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Stability Analysis of Clay Soil Plus Sand, Cement and DIFA Soil Stabilizer Additives Using Unconfined Compressive Strength (UCS) Testing

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Abstract

Tanjung pinang City is located in Riau Islands Province, has coral and kelanauan or kelempungan soil types, but in its implementation there is one location point along 50 meters where the subgrade does not reach the minimum standard density. The purpose of the study was to determine the value of soil density in the form of maximum dry weight and free compressive strength values obtained after a mixture variation of sand, cement and DIFA Soil Stabilizer. The research was conducted using experimental method of laboratory testing. Soil stabilization by mixing native soil plus sand, cement and DIFA soil stabilizer. The compositions carried out were native soil plus sand at 0%, 10%, 20% of the dry weight of the soil, cement 8% of the dry weight of soil and sand weight, and DIFA soil stabilizer 2% of the weight of cement. The testing methods were standard proctor and UCS tests to obtain the density value and free compressive strength value of the stabilized soil. The soil density value based on the standard proctor test is the dry weight value of native soil of 1,410 kg/m3, soil mixture plus 0% sand and 8% cement of 1,450 kg/m3, mixture of 10% sand and 8% cement of 1,470 kg/m3, and mixture of 20% sand and 8% cement of 1,490 kg/m3. The UCS test result of the original soil was 291.50 kN/m2. The test result of mixed soil with 0% sand, 8% cement and 2% DIFA soil stabilizer was 991.25 kN/m2. The test result of mixed soil with 10% sand, 8% cement and 2% DIFA soil stabilizer was 1,241.59 kN/m2. The test result of mixed soil with 20% sand, 8% cement and 2% DIFA soil stabilizer was 1,743.63 kN/m2.

Keywords: Density, free compressive strength, difa soil stabilizer, sand, cement.

INTRODUCTION

The growth of infrastructure development in Indonesia is very rapid, especially road and housing development. The quality of roads and housing land will be good if supported by good subgrade conditions. For this reason, subgrade stabilization needs to be carried out to ensure soil quality in supporting the type of pavement to be built, be it flexible pavement or rigid pavement. Current road development, especially in Tanjungpinang City which is the center of Riau Islands Province, is growing very rapidly, this is because the Riau Islands Provincial Government and the Tanjungpinang City Government are trying to meet the needs of both the community and business people in supporting the mobility process. Along with the development and construction of the road, there are often problems during its implementation, such as the problem of standards that must be achieved in the implementation stage. One example of a standard that must be achieved is the subgrade density of the road construction. In a road section that will be handled, it is always found that the soil conditions are very difficult to achieve the required density, where the required CBR is at least 6% with a minimum density of 95%. In this study, the research location was taken as the second lane of the Dompak Bridge III Road Section to the Dompak Roro

Port Intersection. The type of soil on the road section of the Second Section of the Dompak Bridge III Road to the Dompak Roro Port Intersection is coral and kelanauan or clay, so that in the implementation of handling to get a minimum CBR of 6% by mechanical methods in this case only using a compactor (Vibrator Roller), but in its implementation there is one location point along 50 meters where the subgrade or subgrade cannot reach the minimum standard density [1].

Fig. 1. Existing Condition of Subgrade

Fig 2. Subgrade remains soft after compaction [2]

Based on existing references that DIFA Soil Stabilizer Additive is more suitable for sandy soil both silty-sand and sandy-silt types. From these conditions, research will be conducted on the improvement of subgrade soil using sand, cement and DIFA Soil Stabilizer Additive. This research was conducted with quantitative methods through laboratory tests to obtain density values in the form of maximum dry weight values and free compressive strength values so that the stabilized soil can overcome problems and be able to withstand wet conditions.

RESEARCH METHODS

This research was conducted using the experimental method. This is because this research was conducted by mixing soil specimens with stabilization materials, namely native soil plus sand [3], cement and DIFA Soil Stabilizer additives. Different variations of test specimens were carried out to obtain the most suitable mixture for clay soil improvement, so as to achieve the required density value.

