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Improvement Strength Influence of Sediment Dredging the River Jeneberang with Cement Stabilization as an Alternative Building Materials

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Abstract: The purpose of this study was to determine the extent to which an increase in physical properties, index properties and mechanical indexes of sedimentary material due to the addition of cement (cement stabilization). Materials used are materials sediments of the River Jeneberang (Bili-Bili Dam approximately) due to the occurrence of avalanches of Mount Bawakaraeng. Methods of testing carried out is testing laboratory using ASTM and AASHTO standard analysis, a mixture of cement used is portland cement with a variety of different percentages of cement mix. The results showed that soil sediment including silt in the soil from 95.93-96.47%, from 0.97-1.31% clay and sand soil from 2.56-3.69%. Index properties with 91.805% water content, specific gravity value of 2.477, plasticity index 16.85-17.56% by dry weight content of 0.777 t/m^3, the unconfined strengths comressive 0.11 kg/cm^2 (2.5% of cement) and 7.84 kg/cm^2 (20% cement) to the age of 3 days and 0.592 kg/cm^2 (2.5% of cement) and 16.66 kg/cm^2 (20% cement) for 28 days, tends to increase linearly with the addition of cement volume. While, the speciemen density obtained in the range 1.544 g/cm^3 (2.5% of cement) and 1.643 g/cm^3 (20% cement) to the age of 3 days and 0.592 kg/cm^2 (2.5% of cement) and 16.66 kg/cm^2 (20% cement) for 28 days. It seems to be slightly increased by the addition of cement volume. Based on the results of this study is that with the change of physical properties and mechanical properties of the sediment material will enhance the ability of the soil as an alternative material that meets the technical requirements for building materials.

Key words: Sediment material, dredging, stabilization, cement, plasticity index

INTRODUCTION

Current sediment data indicate that fine sediment has reached ±75 million m^3 reservoir that accumulates based and almost reaching the intake tract, these conditions indicate the potential of the drain will be clogged in the future, it is certain activities regarding the livelihoods of millions of people will be disturbed (Hamdan, 2010).

That condition showed the potency of clogged drain at intake in the future. One of the additional works planned become the priority to be achieved, i.e., dredging of sediment in intake and its surroundings area. Volume of dredged sediment be planned is 100,000-200,000 m^3 year^{-1}. Dredged material planned will be placed at stock yards at left side below Bili-Bili Dam.

Constraints faced by this program is the limited storage capacity of the land, being land that is/are only temporary because the land will be developed.

Based on the problem that is going to the cumulation of sedimentary material, either around intake dam and reservoir in place later which will impact on the disruption of Bili-Bili Dam function and environmental impact. As an alternative to solving the need for assessment in the form of a comprehensive research about the potential for dredging the sediment material. As the analysis of physical characteristics, chemistry and the study of minerals and sediment stabilization as well as laboratory tests to determine the effect of compaction of cement stabilization. The results of the study or research can be utilized for a variety of economic needs and sustainable development.

This study aims to determine the effect of improving the quality of the soil cement mixing soil compaction results of dredging by doing in this case the use of land dredging of Bili-Bili Dam.

Repair the physical properties of the soil is not good to be good ground in the field of civil engineering called soil stabilization. Soil stabilization can be done by adding a certain added ingredients on the land which is not good. Several compounds that have been widely used include lime, portland cement, asphalt, fly ash and sand (Basha *et al*., 2005).

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Soil stabilization: Stabilitasasi land including an accurate way to improve soil strength, the implementation is based on testing in the laboratory (Grubb *et al*., 2010). Stabilization method is widely used is the stabilization of mechanical and chemical stabilization (Justin and Robert, 2004). Mechanical stability (compaction) with various types of mechanical equipment (Pumnia, 1981), whereas the chemical stabilization of soil mixing with chemicals, such as; cement, lime, fly ash etc (Bowles, 1984). Various types of soil stabilization materials, it is expected to be effective for this type of dredging material Bili-Bili Dam and can react either chemically or physically as an ingredient in improving the quality of soil stabilization. As for the stabilization of materials used in this study is portland cement, compaction done well with the original soil compaction, compaction also with the addition of cement ie the percentage variation of 5, 10 and 20%, then the results can be seen.

