 20% and 10% fly ash

Keywords: fly ash, soil sediment, soil stabilization.

INTRODUCTION

Nowdays, the development of construction is getting increased, both in big cities and small towns, especially those that occurred in Makassar. In line with the growth of development, the need for materials also increased. Especially the need for a good soil for building materials, soil base (subgrade) on the pavement (Mochtar,I.B.,2000), can be used as bricks, paving blocks, tiles, ceramics, and others.

In Gowa, there are some places for sewage sludge buildup of soil sediments that can not be put to good use, such as Jeneberang River, mainly in Reservoir Multipurpose Bili-Bili. The stacking these materials affect the function of the reservoir, so the alternative that has to be done is dredging.

Soil sedimentused for the research taken from Reservoir Multipurpose Bili-Bili in Gowa which is located ± 30 km downstream from the caldera. It has been about 85 million cubic meters of fine sediment that accumulates in the bottom of the reservoir and nearly reaches the intake tract (Haeruddin, 2010). The results of dredging stored around the intake weir (dumping material) causes the accumulation of soil sediments where shelters of the soil are not proportional to the volume of soil dredged and increased a significant volume (Grubb, D. G, 2010), while dredging soil in Bili-Bili dam should be done to overcome superficiality and maintain the quality and functionof the dam (Samang, 2010).

On the other hand, the production of coal waste (fly ash) from year to year increases the proportion to the consumption of the use of coal as a raw material in industry. The tendency of abundance of coal waste that has not been optimally usedit becomes a serious environmental problem in the future such as contaminating the surrounding environment and health problems (Lauw Tjun Nji., 2012).

Fly ash used in this study taken from Jeneponto power plant, where the volume of waste material are very abundant and can not be put to good use. Therefore, we conducted a study of the bearing capacity of soil sediments by using a stabilizing agent in the form of Portland cement and fly ash. The use of cement and fly ash as a stabilizing agent is expected to be an alternative to the cheaper costs and can increase the carrying capacity of the soil sediment. (Retno Wardani,S.P. 2008).

Based on the description above, it can be argued the formulation of the problem is how the bearing capacity of the soil sediment stabilized with Portland Cement and Fly Ash as well as the value percentage of a stabilizing agent (Portland Cement and Fly Ash) that must be mixed with soil sediment in order to obtain an increase in the optimum bearing capacity.The aim of this study is to determine the bearing capacity of soil sediment stabilized with Portland cement and Fly Ash and obtaining a percentage mixture of soil stabilization with sediment in order to increase the soil strength.

Soil bearing capacity

Bearing capacity of the soil is the amount of pressure or the soil's ability to receive a load from the outside. Bearing capacity of the soil is affected by soil type, density, moisture content, drainage conditions, and others (Sosrodarsono,2005). Density expressed in percentage of dry weight of soil volume to maximum dry volume weight. Bearing capacity of the soil baseat pavement design is expressed by the value of CBR (Hardiyatmo, 1999).

Soil characteristic

Content of mineral and chemical testing

Testing the mineral and chemical content is conducted to determine the mineral and chemical content of the soil (Inoue,H.2004). In the chemical analysis methods are used, namely:SEM (Scanning Electron Microscopy), EDS (Energy Dispersive Spectroscopy), and XDR (X-ray Diffraction

Water content testing

The water content of the soil is the weight ratio of water contained in the soil with the soil dry weight (Das, B.M. 1993). Water content of the soil can be used to calculate the parameters of soil properties (SNI 1965-2008). Here is the formula:

$$WaterLevel = \frac{W_1 - W_2}{W_2 - W_3} \times 100\%.$$

Descrption:

W_1 = Cup Weight + Wet Soil

W_2 = Cup Weight + Dry Soil

W_3 = weight of empty cup

Bulk densitytesting

Bulk density of soilis the ratio between the weight of the soil and the soil content (Das, B.M. 1993).Here is the formula:(SNI-03-3637-1994).

$$contentweight(\gamma) = \frac{(B_1 - B_2)}{V}.$$

Description

γ = weight of Soil content(gr/cm^3)

B_1 = weight of test mold(gr)

B_2 = heavy mold and specimen (gr)

V = volume of soil (m^3)

Specific gravity

Specific gravity is the ratio between the number grains of soil bulk density and weight of distilled water at the same temperature and volume (Das, B.M. 1993)

Here is the formula: (SNI 1964-2008).

$$\text{Specific gravity(GS)} = \frac{W_2 - W_1}{(W_4 - W_1) - (W_3 - W_2)} \times K.$$

Description

W_1 = weight of empty pycnometer(gram)

W_2 = weight of pycnometer+ Soil (gram)

K = correction factor

W_3 = weight of empty pycnometer+ soil + water (gram)

W_4 = weight of pycnometer+water(gram)

Liquid limit testing

Based on the water content contained in the soil, the soil can be separated into four (4) ground states, they are: a) solid, b) semi-solid, c) plastic, and d) a liquid. The boundaries of are known limits of Atterberg (Atterberg Limits) (Das, B.M. 1993).

