EFFECT OF VERTICAL DRAINAGE MATERIAL VARIATIONS IN CLAY SOIL AGAINST SETTLEMENT DUE TO DISTRIBUTED LOAD

Submitted as partial for filling the requirement for bachelor degree of Civil Engineering Program Engineering Faculty

By:

ERWIN ADITYA SAPUTRA

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by:

ERWIN ADITYA SAPUTRA

NIM: D 100 134 001

Has been reviewed and approved for testing by:

Supervisor

Agus Susanto, S.T., M.T

NIK: 787

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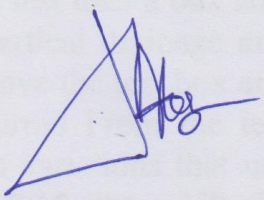

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Abstract

In the building construction, soil has a very important role, which it can acts as the support for building foundation or construction on it. In Indonesia itself, especially in the Klaten Pedan Troketon area has clay soil with a value of PI (Plasticity Index) of 50.20%, and low bearing capacity. To make clay soil have good bearing capacity, this research uses vertical drainage reinforcement with some variation of its material which are sand column, lime, mixture of sand and lime, sand above lime, and lime above sand. Objectives of this study to determine the value of the soil settlement with and without vertical drainage reinforcement. This test uses a box size of 100x40x40 cm which is given reinforcement of vertical drainage and without reinforcement then given a distributed load above the test box and installed with 3 dial to find out the settlement occurred From the test results obtained the largest settlement value occurs in variations that use sand column reinforcement with a settlement value of 5.15 mm, while the least settlement value occurs in variations that use columns containing lime with a value of 2.46 mm. While the variation of sand and lime combination the value obtained is not better than the soil without reinforcement. From these results it can be seen that reinforcement using lime material as a vertical drainage filler has the best reinforcement, because on variations using lime column strength can reduce the soil settlement.

Keywords:*material variations, settlement, vertical drainage.*

Abstrak

Dalam pembangunan suatu bangunan, tanah memiliki peran yang sangat penting, yaitu tanah berperan sebagai penopang pondasi bangunan atau kontruksi di atasnya. Di indonesia sendiri khususnya pada daerah Troketon Pedan Klaten memiliki tanah lempung dengan nilai PI (Plastisiti Index) sebesar 50,20%, dan daya dukung yang rendah. Untuk membuat tanah lempung mempunyai daya dukung yang baik, dalam penelitian ini menggunakan perkuatan drainase vertikal dengan beberapa variasi materialnya yaitu kolom pasir, kapur, campuran pasir dan kapur, pasir di atas kapur, dan kapur di atas pasir. Penelitian ini bertujuan untuk mengetahui nilai penurunan tanah dengan dan tanpa perkuatan drainase vertikal. Pengujian ini menggunakan box berukuran 100x40x40 cm yang diberikan perkuatan drainase vertikal dan tanpa perkuatan selanjutnya diberikan beban merata di atas box pengujian serta dipasang dengan 3 dial untuk mengetahui seberapa besar penurunan yang terjadi. Dari hasil pengujian di peroleh nilai penurunan terbesar terjadi pada variasi yang menggunakan perkuatan kolom pasir dengan nilai penurunan 5,15 mm, sedangkan nilai penurunan paling sedikit terjadi pada variasi yang menggunakan kolom yang berisi kapur dengan nilai penurunanya 2,46

mm. Sedangkan variasi penggabungan pasir dan kapur nilai yang didapat tidak lebih baik dibandingkan tanah tanpa perkuatan. Dari hasil tersebut dapat diketahui bahwa perkuatan dengan menggunakan material kapur sebagai pengisi drainase vertikal memiliki perkuatan yang paling bagus, karena pada variasi yang menggunakan perkuatan kolom kapur dapat mereduksi penurunan tanah yang terjadi.