MATERIALS AND METHODS

The results of the testing laboratory for analysis of properties of dredging soil properties, such as; density, moisture content, weight, volume, wet density, dry density, liquid limit, plastic limit, plasticity index, shrinkage limit, gradation of soil (sand, clay, silt) (Holtz and Kovacs, 1981; Mittal and Shukia, 1999). It can be seen in Table 1, the following laboratory test results using the method standard ASTM and AASHTO (ASTM, 2005, 2006; AASHTO, 1980).

Table 1: Dredging soil index properties

Index properties	Unit	Ranges of value
Specific Grafity (Gs)	-	2.437-2.516
Water content (w)	%	91.020-92.59
Wet density (Wet)	t/m^2	1.673-1.496
Dry density (Dry)	t/m^2	0.769-0.777
Liquid Limit (LL)	%	47.190-48.33
Plastic Limit (PL)	%	30.340-30.77
Plasticity Index (PI)	%	16.850-17.56
Shringkage Limit (SL)	%	15.000-15.64
Sand	%	2.560-4.100
Silt+clay	%	95.900-97.44

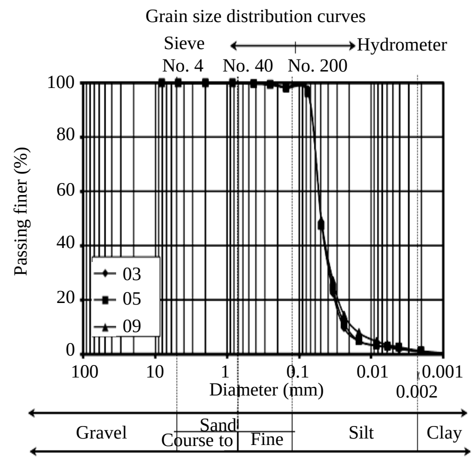

Fig. 1: Gradation curves of sediment Bili-Bili Dam reservoir; Points (03, 05, 09)

Grain size distribution analysis: Grain size distribution characteristics of soil sediment were examined on the basis of sieve and hydrometer test results (Wesley, 1977). Preferable soil sediment of Bili-Bili Dam reservoir contains a small amount of sand particles (dia >0.075 mm), bigger volume of fine grain particles (silt-clay particles).

Curves of sediment grain size distribution are shown in Fig. 1. The distribution shows that sand fraction of sediment is 2.56-3.69% , whereas silt fraction is about 95.93-96.47% and clay fraction is 0.97-1.31%. The curves represent silt particles to be bigger amount compare to that of sand and clay particles laboratory tests was conducted only for 3 selected samples; namely, 03, 05 and 09. These samples represent the distribution of site-sampling points 03, 05 and 09, respectively.

Engineering characteristics of reconstituted soil sediment: In order to justify the strength and compresibility characteristics of the soil sediment samples, a series of direct shear and consolidation tests was conducted to the 2 weeks reconstituted samples.

Test results, represent sediment characteristics; compression index C_c = 0.541 and swelling index C_s = 0.2, preconsilidation pressure p_c = 0.45 kg/cm^2, void ratio e = 1.945, consolidation coefficient at p_c, $c_v = (11.68\sim14.14)\times10^{-2}$ cm^2/min or permeability coefficient $k_v = (9.35\times10^{-5}\sim1.13\times10^{-4})$ cm sec^{-1}. Those compressibility characteistics could be justified as soft silty clay with drainage poor category.

Test results of the reconstituted samples in the direct shear represent soil cohesion C = 0.08 kg/cm^2 and internal angle friction φ = 18°27'. These soil parameters justify to be low strength or bearing capacity.

Mineral, physical and chemical characteristics of soil sediment: The particles of fine-grained soils are composed predominantly of cristalline minerals. Soft soils, such as clay and silty clay, have surface activity on their crystalline minerals such that they develop cohesion and plasticity so reffered to clay minerals. So far, about 15 minerals are classed as clay minerals and these belong to four main groups; kaolinite, montmorillonite, illite and palygorskite. Chemically the clay minerals contain silicates of alluminium and/or iron and magnesium. Some of them also contain alkalines and/or alkaline earths as essential components shown in Table 2.

Most of the clay minerals have sheet or layered structures, several them have elongate tubular or fibrous structures. Clay particles behave like colloids, it is a particle whose specific surface is so high that its behaviour is controlled by surface energy rater than mass energy. From view points of interparticle forces, these colloidal chararcteristics of clay particles are similarly charged (i.e., carrying as residual negative charge).