Plastislimit testing

Plastis limit or border of the plastic is the water content of the soil where the land begins to crack when rolled into a thin roll(Wesley,L.D. 1977).

To determine the limits Plastis (PL) in advance determined water content (w) by the equation:

$$w = \frac{W_2 - W_3}{W_3 - W_1} x100\%$$

Description

W_1 = weight of empty cup

W_2 = Cup weight + wet soil

W_3 = Cup Weight + dry soil

While the plastic limit used to determine the equation:

$$PL = w = \frac{w1 + w2 + ... + wn}{h}$$

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Plastis index (IP) is the difference between the liquid limit and plastis limit expressed by the equation:

IP =LL - PL

Where

LL = Liquid Limit
PL = Plastis Limit

Sieve analysistesting

The method often used to classify the soil grain size is Sieve Analysis. Sieve analysis is used to determine the grain size of land larger than 0.074 mm (sieve No. 200).(Wesley,L.D. 1977)

The use of the following formula in data processing:

Soil weight restrained (g) = (weight of a small cup + soil hold) + small empty cup weight.

$$(\ \%\ )\ \text{Heavy soil stuck} = \frac{\text{weight of soil retained}}{\text{amount of weight}}\ \text{x}\ 100\ \%.$$

Compaction testing

Soil compaction in the laboratory aims to determine the optimum of moisture content and maximum dry density (Das, B.M. 1993). The maximum moisture content and density can be used to determine the requirements that must be achieved in the work of soil compaction in the field (SNI 03-1743-1989). Here is the formula:

$$\text{Wet density}\ (\rho) = \frac{B_2 - B_1}{V}$$

Description

ρ = density of wet, expressed in grams / cm^3
B_1 = mass of the mold and pieces of footwear, expressed in grams
B_2 = mass of the mold, the base pieces and the test specimen, expressed in grams
V = volume of test objects or mold volume, expressed in cm^3.

$$\text{Dry density}\ (\rho_d) = \frac{\rho}{(100+w)} \times 100\%.$$

Description

ρ_d = dry density, expressed in grams / cm^3
P = wet density, expressed in grams / cm^3
w = moisture content, in the state in%

CBR testing

This test is intended to determine the CBR (California Bearing Ratio) soil and compacted mixture of soil aggregates in a laboratory at a certain moisture content (Gouw2009). CBR laboratory is the comparison between the load of penetration of a substance against a standard material with the depth and speed of penetration of the same (SNI 03-1744-1989).

Unconfined compressive strength testing

Unconfined Compressive Strength is the axial pressure test object at the time of collapse or when the axial strain reaches 20% (Gouw2009).

Here is the calculation formula (SNI 03-3638-1994):

Calculation axial strain

$$\varepsilon = \frac{L}{Lo}.$$

Description

ε = axial strain (%)
L = height change of the test specimen
Lo = initial height of the test specimen

Sectional area of the specimen average

$$A = \frac{A_0}{(1-\varepsilon)}$$

Ao = initial specimen surface area
Stress calculations

$$P = n \times \beta$$

$$\sigma = \frac{P}{A}$$

Description

n = readout wristwatch load
P = axial load (kN)
β = number of ring tester calibration
n σ = stress (kPa)

Standards testing

Laboratory testing was conducted using a standard test AASHTO, ASTM and ISO.

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Table-1. Standards used in the test.

Type test method	Standard number		
	AASTHO	**ASTM**	**SNI 03 -1989-2000**
Sieve Analysis	T-88	D-422	SNI 03 -1968-1990
Limits of Atterberg			
Pliastis Limit (PL)	T-90-74	D-424-74	SNI 03 -1966-1990
Liquid Limit (LL)	T-89-74	D-423-66	SNI 03 -1967-1990
Spesific gravity of soil	T-265	D-162	SNI 03 -1964-1990
Water content	T-265-79	D-2216	SNI03 -1965-1990
Hidrometer			SNI 03 -3423-1994
Unconfined compression (UCS)	T-208-70	D-633-994	SNI 03- 6887-2002
Laboratory compaction	T-99-74	D-698-70	SNI 03 -1742-1989
CBR (California Bearing Ratio)	T-193-74	D-1883-73	SNI 03-1744-1989

RESEARCH METHODS

This study aims to determine the carrying capacity of the soil stabilized with Portland cement and fly ash as well as obtaining the percentage mix stabilizing agent to increase the bearing capacity of the soil.