Kata Kunci: ***drainase vertikal, penurunan tanah, variasi material***

1. INTRODUCTION

1.1 Background

Soil has an important role to a building or construction, soil is the part of foundation on a building as a support for the building or construction on it, so that it can stand firmly and securely. Based the geography of country Indonesia has a tropical climate with warm temperatures, humidity and high rainfall are factors that accelerates the weathering process that can lead to soil in a particular area is not necessarily the same type, characteristic of soil and soil properties.

According Merdhiyanto (2015), the soil in the Troketon Village, Pedan District of Klaten has a high plasticity index that is equal to 50.20%. So in the Troketon Village, Pedan District of Klaten there are many buildings that suffered damage, for example in building or construction, building elevations are uneven and many cracks in the walls of buildings. Because the soil have high value of PI it was clear that land has a low bearing capacity, during the dry season the land is shrinking water levels, causing cracks. When the rainy season occurs the soil become expansive, so that necessary repairs on Troketon Village,Pedan District of Klaten.

In this study to overcome the unsuitable soil conditions that are expected, there are several techniques that can be used to improve the quality of clay soils such as vertical drainage method, because clay soils are identical with high water content, high compressibility, and small permeability coefficients. To stabilize the clay soil is by filling the columns in the vertical drainage with a mixture of sand and lime or reverse with some variation.

Reinforcing on soil stabilization lately are highly developed. Awareness of the importance of the process of soil improvement prior to the development process raises the idea of using variations of vertical drainage filler material for soil strength improvement. Modeling using variations of vertical drainage filler material as a soil reinforcement aims to find out how much variation of the vertical drainage material reduces the decrease caused by axial load.

Based on the above background, the research of influence variation of vertical drainage material as reinforcement of soil is conducted

1.2 Problem Formulation

Based on this background, the problem can be formulated as follows:

1. How much the settlement in clay soil without vertical drainage due to distributed load ?
2. How much the settlement in clay soil with sand column due to distributed load ?
3. How much the settlement in clay soil with lime columns due to the distributed load ?
4. How much the settlement in clay soil with a mixture of sand and limestone column due to distributed load on it ?
5. How much the settlement in clay soil with sand-lime column due to distributed load ?
6. How much the settlement in clay soil with lime-sand column due to distributed load ?

1.3 Research Purpose

1. Determining the value of settlement in the Troketon Village Pedan District of Klaten without vertical drainage due to distributed load on it.
2. Determining the value of settlement in the Troketon Village Pedan District of Klaten using sand column due to distributed load on it
3. Determining the value of settlement in the Troketon Village Pedan District of Klaten using lime column due to distributed load on it.
4. Determining the value of settlement in the Troketon Village Pedan District of Klaten using a mixture of sand and limestone column due to distributed load on it.

5. Determining the value of settlement in the Troketon Village Pedan District of Klaten using sand-lime column due to distributed load on it.
6. Determining the value of settlement in the Troketon Village Pedan District of Klaten using lime-sand column due to distributed load on it.

1.4 Benefit of Research

The benefits of this research is:

1. Provide solutions and alternatives with vertical drain method using a variation of the column material to stabilize the soil in the Troketon Village Pedan District of Klaten.
2. As a suggest to the relevant agencies about conditions of soil in Troketon Village Pedan District of Klaten, so them can plan a building or construction is safe

1.5 Limitation of The Research

In order to avoid expansion of discussion this final project, this research needs to their scope as follows:

1. The research was conducted at the Laboratory of Civil Engineering, University of Muhammadiyah Surakarta.
2. Soil Sample is clay with disturbed conditions were taken from the Troketon Village Pedan District of Klaten with soil depth of approximately 40 cm from the ground.
3. The method of soil stabilization with vertical drain method using a variation of column material using sand, lime, a mixture of sand and lime, sand above the lime, and lime on the sand.
4. The instrument used to measure land subsidence is a dial gauge.
5. Type of lime used is slaked lime acquired from nearby store around campus UMS.
6. The sand used in this research came from Merapi
7. Testing was done by test distributed load in box which has size 100 cm x 40 cm x 40 cm to observe the settlement