The soil test specimen used in this research/testing is a silty clay test specimen where the calculation and planning process of the mixture between the clay test specimen and DIFA Soil Stabilizer and cement refers to the product profile issued by PT. DIFA MAHAKARYA as a manufacturer and distributor of DIFA Soil Stabilizer containing in it regulates that the use of 2% DIFA Soil Stabilizer by weight of cement [4] while the use of additives in the form of cement is set at 5-12% of the dry weight of the soil used [5]. The research was conducted to obtain density values in the form of maximum dry soil content weight values and free compressive strength values after stabilization with the addition of sand, cement and DIFA Soil Stabilizer additives with several mixture variations, with the aim of obtaining density values and base compressive strength values that meet the standards.

The mixture of soil, sand, cement that has been determined, mixed and wrapped in plastic bags to avoid changes in moisture content, then compaction is carried out based on standard compaction. The results of compaction testing will obtain the maximum dry density and moisture content, which can be used as a reference in making UCS test specimens based on the standard, each mixture composition is made as many as 3 test specimens. Variations made for making UCS test specimens are native soil, soil mixture, 0% sand, 8% cement and 2% DIFA Soil Stabilizer, then soil mixture, 10% sand, 8% cement and 2% DIFA Soil Stabilizer, and soil mixture, 20% sand, 8% cement and 2% DIFA Soil Stabilizer. Day variations were performed for 7 days and 14 days of curing the specimens. Based on the results of Niko's research, which stabilizes soil-cemet on silty clay using DIFA SS, where it is found that the free compressive strength value will increase along with the length of curing time of 1, 4 and 7 days.

The test data will be analyzed using the following formulas and presented in the form of curves and tables so that conclusions will be obtained from the results of this study.

1. Soil Density
   $\gamma = \frac{berat\ tanah}{volume}$; $\gamma dry = \frac{\gamma}{1+w^2}(\frac{gram}{cm^3})$ (1)
   Where:
   γ = Wet weight;
   γdry = Dry weight,
   w = moisture content (in decimal)
   Gs = Spesific gravity,

2. *Unconfined Compressive Stength* (UCS)
   Unconfined Compressive Strength (UCS) or also called free compressive strength is the amount of axial pressure (kg/cm2) required to press a cylindrical mass of soil to crack and break or the amount of pressure that causes the soil to shrink up to 20%. UCS or free compressive strength testing refers to [6].

RESULTS AND DISCUSSION.

The data from the physical and technical properties test [7] of the soil taken from the quarry can be seen in Table 1, if classified based on [8] is a soil of silty or clayey gravel and sand. Based on the general classification and group classification, the soil sample is included in the main material in general is silty or clayey gravel and sand. The data obtained are listed in **Table 1** as follows:

Table 1. Test Result Data of Physical Properties of Native Soil

No.	Uraian Pengujian	Satuan	Hasil	Keterangan
1	Analisa Saringan			
	% Lolos saringan :	%	99,83	
	No. 4	%	79,53	
	No. 10	%	65,30	
	No. 20	%	54,04	
	No. 40	%	19,42	
	No. 80	%	17,95	
	No. 100	%	4,91	
	No. 200			
2	Berat Jenis Tanah		2,57	
3	Atterberg Limit			Plastis > Sedang
	Batas Cair LL	%	37,02	(7-17)
		%	22,59	Lempung
	Batas Plastis PL	%	14,43	Berlanau
				Kohesi
	Indeks Plastisitas IP			
4	Compaction γd			
	Maks	kg/m^3	1.410	
	w Optimum	%	23,90	
5	Hasil Klasifikasi Tanah :			
	Klasifikasi tanah			
	*)Klasifikasi umum : Material granular (≤35% lolos saringan no.200)			
	*) Klasifikasi kelompok : A – 2 – 7			
	*) Tipe material yang pokok pada umumya : Kerikil berlanau atau berlempung			
	*) Penilaian umum			
	Sebagai tanah dasar : Sangat baik sampai baik			
	Sifat tanah : Plastisitas > Sedang			
	Macam tanah : Lempung Berlanau Kohesi			