In consideration the above mentioned characteristics; mineral, physical and chemical contents of soil sediment was investigated and to be conducted by the appropriate collaboration tests with other laboratory (Chrysochoou *et al*., 2010). Detected metal contents of sediment are predominantly by Fe (Ferro) of amount 30.436-33.346±572 ppm, Ti (Titanium) of amount 4.298-5.021±604 ppm and Mn (Mangan) of about 1.778-1.875±103 ppm. Other metal contents for Co, Cu, Zn, Fb, Rb, Zr and Sb are observed in a small amount shown in Table 3.

Soil classification and utilization of dredging sediment: Soil classification has an important meaning to group of a soil which exhibit similar behaviour, it is usually an empirical one developed through considerable experience. Most of soil classifications employ very simple index-type tests to obtain the characteristics soil needed to place it in a given group. So far, soil classification has proved to be valuable tool to the engineer as the guidance trough making available in an empirical manner the results of field experience.

This investigation advantages such soil classification lead to develop a utilization program of dredging sediment of Bili-Bili Dam reservoir.

Table 2: Mineral characteristics of soil sediment wet soil

Mineral parameters to be analized	Unit	Ranges of value
SiO_2	%	75.42-77.31
Al_2O_3	%	6.76-6.810
Fe total	%	4.16-4.210
CaO	%	1.12-1.210
MgO	%	0.56-0.970
K_2O	%	0.87-0.980
Na_2O	%	1.06-10.70
H_2O	%	6.20-7.210

Lab. of Chemistry and Soil Fertility, Land Department of Agriculture Faculty, Hasanuddin University

Table 3: Chemical contents of soil sediment dry soil

Chemical contents	Unit	Ranges of values
Detected		
Ti (Titanium)	ppm	4.586±59-5.021+604
Mn (Mangan)	ppm	1.778±74-1.875±103
Fe (Ferro)	ppm	30436±519-33346±572
Co (Cobalt)	ppm	38±9-53±9
Cu (Cupper)	ppm	54±12-64±13
Zn (Zinc)	ppm	45±6-46±8
Pb (Plumbium)	ppm	37±6-47±6
Rb (Rubidium)	ppm	64±3-74±4
Sr (Stronsium)	ppm	981±17-1004±19
Zr (Zirkonium)	ppm	233±7-254±7
Sb (Antimonium)	ppm	103±33
No detected		
Ba (Barium)	ppm	<573
Cr (Cronium)	ppm	<201
Ni (Nickel)	ppm	<84

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Basic classification of soil sediment: From engineering view point, the classification is generally done with the objective of finding the suitability of the soil for construction (such as; dam, highway and/or foundation, etc.). For engineering general purposes, soils may be classified on the basis of; particles size, textural, Highway Research Board (HRB) classification and Unified Soil Classification and IS Classification System (USCS).

Those soil classifications systems were partially applied during the discussion of test results as illustrated by several Tables and Figures mentioned in this study. From the discussion, it could be summarized as follows:

Particle size classification: In this system, soil sediment gradations are arranged according to the grain-size. Terms, such as; gravel, sand, silt and clay are used to indicate grain sized (Das, 1994). Grain-size classification scale, the soil sediment of Bili-Bili Dam reservoir is identified to be predominantly by silt fraction of ±95% with <0.002 mm in diameter.

Engineering justification for soil sediment utilization: Soil classification systems of soil sediment interpretation is essentially to generalize as silty-clay organic low to slight plasticies.

It could be advantaged to provide useful soil parameters for evaluation of soil material quality for utilization program development of dredging sediment of Bili-Bili Dam reservoir such as for construction works raw material, erathern works, stabailized admixture, etc.

Characteristics of soil sediment stabilized admixture-cement: It was stressing in the implementation plan of dredging sediment program of Bili-Bili Dam reservoir that the most important part of activities is to develop an appriori ate utilization method. Several alternatives could be taken into consideration such as use dredged sediment dump as raw material substitute to local community for construction material, improve strength of soil sediment with stabilized admixture principles, etc.