2. RESEARCH METHOD

2.1 RESEARCH MATERIALS

1. Soil samples from the Troketon Village area, District Pedan, Klaten regency with undisturbed conditions (disturbed), acquisition of land is done at a depth of approximately 40 cm.
2. The water comes from the Civil Engineering Laboratory of the Universitas Muhammadiyah Surakarta.
3. Limes used is the type of $Ca(OH)_2$ obtained from the store buildings around campus UMS
4. The sand used was sand from Merapi.
5. The weight of distributed load is 60 Kg

2.2 RESEARCH EQUIPMENT

The equipment used in settlement test are as follows:

1. Box with dimentions 100 cm x 40 cm x 40 cm
2. Dial Gauge
3. Case of Vertical Drainage
4. Distributed Load
5. Plywood

2.3 STAGE OF RESEARCH

The research was conducted at the Laboratory of Soil Mechanics Civil Engineering Universitas Muhammadiyah Surakarta which consists of several stages, as follow:

1. Stage I

   An early stage began with the study of literature to determine the location of soil samples and prepare the materials and tools needed. Setting up a box measuring 100 cm x 40 cm x 40 cm. Then set up the column as a vertical drain mold semicircular placed on the edge of the edge of the box. Further preparation for loading the distributed load on the sample.

2. Stage II

   In this second phase, the first test without the use of a vertical

drainage, the process of testing is input clay into the box until height of 30 cm are arranged into three layers, each layer stroke as much as 25 blows. then process saturation sample with water for four days. After saturated for 4 days, remove the water through a faucet that has been provided allow up to 24 hours.

Then, in the second test and sixth test using vertical drainage column variety of granulated materials and lime with the first step to input the sand at the bottom of the box with a height of 5 cm as horizontal drainage and install a case of column semicircular on both sides of the box, then input the soil into the box up to a height of 30 cm are arranged into three layers, each layer pounded by 25 punches. After that, process of saturation sample with water until four days. After saturated for 4 days, remove the water through a faucet that has been provided allow up to 24 hours. then remove the mold column of the box, then fill the hole with sand and lime material variation then input the sand on the sample the thickness is 5 cm horizontal drainage

3. Stage III

In this stage giving the distributed load over the test box, with paired 3 dial to find out how much the settlement after the clay soil reinforced with vertical drain method using variations of sand and limestone columns and without reinforcement.

4. Stage IV

This stage contains a discussion of the test results that have been obtained from the phase II and III. From this stage can be made a conclusion would be the results obtained and providing advice if necessary.

For more detailSsthe stages of research can be seen in Figure IV.8

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Research Methods can be shown in figure IV.8

