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THE USE OF SALT AS CLAY SOIL STABILIZATION AGENT IN CENTRAL KALIMANTAN

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Abstract

A building structure is built on the ground. Therefore, it needs to know the properties of soil in order the plan of building structure can be performed well. The commonly soil properties is CBR. The higher the scores of CBR the better of soil properties. Clay soil generally has low scores of CBR. The attempts to improve the original of clay have been conducted, such with soil stabilization. One of the clay stabilization materials is salt. The purpose of the particular research was to know the scores of CBR clay soil in Central Kalimantan before and after stabilized using salt. Clay soil samples were taken from six regencies in Central Kalimantan. The clay soil tests performed was CBR test before and after the stabilization with salt. The planned salt mixtures were 5, 10, 15, 20, 25% and 30% toward the dried content of clay soil. The results of the study showed the original soil of CBR score ranges from 3.90% to 4.75%. Then, after stabilization 5% to 15%, the score of CBR tends to rise of 5% to 9%. Concluded, the CBR score has reached the maximum score with salt addition 10% to15% of the weight of the soil.

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1. Introduction

Soil stabilization is an attempt to change or improve the technical properties of soil in order to fulfill the certain technical requirements. The technical properties of soils such as the capacity California Bearing Ratio (CBR) and Unconfined Compression Strength (UCS) of clay soils are generally very low. Similarly, clay soils in Central Kalimantan including in Palangka Raya have low capacity with CBR score betwen 3.20% and 3.50% (Anwar Muda, 2011). Meanwhile, Nirwana and Hendra (2015) in a study, obtained the CBR score 4.60% for land in Bukit Rawi Village, Central Kalimantan. Based on the soil classification on CBR score (Bowles, 1993), the soil is categorized as bad/low because it has 3-7% of CBR score with function as subgrade.

Based on the background, it needs to stabilize the clay soil, especially in Central Kalimantan Province, in order to increase the capacity of CBR and Unconfined Compression Strength. In the particular research, salt is used as stabilization agent of clay soil in central Kalimantan by mix the salt in the mixture to reduce the compaction of clay soil. The planned salt mixtures are 5, 10, 15, 20 and 25% toward the dried content of clay soil. The determination of mixture score is based on the research results of Sudjianto (2007) and Nirwana and Hendra (2015). In the mixture, was tested by the type of heavy testing of specific gravity, standardized compaction, CBR and UCS.

2. Research Objectives

The research objectives are:

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1. Determine the original soil properties on the test of grain size analysis, specific gravity, plasticity index (PI), standardized compaction, CBR and UCS
2. Determine the plasticity index (PI) of clay soil after stabilization using kitchen salt.
3. Determine the scores of CBR and UCS clay soil before and after stabilization with kitchen salt.

3. Literature Review

Grain Size Analysis

The properties of soil depend on the grain size. The naming and classification of soil depend on the size of grain. Then, the grain size analysis is the main factor to determine the percentage of grain weight on one filter unit in a specific hollow diameter size. Generally, the measurement of grain size analysis is performed in two ways; sieve analysis and hydrometer analysis.

Placticity Index (PI)

Generally, the fine grain soils naturally are in plastic conditions. The upper and lower limits of the moisture content which the soil has still plastic characteristic successively called as liquid limit (LL) and plastic limit (PL). The moisture content is defined as the plasticity index (PI), as in the equation:

$$PI = LL - PL$$

Specific Gravity (Gs)

Specific gravity (Gs) aims to determine the soil specific gravity that passed the grain filter No. 4, No. 10 and No. 40 with a pycnometer, which the ratio between the weight of density grain (γs) and the volume of distilled water (γw) in the same contents and at 25 ° C as in the equation:

$$G_s = \frac{\gamma s}{\gamma w}$$

Compaction

The compaction test is used to determine the relationship of moisture content and volume, and to evaluate the soil to fulfill the density requirements. According to Proctor (1933) in Hardiyatmo (2010), has been observed that there is a definite relationship between the moisture content and the dried solid volume. For various soil types in general, there is one certain optimum moisture content score to achieve the maximum dried volume. The relationship among dried volume weight (γd) and wet volume weight (γb) and moisture content (w), is declared in equation:

$$\gamma d = \frac{\gamma b}{1 + w}$$

California Bearing Ratio (CBR)

CBR test was issued by California Transportation Department on 1992. The test aims to determine the feasibility of subsoil which will use as base course in a highway construction.

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Since the World War II, U.S Army Corps of Engineers adapts this test in the construction of airfield.

The score of CBR is a comparison between the penetration load of a material and the standard material on the same depth and penetration speed.
In a formula;
CBR = (tension test / tension standard) x 100%.