In this test, the soil samples used the soil dredged at Bili-Bili dam Gowa in South Sulawesi. It is taken from the dredging by using a scraper. This test also uses fly ash, which is derived from the burning of coal, and Portland cement. In the early stages, soil sediment, Portland cement and fly ash are tested. On the soil sediment itself, conducted some tests namely: mineral and chemical testing, testing of water content, bulk density, density, limits of Atterberg, and sieving. While the Portland cement and fly ash carried out as well as the specific gravity testing.

After the initial phase of testing or physical testing of these materials, then followed by the mixing or manufacturing of the test specimen with the followings composition:

a.The original sedimentary soil (0%);

Soil sediment + 5% Portland cement + 2.5% fly ash;

Soil sediment + 5% Portland cement+ 5% fly ash

Soil sediment + 5% Portland cement+ 10% fly ash

b.Soil sediment + 10% Portland cement + 2.5% fly ash

Soil sediment + 10% Portland cement+ 5% fly ash;

Soil sediment + 10% Portland cement+ 10% fly ash

c.Soil sediment + 20% Portland cement + 2.5% fly ash

Soil sediment + 20% Portland cement + 5% fly ash Soil sediment + 20% Portland cement f+ 10% ly ash.

Then performed mechanical testing, where testing is divided into three, namely: Testing compaction, CBR, and Unconfined Compressive Strength.

RESULTS AND DISCUSSIONS

Chemical testing

Graphic of the testing mineral and chemical content in the soil and sediment.

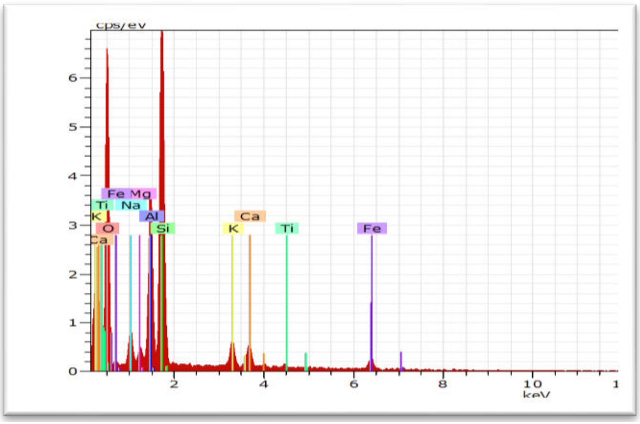

Figure-1. Graphic the results of testing the mineral and chemical content in the soil and sediment.

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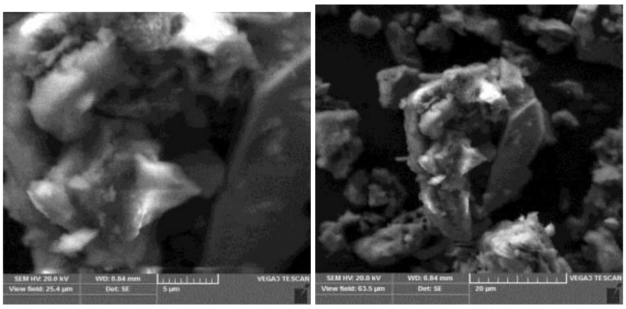

Figure-2. Soil sediment Vega 3 Scan results.

Table-2. The components in soil sediments.

Material	%
Oxygen	0.00
Silicon	53.17
Aluminium (Al2O3)	24.89
Sodium (Na2O)	6.08
Magnesium (MgO)	2.41
Potassium (K2O)	3.50
Calcium (CaO)	4.26
Titanium (TiO2)	1.07
Iron (FeO)	4.62

Soil sediment Fly Ash Cement

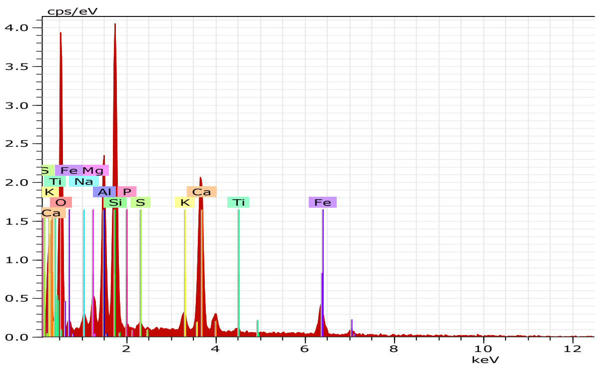

Figure-3. Graphic the results of testing the mineral content in the soil and sediment chemistry, fly ash, cement.