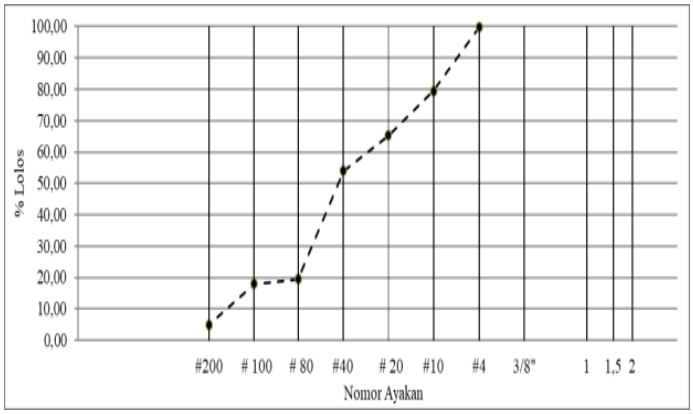

Fig 3. Soil Sieve Analysis Curve

Mechanical properties of native soil based on [9] and the results of laboratory testing obtained the value of dry weight content and optimum water content [10] as follows: Proctor standard test results obtained the dry weight of native soil (γd) is 1,410 kg/m3 with the optimum moisture content of native soil is 23.9%.

Table 2 . Test Result Data of Physical Properties of Native Soil

	Orginal Soil				
Ɣdry (kg/m^3)	1.338	1.377	1.424	1.386	1.341
W (%)	17,78	20,83	23,91	26,45	29,87

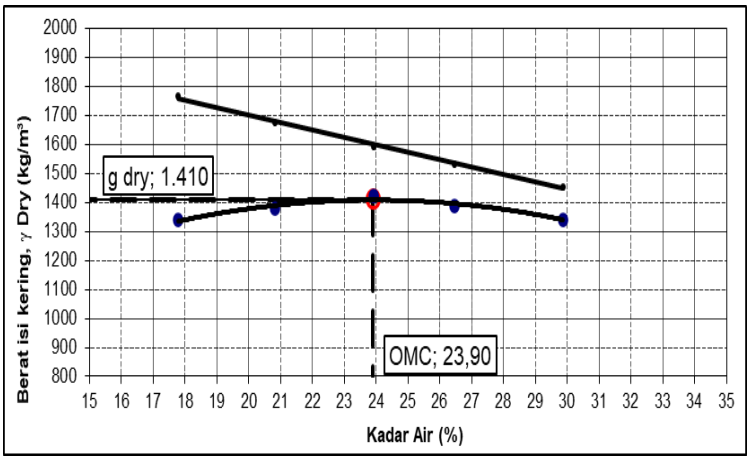

Fig 4. Original Soil Density Testing Chart

The standard proctor test on the mixed soil, in this case a mixture of native soil plus 0% sand and 8% cement, obtained the dry weight of 0% sand mixed soil (γd) is 1,450 kg/cm3 and the optimum moisture content of 0% sand mixed soil is 25.50%.

Table 3. Density Testing Data of 0% Sand Mixture Soil

	Mixeture Soil (Original Soil + Soil 0% + Cement 8%)				
Ɣdry (kg/m^3)	1.427	1.444	1.462	1.443	1.333
W (%)	21,21	24,44	25,82	26,88	32,02