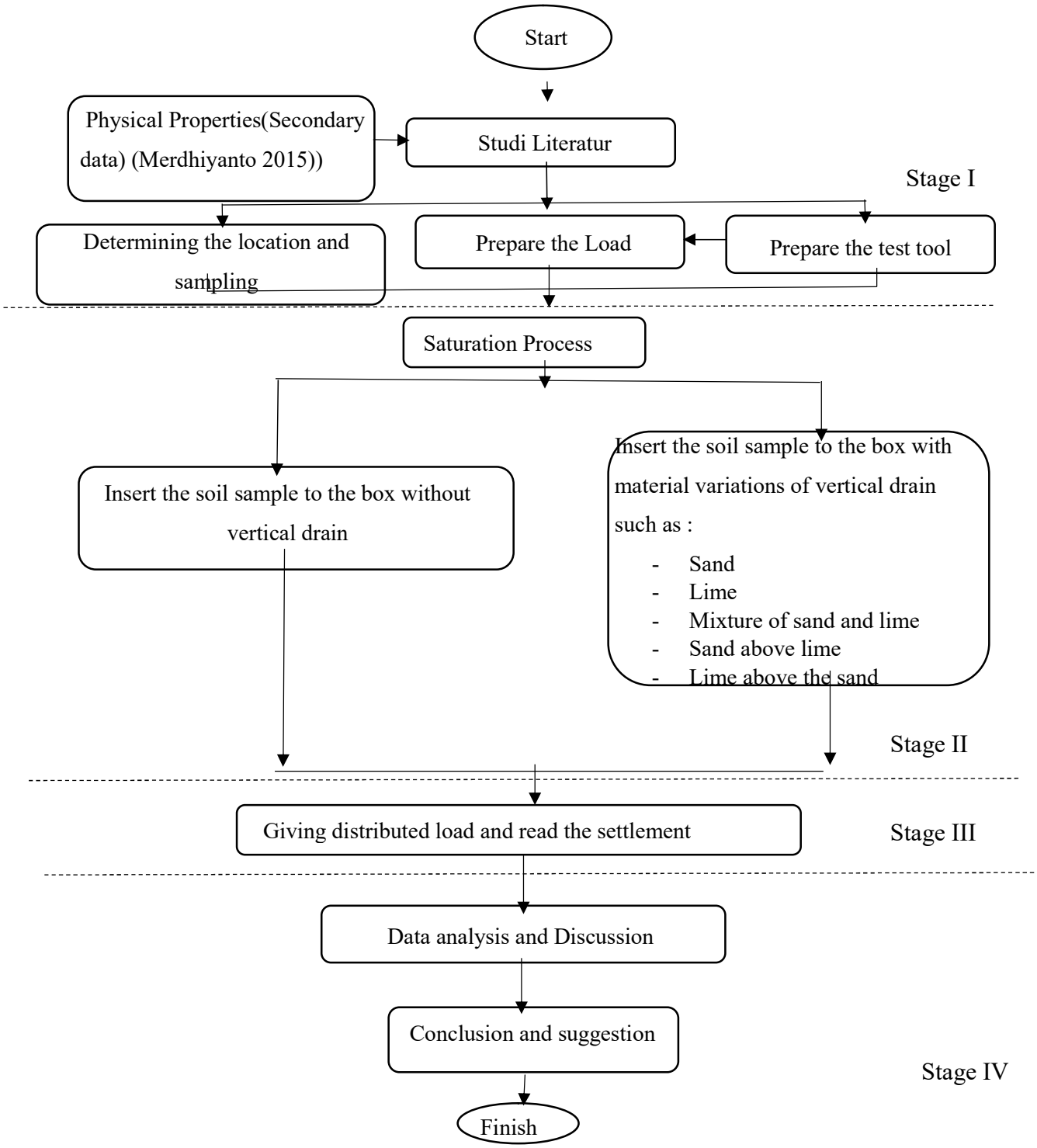

Figure IV.8 Flow chart of research

3. ANALYSIS AND DISCUSSION

3.4 Physical Soil Properties

The result of physical soil properties test is taken from secondary data conducted by Merdhiyanto (2015) the soil sample used comes from Troketon Village, Pedan district of Klaten which included to clay.

3.4.1 Grain Size Analysis Test

Result of grain size distribution can be seen in Table V.1 and Graph V.1

Tabel V.1 Result of grain size distribution

Grain size (mm)	Passing finer (%)
4,75	100
2,36	100
1,18	99,36
0,6	97,66
0,3	94,04
0,15	90
0,075	84,04
0,04	20,77
0,028	20,2
0,015	17,94
0,01	15,95
0,0074	12,27
0,0036	11,42
0,0015	5,24