Salt

The NaCl structure includes an anion in the middle and the cation occupies in the octahedral cavity. The salt liquid is an electrolyte and has larger brown motion in the surface than brown movements on pure water. It can lower the water density and add the cohesion between the particles, and then, the bonding particles become compact (Bowles, 1984) in Muda (2016). Besides that, the liquid facilitates in compacting the soil (Ingles and Metcalf, 1972). Soil stabilization is an attempt made to improve the original soil properties, and essentially, the soil stabilization using salt has the same principle of stabilization using other chemicals. The advantage is, to increase the density and the soil strength. Soils with high of LL (liquit limits) usually give a good reaction with the addition of salt (Ingles and Metcalf, 1972).

Methodology

The research is conducted through the stages:

1. Take the sample / sampling from six (6) regencies in Central Kalimantan Province, which are Kapuas, Pulang Pisau, Katingan, Barito Selatan, Kotawaringin Timur and Seruyan.
2. Test / Assess the soil samples including grain size, specific gravity, liquid limit, standarized compaction, plasticity limit.
3. Make the mixture of soil and salt (mix the soil and salt) with the composition of:
   0% salt and 100% clay soil
   5% salt and 95% clay soil
   10% salt dan 90% clay soil
   15% salt and 85% clay soil
   20% salt and 800% clay soil
   25% salt and 75% clay soil
4. Test/ Trial the mixture of soil and salt includes specific gravity and compaction. Then mixture of clay soil and salt by mixing for 3 days and soaking for 4 days, including CBR Test.

4. Findings

Result of Original Soil Identification

The identification result of the original soil is a description of the soil properties. Its will be compared to some theories, and existing laws / previous studies. The result is presented in Table 1.

Table 1 Result of Original Soil Identification

Theories/ Laws	Requirements	Testing Result	Conclusion
AASHTO	PI > 11%	Gunung Mas PI = 12,61% Kotawaringin Timur PI= 12,41% Katingan PI= 12,80% Seruyan PI= 12,40%	Medium Plasticity Index

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		Kapuas PI= 12,65%	
		Barito Selatan PI= 12,56%	
USCS	LL < 50%	Gunung Mas LL= 41,30%	Anorganic soil and organic silt with low to medium plasticity index in the groups of CL/OL/ML
		Kotawaringin Timur LL= 42,90%	
		Katingan LL= 44,90%	
		Seruyan LL= 41,10%	
		Kapuas PI= 43,50%	
		Barito Selatan PI= 42,10%	
Atterberg (1911)	7 < PI < 17	Gunung Mas PI = 12,61%	Cohesive clay silt soil with medium plasticity index
		Kotawaringin Timur PI= 12,41%	
		Katingan PI= 12,80%	
		Seruyan PI= 12,40%	
		Kapuas PI= 12,65%	
		Barito Selatan PI= 42,10%	
Hardiyatmo (2006)	2,62 < Gs < 2,68	Gunung Mas Gs= 2,670	Has organic silt
	2,68 < Gs < 2,75	Kotawaringin Timur Gs= 2,682	Anorganic clay soil
		Katingan Gs= 2,692	
	2,62 < Gs < 2,68	Seruyan Gs= 2,664	Has organic silt
	2,68 < Gs < 2,75	Kapuas Gs = 2,684	Anorganic clay soil
	2,62 < Gs < 2,68	Barito Selatan Gs= 2,621%	Has organic silt
Dirjen Bina Marga (1976)	3% < CBR < 5%	Gunung Mas CBR= 4,75%	Bad CBR subgrade
		Kotawaringin Timur CBR= 4,00%	
		Katingan CBR= 4,60%	
		Seruyan CBR = 4.55%	
		Kapuas CBR = 4.75%	
		Barito Selatan CBR = 3.90%	
Bowles (1993)	3% < CBR < 7%	Gunung Mas CBR= 4,75%	Poor to fair. Soil types of OH,CH,MH,OL and A4,A5,A6,A7
		Kotawaringin Timur CBR= 4,00%	
		Katingan CBR= 4,60%	
		Seruyan CBR = 4.55%	
		Kapuas CBR = 4.75%	
		Barito Selatan CBR = 3.90%	

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And, the soil classification based on the classification system by AASHTO and USCS, the original soils in six (6) regencies is described:

Table 2 Classification of Original Soil

Theory/Laws	Location	Classification of Original Soil
AASHTO	Gunung Mas	A-7-6
	Kotawaringin Timur	
	Katingan	
	Seruyan	
	Kapuas	
	Barito Selatan	
USCS	Gunung Mas	ML/OL
	Kotawaringin Timur	
	Katingan	
	Seruyan	
	Kapuas	
	Barito Selatan	