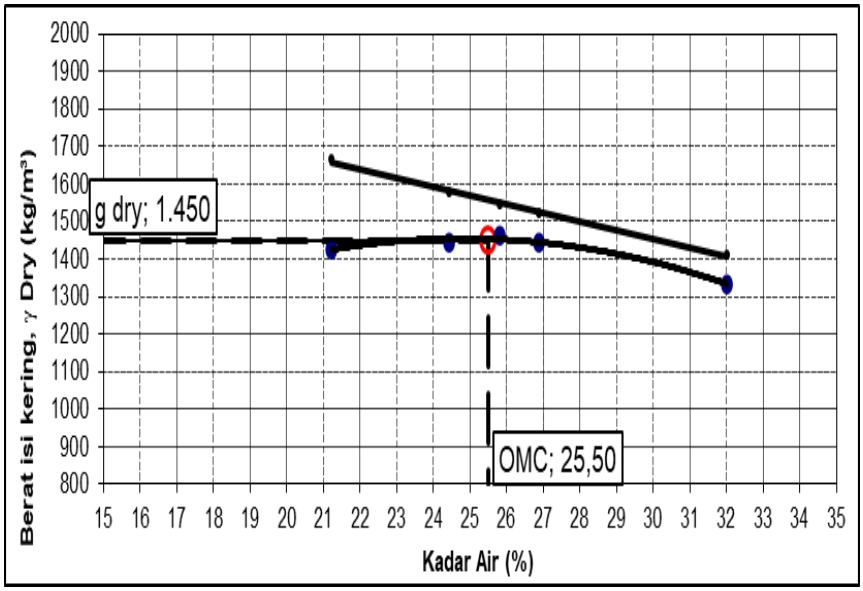

Fig 5. Density Testing Chart of 0% Sand Mixture Soil

The standard proctor test on the mixed soil in this case is a mixture of native soil plus 10% sand and 8% cement, the dry weight of 10% sand mixed soil (γd) is 1,470 kg/cm3 and the optimum moisture content of 0% sand mixed soil is 25.50%.

Table 4. Density Testing Data of 10% Sand Mixture Soil

	Mixture Soil (Orginal Soil + Sand 10% + Cement 8%)				
Ɣdry (kg/m³)	1.441	1.479	1.485	1.427	1.371
W (%)	21,28	23,63	25,77	27,70	30,67

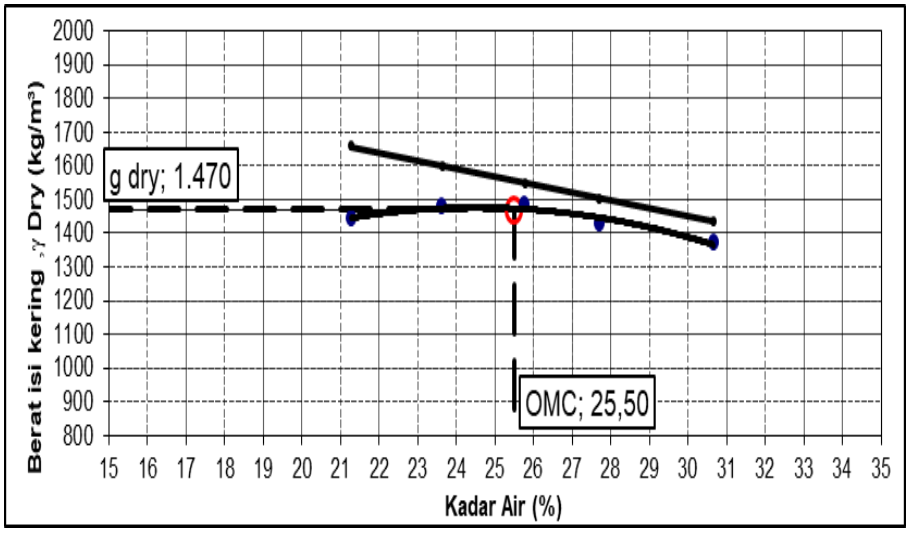

Fig. 6 - Density Testing Chart of 10% Sand Mixture Soil

The standard proctor test on mixed soil, in this case a mixture of native soil plus 20% sand and 8% cement, obtained the dry weight of 20% sand mixed soil (γd) is 1,490 kg/cm3 and the optimum moisture content of 0% sand mixed soil is 25.05%.

Table 5. Density Testing Data of 20% Sand Mixture Soil

	Mixture Soil (Original Soil + Sand 20% + Cement 8%)				
Ɣdry (kg/m³)	1.457	1.473	1.504	1.421	1.368
W (%)	20,61	23,22	25,06	28,51	30,87