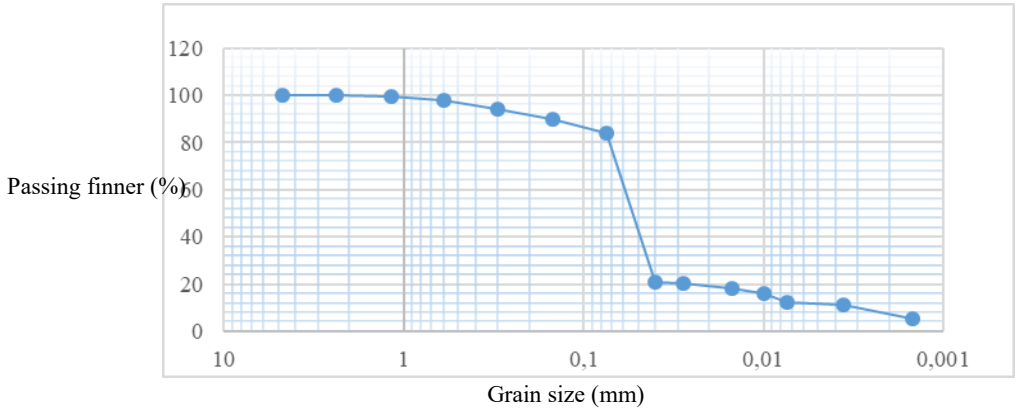

Figure V.1 Chart of result grain size distribution

3.4.2 Atteberg Limit Test

Atteberg (1991) in (Hardiyatmo, 2002) provides a way to illustrate the consistent limits of fine grained soils with regard to their moisture content. The results of the Atteberg limit test in Troketon Village can be seen in Table V.2

Table V.2 Atteberg Limit Test

Soil sample	Atteberg Limit Test			
	LL (%)	PL (%)	PI (%)	SL (%)
	82,00	31,80	50,20	13,67

Based on Table V.1, Table V.2 and Graph V.1 the results are obtained, land in Troketon Pedan Village Klaten according to the *Association of State Highways And Transportation Official* (AASHTO), including the type A-7-5 which means the soil is clay having Poor quality. According to the method of *United Soil Clasification System* (USCS), it can be classified into CH non organic clay with high plasticity.

3.4.3 Spesific Gravity Test

Specific Gravity test (Gs) is the ratio between the weight of solid grain volume (ɣs) and the weight of water volume on the soil.

Based on research conducted by Merdhiyanto (2015), the results of soil type of soil test on Pedan Klaten Troketon can be seen in Table V.3.

Table V.3 Specific Gravity Test

Type of test	Value
Gs	2,705

Based on the results of specific gravity test can be concluded that the soil in Troketon Pedan Village Klaten including inorganic clay type of soil with the specific gravity is (Gs) 2.705.

3.4.4 Settlement Test.

The results of load testing on clay soil reinforced by some variations of vertical drainage filler obtained a decrease value that can be seen in Table V.4

Table V.4 Settlement Value

Type of Reinforcement	Settlement			Average Settlement (mm)
	Dial 1 (mm)	Dial 2 (mm)	Dial 3 (mm)	
Without Reinforcement	3,85	2,54	2,23	2,87
Reinforced by Sand	4,91	4,97	5,56	5,15
Reinforced by Lime	1,12	1,72	4,54	2,46
Reinforced by Mixture of Sand and Lime	1,72	3,68	3,87	3,09
Reinforced by Sand above Lime	3,46	2,93	2,77	3,05
Reinforced by lime above Sand	4,67	2,92	1,90	3,16