CBR Test Of Soil And Salt Mixture

The following figures are the CBR test graph of soil and salt mixture:

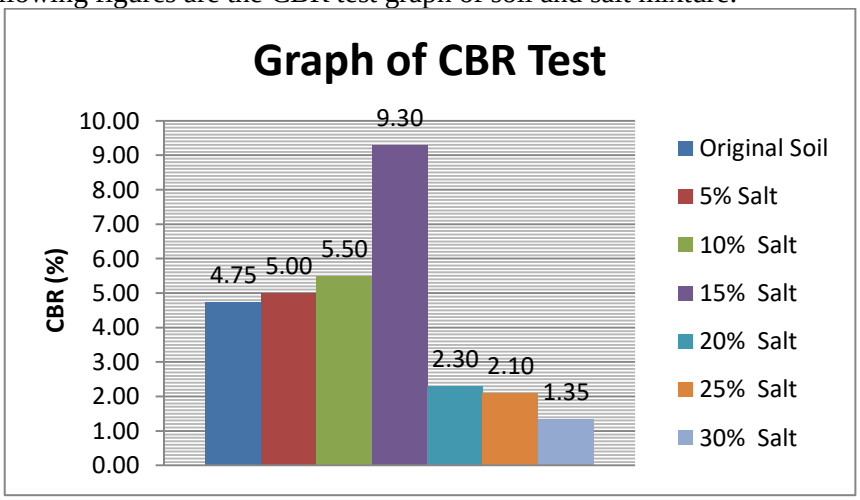

Figure 1. CBR Test Graph of Soil and Salt Mixture in Gunung Mas

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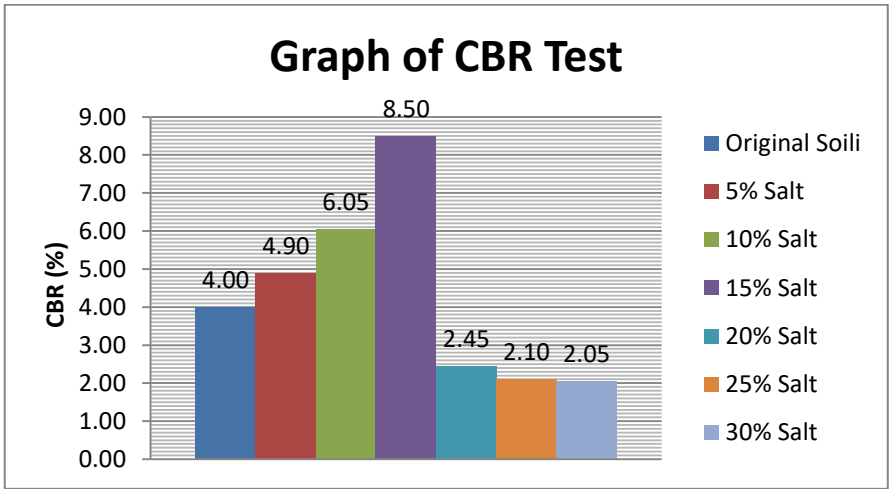