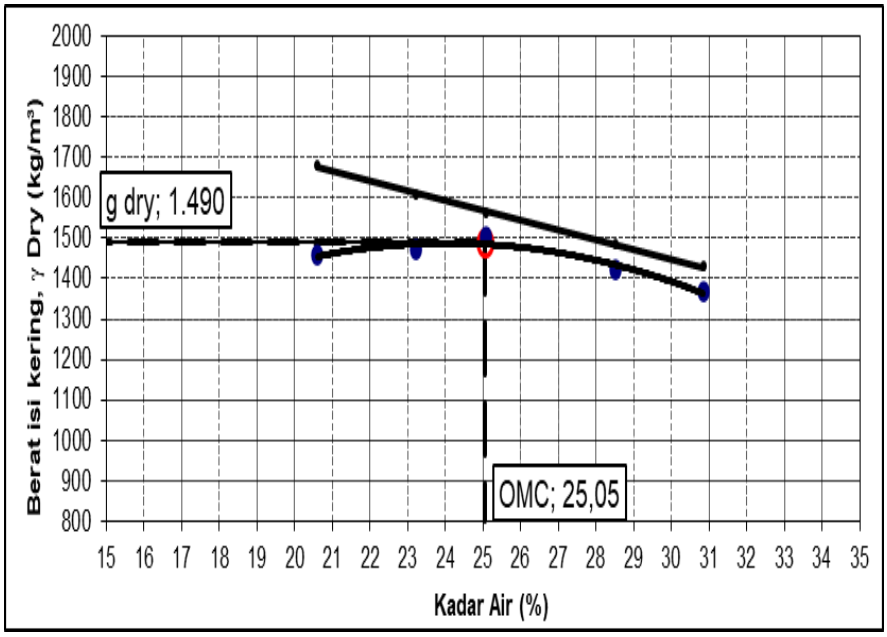

Fig. 7 - Density Testing Chart of 20% Sand Mixture Soil

The dry weight and optimum moisture content test results for native soil and stabilized soil can be seen in **Table 6.**

Table 6 . Recapitulation of Dry Fill Weight (γd) and Optimum Moisture Content (Wopt)

No	Type of soil	Dry Fill Weight (γd) (kg/m^3)	Optimum Moisture Content wopt (%)
1.	Original Soil	1.410	23,90
2.	Original Soil + Sand 0% + Cement 8%	1.450	25,50
3.	Original Soil + Sand 10% + Cement 8%	1.470	25,50
4.	Original Soil + Sand 20% + Cement 8%	1.490	25,05

Criteria for soil stabilization using cement based on its intended use proposed by Ingels and Metcalf (1972) in [11] in Table strength criteria of stabilized soil where the minimum standard UCS value of cement foundation between 686.70 kN/m2 to 1,373.40 kN/m^2, indicated by the strength properties and durability values, as shown in [12]which is based on SNI 03-6887-2002 in Table 3.5 and the strength of soil stability with cement by [5] which is based on SNI 03-3438-1994 minimum requirement of 600 kN/m^2.

Table 7. UCS Testing Sample Result Data

Type of Soil	*Unconfined Compressive Strength* (UCS) (kN/m^2)		Criteria for soil stabilization using cement
	7 Days	14 Days	
Original Soil	172,74	291,50	SNI 03-3438-1994 : Lower Foundation Layer, for 3-day soak, 4-day soak, UCS value of at least 600 kN/m^2. According to Ingels and Metcalf (1972):
Original Soil + Sand 0% + Cement 8%+ Additif DIFA *Soil Stabilizer* 2%	909,55	991,25	
Original Soil + Sand 10% + Cement 8%+	1.058,05	1.241,59	

Additif DIFA *Soil Stabilizer* 2% Original Soil + Sand 20% + Cement 8%+ Additif DIFA *Soil Stabilizer* 2%	1.560,09	1.743,63	Road subbase, pari allotment embankment and others, UCS values between 343.35 kN/m2 and 1,030.05 kN/m^2.

Based on [13] The results of the UCS test which are poured through a graph of the relationship between stress and strain in the 7-day curing sample can be seen in **Fig.8.**