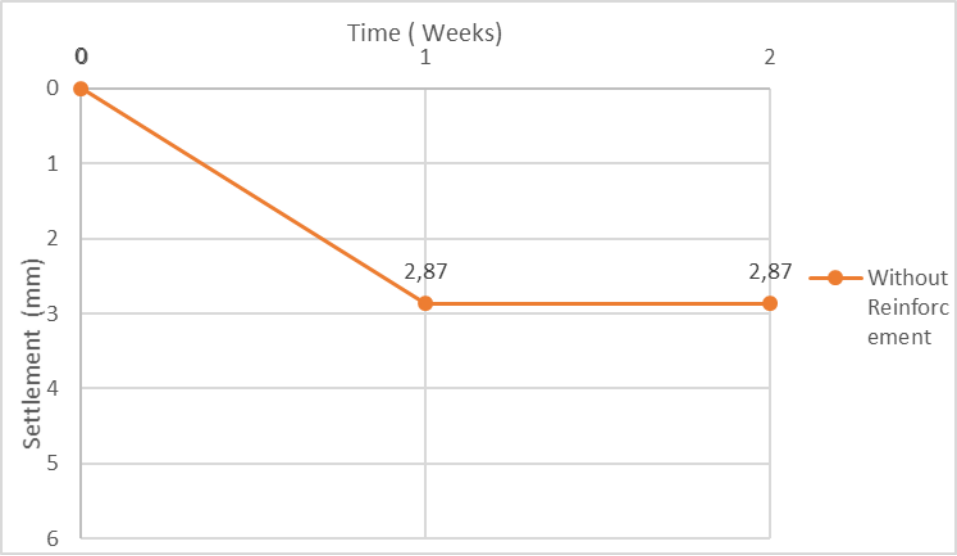

Figure V.2 Graph of Soil Settlement Without reinforcement of vertical drainage

Figure V.2 indicates that the value of clay soil settlement tested by loading without reinforcement resulted is 2.87 mm. This is due to the

water still trapped in the ground can not be channeled out to the valves are available.

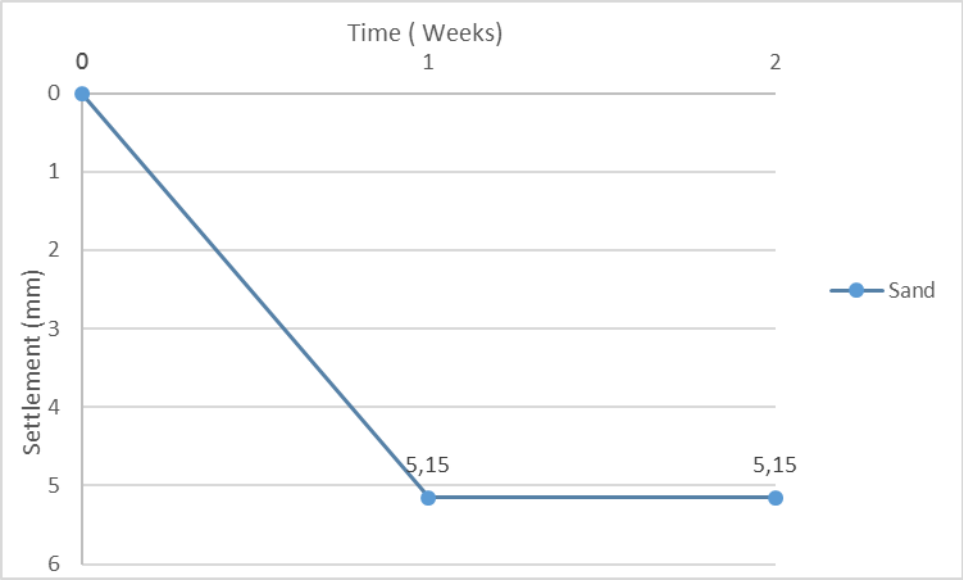

Figure V.3 Graph of Soil Settlement uses sand reinforcement as a vertical drainage filler material

Figure V.3 shows the settlement value of soil reinforced by sand as a vertical drainage filler of 5.15 mm. The value of the decrease in the sand is caused by the discharge of water at which it flows to the tip of the box end of the sand column. This is very natural because the characteristic of the sand that has large pores so it can passed by water.