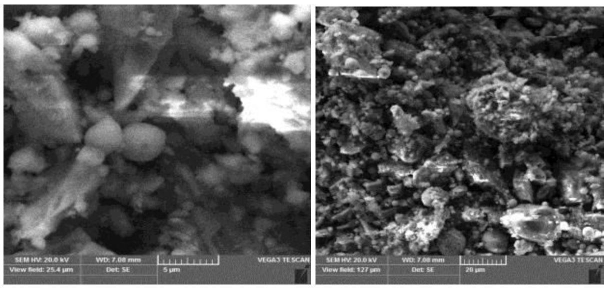

Figure-4. Figure soil sediment, fly ash, and cement test results Vega 3 Scan.

Table-3. The components in soil sediments, fly ash, and cement:

Material	%
Oxygen	0.00
Silicon (SiO2)	35.38
Aluminium (Al2O3)	20.00
Sodium (Na2O)	2.32
Magnesium (MgO)	4.01
Potassium (K2O)	2.05
Calcium (CaO)	23.74
Titanium (TiO2)	0.99
Iron (FeO)	10.55
Phosphorus (P2O5)	0.25

Property testing

Here is the data of properties test results shown in the Table below:

Table-4. Result of testing properties.

Observe method	Result	Unit
Moisture	97,13	%
Weight Content land	1,61	gr/cm^3
Heavy Soil	2,51	-
Fly Ash Density	2,64	-
Density Portland Cement	3,034	-

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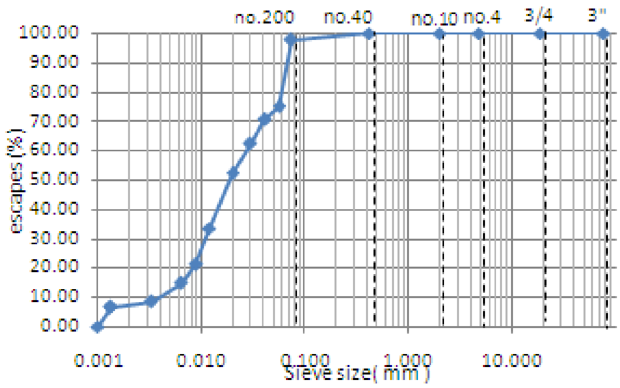

Figure-5. Graphic analysis of sieve and hydrometer.

Mechanical testing results

Mechanical testing consists of testing the liquid limit, plastic limit test, compaction test, CBR testing laboratories, and testing unconfined compression Strength (UCS).

a. Atterberg limits

Here is the data of the liquid limit test results shown in the figure below:

Table-5. Results of mechanical testing for testing liquid limit (LL).

Outcome type	Research	Unit
Liquid Limit	33,80	%
Plastis Limit	22,52	%
Plastis Index	11,28	%

b. Compaction

Here is a table of compaction test results:

Table-6. Results of testing compaction.

Sampel	W opt.	γd max
Sedimen Soil	29.7	1.354
Cement 5% + Fly Ash 2,5%	29.5	1.368
Cement 5% + Fly Ash 5%	28.5	1.405
Cement 5% + Fly Ash 10%	28	1.426
Cement 10% + Fly Ash 2,5%	27.8	1.436
Cement 10% + Fly Ash 5%	26.6	1.47
Cement 10% + Fly Ash 10%	25.8	1.5
Cement 20% + Fly Ash 2,5%	24.2	1.598
Cement 20% + Fly Ash 5%	22.8	1.64
Cement 20% + Fly Ash 10%	22	1.67

c. CBR Laboratories

Here is the test results Laboratory CBR shown in the table below:

Table-7. Results of testing CBR.

Sampel	0.1"	0.2"
Sedimen Soil	5.77	6.67
Cement 5% + Fly Ash 2,5%	25.15	47.89
Cement 5% + Fly Ash 5%	28.65	51.26
Cement 5% + Fly Ash 10%	32.4	58.53
Cement 10% + Fly Ash 2,5%	38.15	51.11
Cement 10% + Fly Ash 5%	42.67	55.56
Cement 10% + Fly Ash 10%	48.61	63.93
Cement 20% + Fly Ash 2,5%	62.15	71.21
Cement 20% + Fly Ash 5%	65.23	75.26
Cement 20% + Fly Ash 10%	71.26	85.32

d. Unconfined compression

Here are the data of Unconfined compression test results shown in Table-8 below:

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Table-8. Results of mechanical unconfined compression test.