Reviewing basic characteristics of soil sediment as raw material could face several problematics, arising due to its characteristics to soft silty clay in the category medium degree of expansiveness soil and has general rating as subgrade to be fair to poor. For utilization program, it seems from further analysis that a neccerary treatment required for improving strength of soil sediment. Present improvement program in this investigation is concerned with soil sediment stabilized admixture pozzolane cement.

Characteristics of stress-strain curves: Testing program of soil sediment stabilized cement was conducted in terms of 5 cement content variations with 4 curing time. A method for testing specimen preparation is based on the SNI 03-6791-2002; where as a method for unconfined compression test is referred to the SNI 03-6887-2002, JIS A1108, SKSNIM 14-1989-F, ASTM D 2166-66, etc. The main stage in the testing program is briefly discussed.

Specimen and test preparation: Determination of cement contents is justified "trial and error", to be supposed 2.5, 5, 10, 15 and 20% of sediment samples weigth. Curing time of the specimen was designated 3, 7, 14 and 28 days, adopting to be similar to the curing time for concrete specimens. Specimen for 0% cement content is not appropriated due to orgininal state of sediment sample disturbed or liquid state. Procedure for specimens curing is fully treated as suggested in the specimen preparation according to SNI as well as other manual standard mentioned earlier. For specimen curing, samples was taken from the molds after 3 days and wrapped by polypropylene bags or aluminum foil to avoid dry out.

Proving ring calibration was firstly validated before unconfined compression tests to be conducted on the apparent specimen for various cement contents and cutting times. Load convertion of dial gauge reading (proving ring) used for each testing is about 0.136 kgf/div.

A series unconfined compression tests for each apparent curing time was conducted for various cement contents.

Strength and its elasticity curves with time curing: Unconfined compression test is carried out for specimens who have 5 different cement contents to grasp relation between cement contents and unconfined compression strengths as well as soil sediment moduli. In order to identify such as relations, test results are briefly summarized.

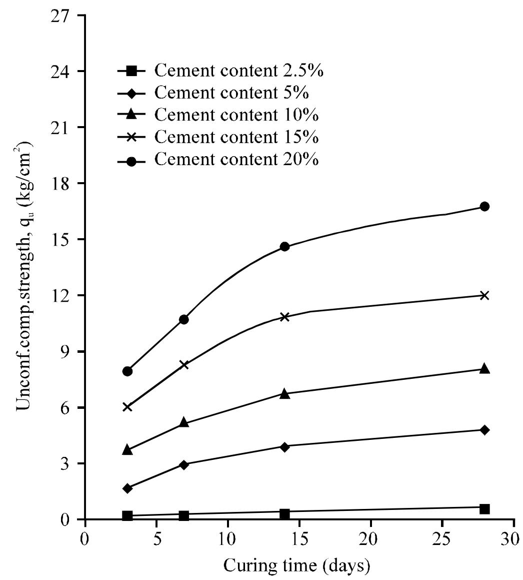

Fig. 2: Typical conditions of soil sediment strength curves with time for various cement contents

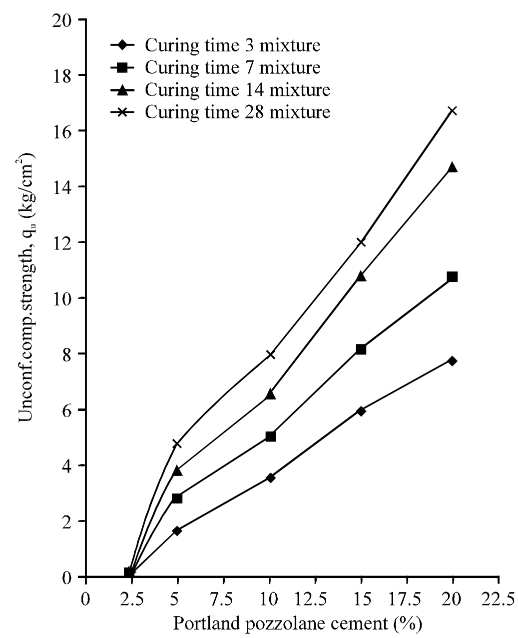

Fig. 3: Typical conditions of soil sedimen strength curves with cement contents for various curing time

Unconfined compressive strength of sediment stabilized-cement was obtained from the stress-strain curves. The peak stress curves show the tendency to develop in the ranges 0.11 kg/cm^2 (2.5% cement) to 7.84 kg/cm^2 (20% cement) for 3 days age and 0.592 kg/cm^2 (2.5% cement) to 16.66 kg/cm^2 (20% cement) for 28 days age, tend to increase linearly with the increased cement contents. Whereas, the speciemen wet density is obtained to increase in the ranges 1.544 g/cm^3 (2.5% cement) to 1.643 g/cm^3 (20% cement) for 3 days age and 0.592 kg/cm^2 (2.5% cement) to 16.66 kg/cm^2 (20% cement) for 28 days age. It seems to be slightly increased with the increased cement contents.