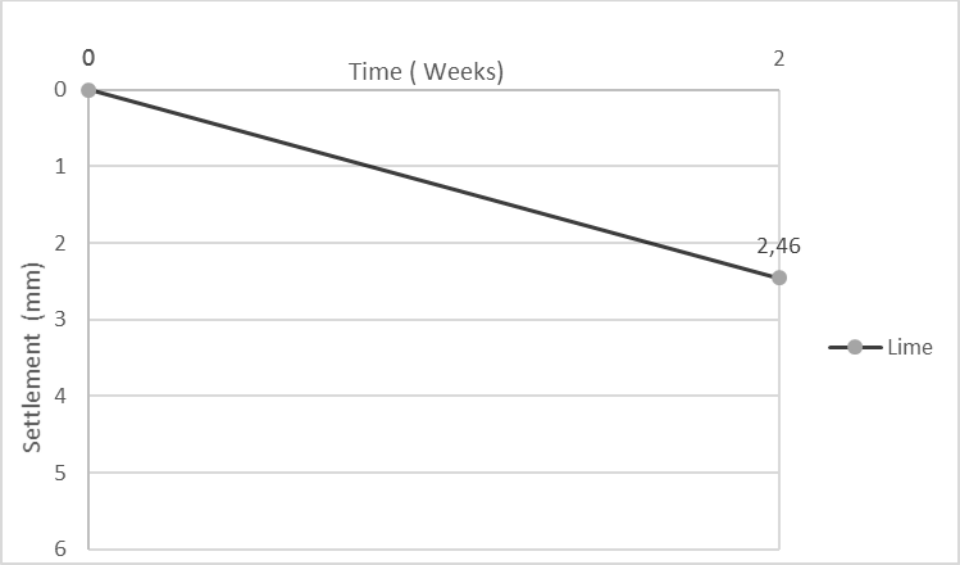

Figure V.4 Graph of Soil Settlement uses Lime reinforcement as a vertical drainage filler material

Figure V.4 shows the value of settlement in clay soil reinforced with lime as a filler material of veritcal drainage of 2.46 mm. The values aboves show that lime is able to reduce the settlement that occurs rather than without reinforcement. Because lime has properties similar to cement so it can stabilize the soil well.

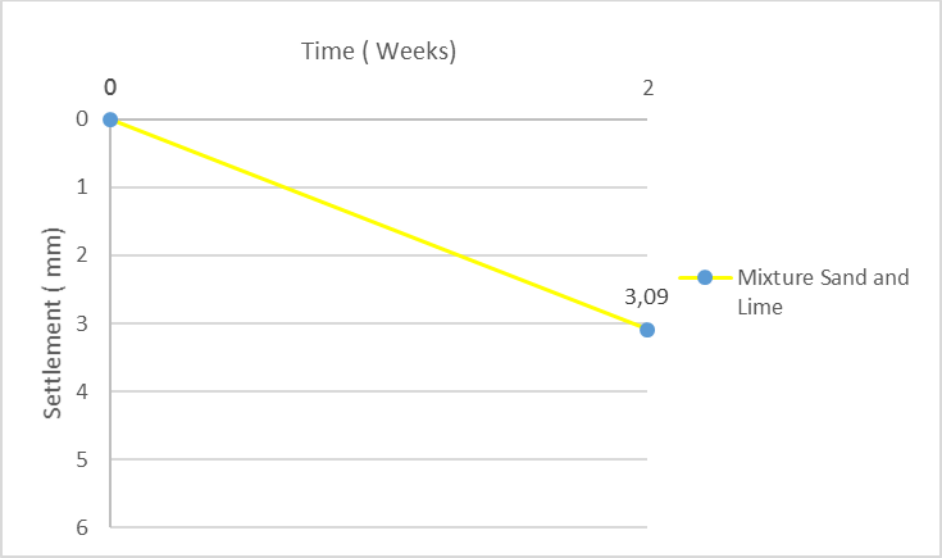

Figure V.5 Graph of Soil Settlement uses mixture of sand and lime reinforcement as a vertical drainage filler material

Figure V.5. Showed a settlement value in clay soil reinforced with a mixture of lime and sand as a vertical drainage filler material of 3.09 mm. In this Variation, mixing of sand and lime material produces value higher than without the reinforcement of vertical drainage.