Figure 2 CBR Test Graph of Soil and Salt Mixture in Kotawaringin Timur

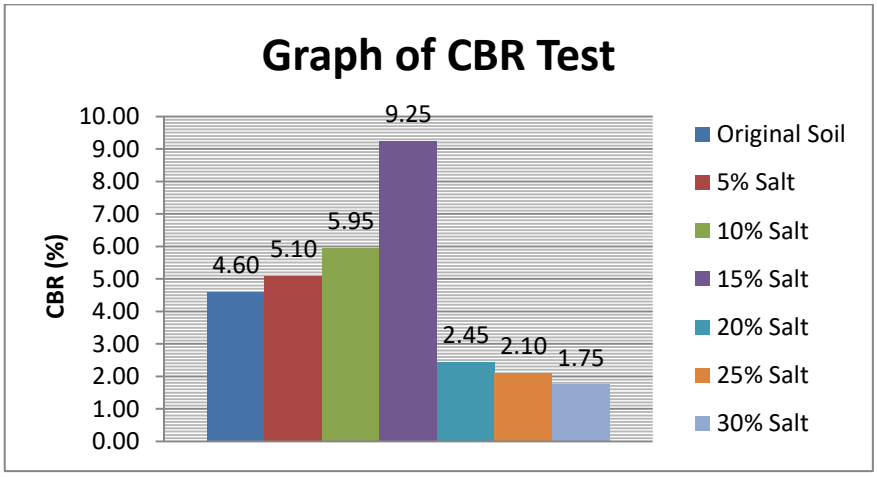

Figure 3 CBR Test Graph of Soil and Salt Mixture in Katingan

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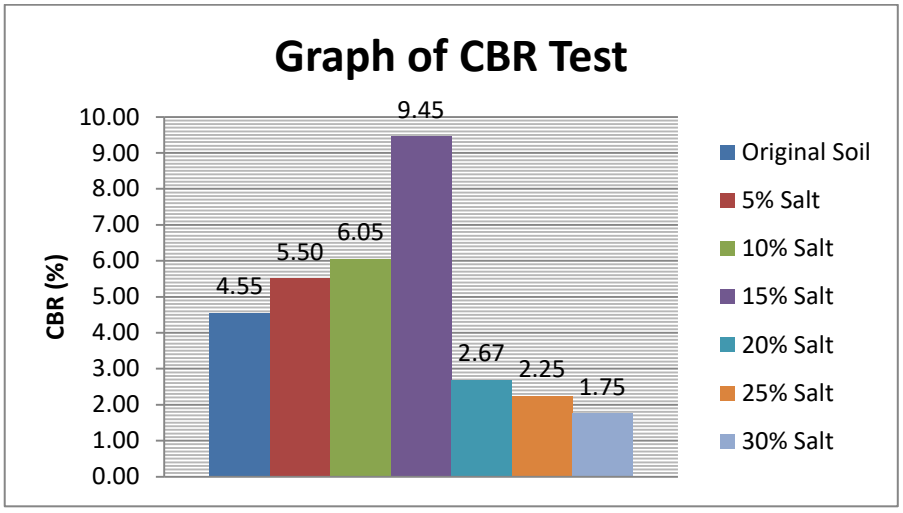

Figure 4 CBR Test Graph of Soil and Salt Mixture in Seruyan

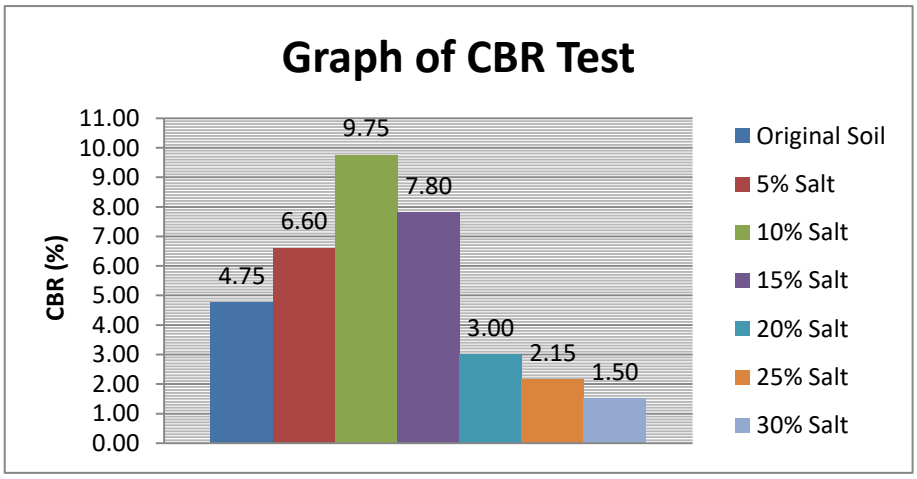

Figure 5 CBR Test Graph of Soil and Salt Mixture in Kapuas

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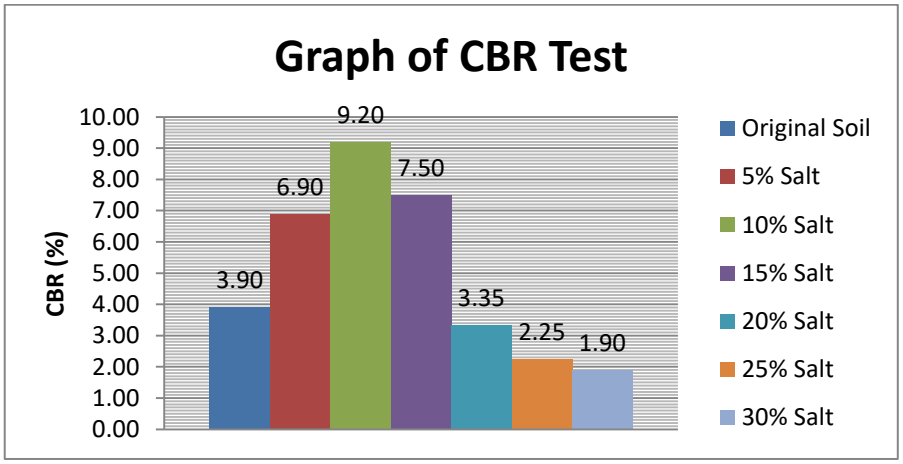