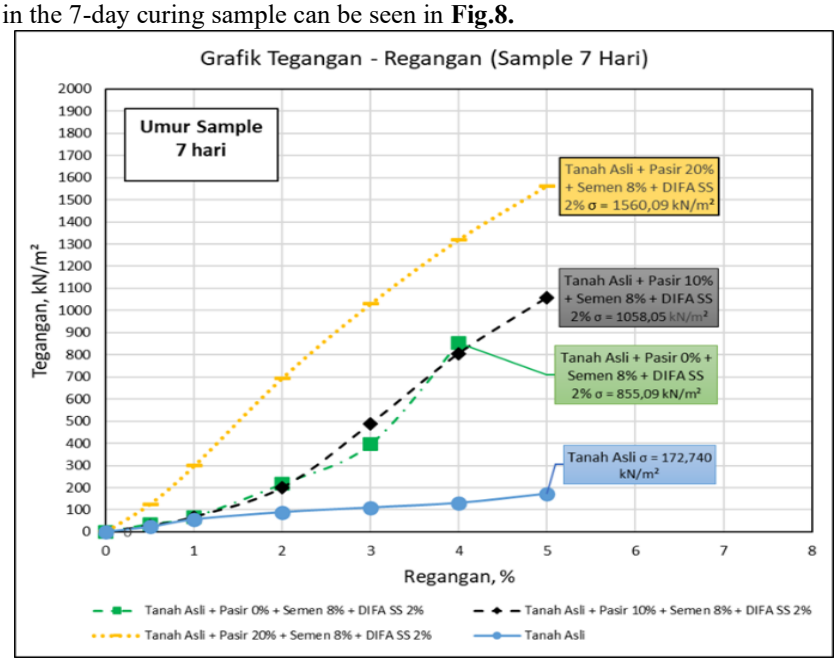

Fig 8. Stress - Strain Relationship Graph of 7-Day Aging Sample

The results of the UCS test which are poured through the graph of the relationship between stress and strain in the 14-day aging sample can be seen in **Fig. 9.**

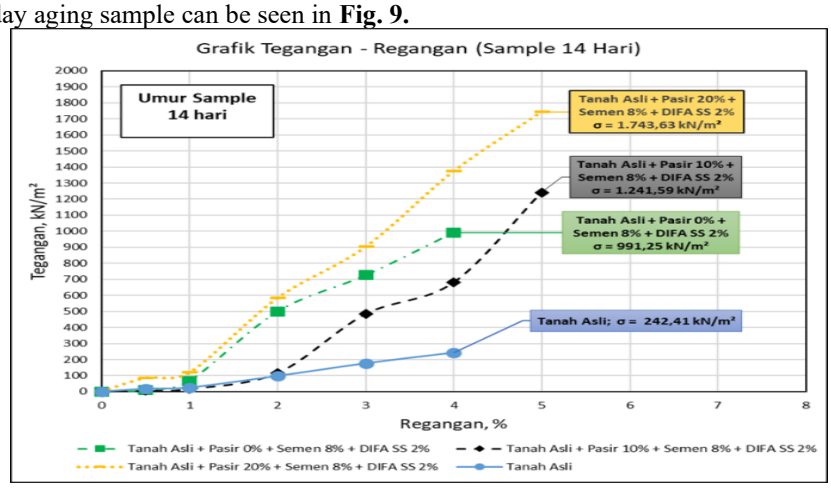

Fig 9. Stress - Strain Relationship Graph of 14 Days Aging Sample

Fig. 10 shows that the results of the UCS test on the original soil show that the original soil stress value changes along with the increase in curing age.