Strength and its elasticity curves with cement contents: In order to identify the development characteristics of unconfined compressive strength and soil moduli of sediment stabilized cement. In such way, the strength as well as module of soil sediment sediment with cement contents of soil sediment for different curing times is represented in Fig. 2 and 3. Relationships represent a similar simple non-linier curve at 2, 5% cement contents and almost linier relation for cement >5%.

The curves tend to develop with the cement content incement and their magnitude increase proportionally with curing time.

Typical utilization of soil sediment as construction material: The limited capacities of stock yard for the dredged sediment of Bili-Bili Dam reservoir were concerned by conducting a series investigation on mineralogy and physical-chemical characteristics of dredged sediment. Test results justified main characteristics of dredging sediment of Bili-Bili Dam reservoir as soft silty-clay, predominantly of silt fraction. Degree of sediment expansiveness is categorized into medium to high with clay mineral illite.

In considering several alternatives for utilizing sediment potency for various need economically (besides for congeries), such as; brick industry, roof-tile, concrete brick, paving block, earthenware, plant media (paddy field), etc., sediment characteristics could be advantaged by soil stabilization methods. It seems, the potency stabilized admixture is very supported by the existence of the other raw materials (such as; sand, clay, lime, chaff, rice field, etc.) around the stock yard. The condition is also relevant due to the existence of such industrial to be widespread quite a lot in Gowa District.

CONCLUSION

Conditions of site-deep sampling of sediment and briefly representation of test resuts including its typical utilization potential, could be summarized as follows. Soil sediment index properties represent basic characteristics, i.e:

- Specific gravity of this soil sediment in the ranges of 2.437-2.516. Its interpretation justify soil mineral illite (G_s ranges, 1.6-2.84) and soil type silt with organic admixture (G_s ranges, 2.4-2.5)
- Water content of soil sediment ranges from 88.80-96.38%, whereas the wet density represents 1.44-1.51 g/cm^3. These properties justify soil type very-slightly soft organic clay in accordance with typical soils in natural
- Variations of liquid limit ωL = 47.19-48.99% and Platicity Index (PI = 17.56-18.41%) in the Cassagrande's Chart justify soil classification of organic silty clay with low-slight plasticities
- The shrinkage parametrics of soil sediment represent Shrinkage Limit (SL = 14.64-16.01%), Shrinkage Ratio/index (SR = 2.15-2.76) and Linear Shrinkage (LS = 5.92-6.57). It seems that soil deposits could be justified to has medium or marginal degree of expantion
- The distribution shows that sand fraction of sediment is 2.56-3.69%, whereas silt fraction is about 95.93-96.47% and clay fraction is 0.97-1.31%. The curves represent silt particles to be bigger amount compare to that of sand and clay particles
- Unconfined compressive strength of sediment stabilized-cement was obtained from the stress-strain curves. The peak stress curves show the tendency to develop in the ranges 0.11 kg/cm^2 (2.5% cement) to 7.84 kg/cm^2 (20% cement) for 3 days age and 0.592 kg/cm^2 (2.5% cement) to 16.66 kg/cm^2 (20% cement) for 28 days age, tend to increase linearly with the increased cement contents. Whereas, the speciemen wet density is obtained to increase in the ranges 1.544 g/cm^3 (2.5% cement) to 1.643 g/cm^3 (20% cement) for 3 days age and 0.592 kg/cm^2 (2.5% cement) to 16.66 kg/cm^2 (20% cement) for 28 days age. It seems to be slightly increased with the increased cement contents

Based on the description of the analysis of the characteristics of sediment dredging the River Jeneberang (Bili-Bili Dam), stabilized with cement showed that; land dredging can be developed and utilized as an alternative building materials, such as; block paving, brick walls and subgrade layers because large volume changes in the dry state.

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