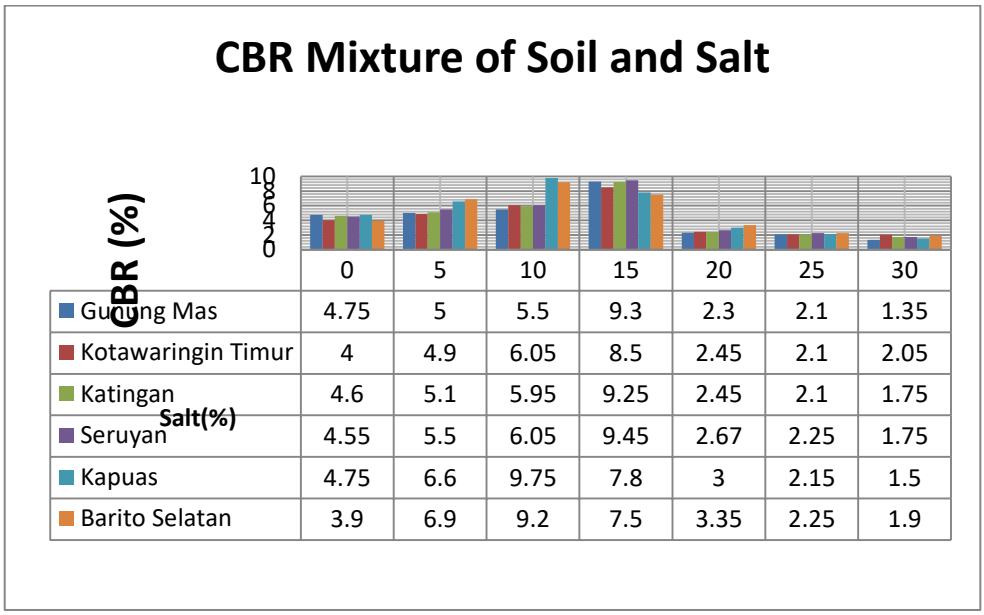
Figure 6 CBR Test Graph of Soil and Salt Mixture in Barito Selatan

5. Discussion

Based on figure 1 to 6, the dry content weight (γ_d) increases with the increasing of moisture content until reaches its optimum score at one point, called as the optimum moisture content (OMC). After that, the dry content weight (γ_d) decreases with the increasing of moisture content.

California Bearing Ratio (CBR) Mixture of Soil and Salt

Mixture of soil and salt with a predetermined percentage is tested through CBR test. The soil samples are taken from six regencies in Central Kalimantan. The final graph of research result of CBR soil stabilized with salt and its variations of mixture are presented in Figure 7:



	0	5	10	15	20	25	30
Gunung Mas	4.75	5	5.5	9.3	2.3	2.1	1.35
Kotawaringin Timur	4	4.9	6.05	8.5	2.45	2.1	2.05
Katingan	4.6	5.1	5.95	9.25	2.45	2.1	1.75
Seruyan	4.55	5.5	6.05	9.45	2.67	2.25	1.75
Kapuas	4.75	6.6	9.75	7.8	3	2.15	1.5
Barito Selatan	3.9	6.9	9.2	7.5	3.35	2.25	1.9

Figure 7 Graph of CBR Mixture of Soil and Salt

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Based on figure 7, concluded that the addition of salt in soil stabilization in Central Kalimantan is recommended only for 10% to 15% by soil weight. This is based on the CBR score on soil and salt mixtures of 10% to 15%, the mixture fulfilled the criteria of good subgrade (Bina Marga) and fair (Bowles). Moreover, according to Bowles criteria, the soil layer of fair criteria is able to use as subbase.

Conclusion

1. The original soil samples in six regencies in Central Kalimantan, based on test, have medium plasticity properties with PI scores ranging from 12.40% to 12.80%, has liquid limit ranging from 41.30% to 44.90%. And then, the soils can be categorized into the CL / OL / ML classification. The specific gravity (Gs) ranges from 2,621 to 2.692. The CBR of original soil ranges from 3.90% to 4.75%. And, the soils can be categorized as soils with poor / low capacity. Based on the original AASHTO classification system, the clay soils categorized in groups A-7-6.
2. In general, the test results toward mixture of original soils + salt based on CBR parameters, found that the addition of salt can increase the CBR with the best percentage is 10% to 15% by the soil weight.

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