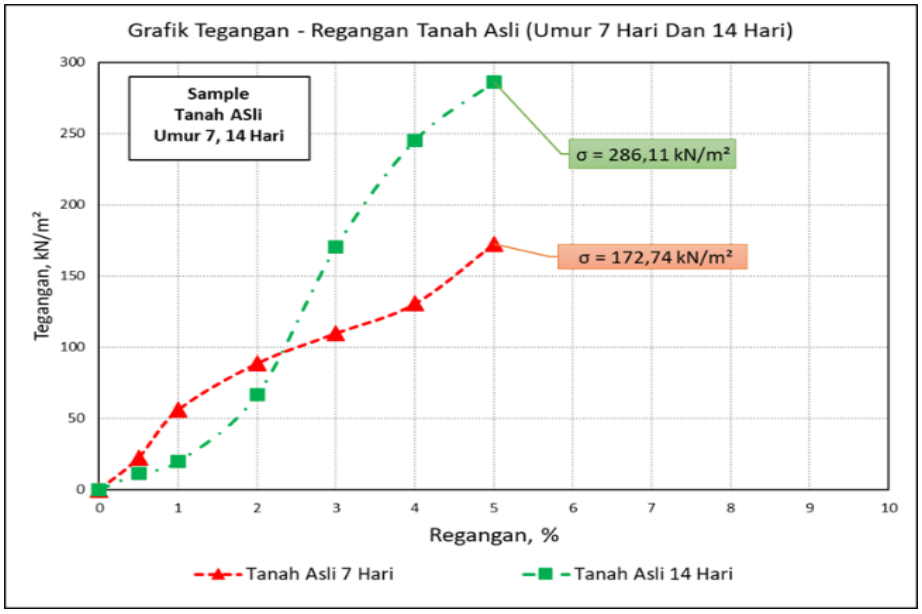

Fig 10. Stress - Strain Relationship Graph of Native Soil Samples of 7 Days and 14 Days Burial

From Figure 11, the UCS test results show that the stress value of the mixed soil (native soil + 0% sand + 8% cement + 2% DIFA SS) has increased.

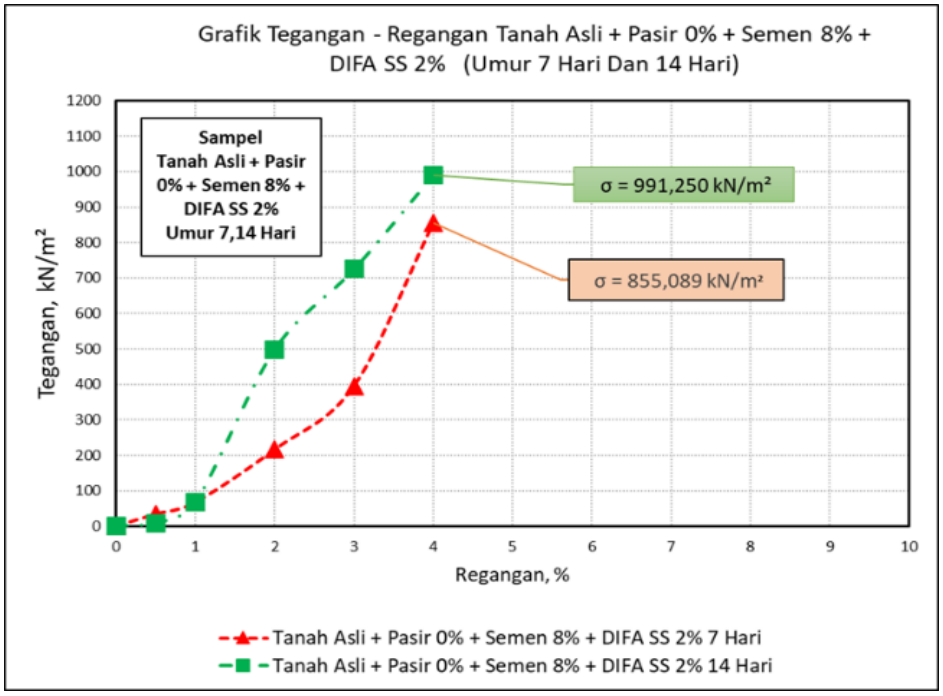

Fig. 11 Stress - Strain Relationship Graph of Original Soil + 0% Sand + 8% Cement + 2% DIFA SS 7 Day and 14 Day Curing Samples

Fig. 12 shows that the stress value of the mixed soil (native soil + 10% sand + 8% cement + 2% DIFA SS) UCS test results give good results.