Cement	5%			10%			20%		
fly ash	2,5 %	5%	10%	2,5 %	5%	10%	2,5 %	5%	10%
3 hr	0.465	0.815	1.548	0.786	0.952	1.645	1.576	1.773	2.295
7 hr	0.944	1.348	2.124	1.436	1.691	2.299	2.036	2.349	3.035
14 hr	3.054	3.533	4.288	3.248	3.625	4.486	3.948	4.232	4.793
28 hr	3.565	3.953	4.721	3.712	4.162	4.884	4.326	4.661	5.178

DISCUSSIONS

Testing results and mineral chemical properties

Soil sediment

Soil Sediment SiO2 obtained from the decomposition of minerals montmorillonite group. Free SiO2 by 53.17% and the value of 4:26% CaO. SiO2 is always contained in a state bound to CaO which serves as a binder.

Soil sediment, fly ash, and cement

In the process of Calcium (CaO) is the most important oxide, as well as the greatest number of compounds also a compound react with compounds silicate, aluminate and iron compound-forming potential compounds constituent of cement and fly ash. SiO2 value amounted to 34.38% and amounted to 23.74% CaO values.

Properties laboratory tests results

Water content

Testing of the water content is done with the original soil conditions. Water content is obtained by 97.13%.

Bulk density

Tests carried out by the weight of the contents of sedimentary soil conditions (original) without mixing Portland cement and Fly Ash. Bulk density values obtained of 1.61 g / cm^3.

Specific gravity

In this test, the samplesaretestedthreespecific gravity; Soil Sediment (original), portland cement and fly ash. The values obtained from the results of this test are:

- Soil Sediment (Original): 2.51
- Fly Ash: 2,64
- Cement Portland: 3,034

Sieve analysis

In the sieve analysis test, it is shown from the curved gradation in Figure 5, the fine sand as much as 2.281% and as much as 97.719% Silt.

Mechanical testing laboratory

Atterberg limits

In Table-5 shows that the value of liquid limit (LL) amounted to 33.80%, the value of plastic limit (PL) amounted to 22.52% and the value of plasticity index (PI) of 11.28%. Testing is conducted on soil conditions dredging (original) without the addition of Portland Cement and Fly Ash.

Compaction

Testing compaction produces two values, namely dry density value (γd) and the value of the optimum water content (ωopt).

For dry density value (γd), seen from Table 6, the value of dry density and optimum moisture content in the soil increased with the addition of cement 5%, 10%, 20% and variations of Fly Ash 2.5%, 5%, 10%.

CBR Laboratories

In the research results presented in Table 8 shows that the penetration of CBR 0.1 "and 0.2 CBR" has increased with the addition of cement variation of 5%, 10%, 20% and fly ash variation of 2.5%, 5%, 10%.

Unconfined compression strength

Unconfined compressiontest is done using soil sediments (native) and soil sediments with cement addition of 5%, 10%, and 20% and the addition of fly ash variation of 2.5%, 5%, and 10% were cured within 3 days of age, 7 days, 14 and 28 days for each variation. The addition of portland cement and fly ash can increase the large value of the Unconfined compression strength.

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Soil classification

From the results of the soil characteristics of the sediments, using AASHTHO, the land is classified into soil types A-7-6 (CL = Clay Low) clays that have low plasticity values.

CONCLUSIONS

Based on test results and discussion that has been described previously, it can be concluded that:

1. From the characteristics of the soil sediment, using AASHTHO, the land is classified into soil types A-7-6 (CL = Clay Low) clays that have low plasticity values.

2. Nature Chemistry / minerals in the soil sediment containCaO (calcium) as a binder for 4:26%, and soil sediments stabilized with cement and fly ash increased to 23.74%. Of the value of the soil bearing capacity of sediment dredged DAM Bili-bili without the addition of stabilizing the Portland Cement and Fly Ash, the value of CBR and Compressive Strength quite low, but with the addition of cement and fly ash increased CBR value continuously until the cement composition 20 % and 10% fly ash, as well as the compressive strength testing is free, has increased continuously until the addition of the cement composition of 20% and 10% fly ash with curing time for 28 days.

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