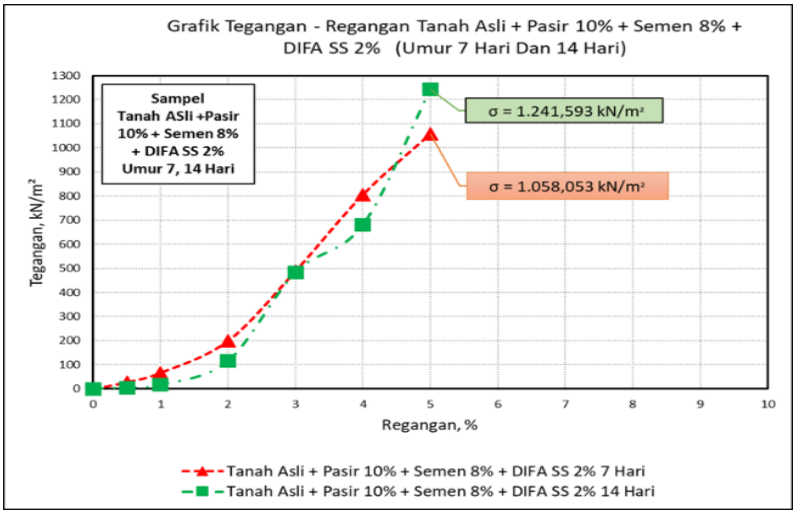

Fig 12. Stress - Strain Relationship Graph of Original Soil + 10% Sand + 8% Cement + 2% DIFA SS 7 Day and 14 Day Curing Samples

Fig.13. shows that the stress value of the mixed soil (native soil + 20% sand + 8% cement + 2% DIFA SS) UCS test results give good results.

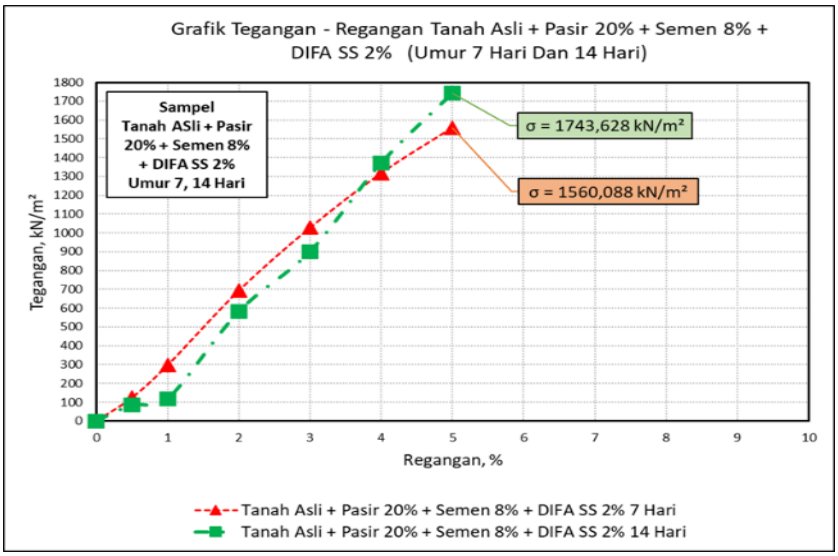

Fig 13. Graph of Stress - Strain Relationship of Original Soil + 20% Sand + 8% Cement + 2% DIFA SS 7 Day and 14 Day Curing Samples

Fig.14. Shows that based on the UCS test sample, the dry weight content of soil (γd) has increased from the original dry weight content of soil, this is in line with the addition of sand content and the determination of cement content plus DIFA soil stabilizer additives.

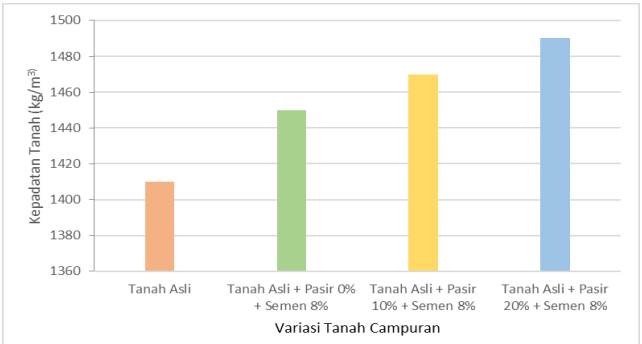

Fig 14. Soil Density Relationship Graph - Mixed Soil Variatio

CONCLUSIONS.

Based on the results of the research that has been done that the value of soil density based on the standard proctor test is showing increasing results, along with the addition of sand and cement. The value of free compressive strength or UCS test results on native soil and stabilized soil with the addition of sand, cement and DIFA soil stabilizer additives shows an increasing value along with the addition of sand and the addition of curing age.

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