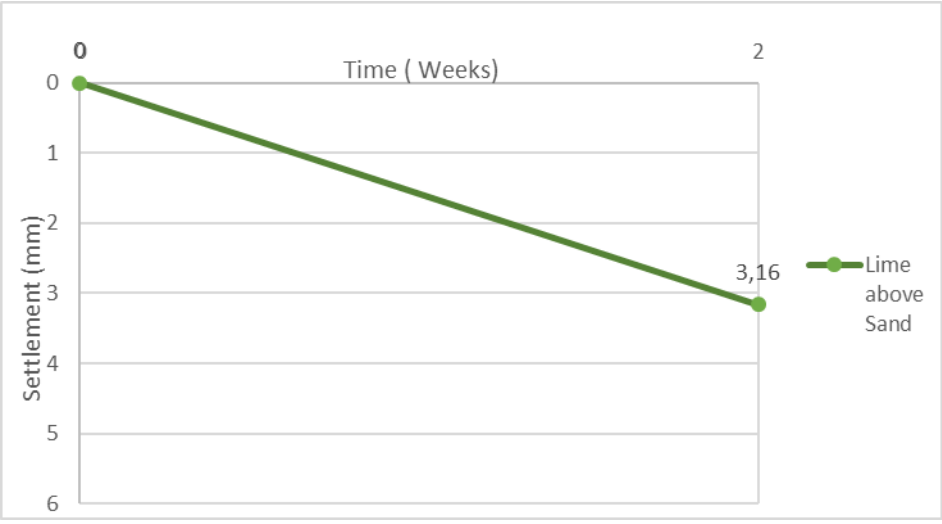

Figure V.6. Graph of Soil Settlement uses lime above sand reinforcement as a vertical drainage filler material

Figure V.6 Obtained a settlement value in clay soil reinforced with composition of lime over sand as a vertical drainage filler is 3.16 mm. In this variation obtained a greater decrease value compared with variations without reinforcement of vertical drainage.

Figure V.7. Graph of Soil Settlement uses of sand above lime reinforcement as a vertical drainage filler material

Figure V.7. Shows the settlement value obtained on clay reinforced with composition Sand above lime as a vertical drainage filler material is 3.05 mm. This variation is a continuation of the variation of sand and lime incorporation as clay reinforcement and this variation get the best result among 3 variations of sand and lime incorporation.

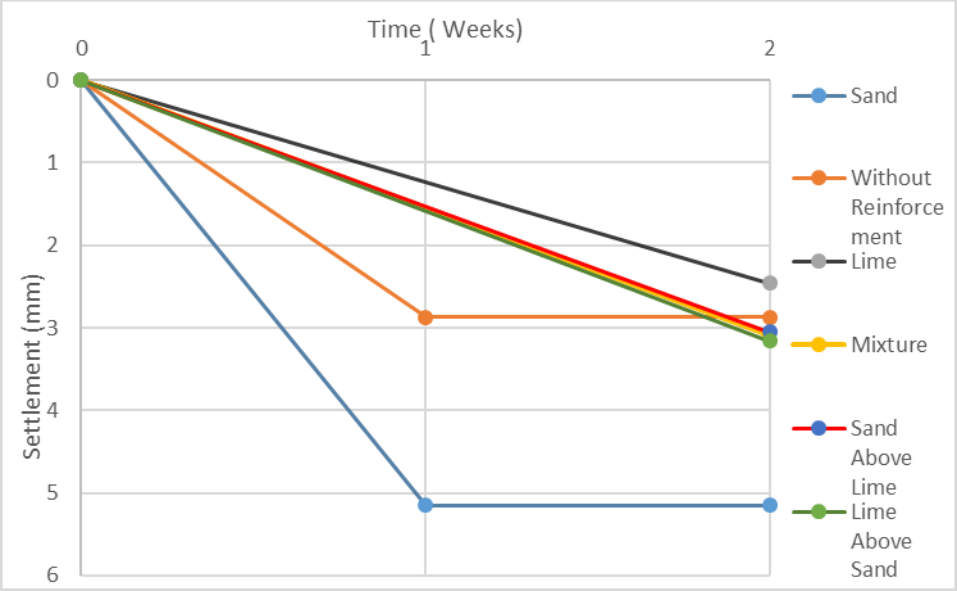

Figure V.8 Comparison Graph of Soil settlement using vertical drainage reinforcement and without reinforcement.

Figure V.8 above shows the greatest soil settlement value occurs in sand filled columns with a settlement value is 5.15 mm, this is because the sand has a high permeability properties where the sand has a large gap or cavities between particles one with The other so that water can seep out through the column well. While the smallest settlement is on the reinforcement containing lime with a value of 2.46 mm decrease, it is in because lime has properties similar to cement that will react with water and become hardened, this process is called the hydration process. In addition, according to Apriyono (2008) the use of lime as reinforcement can reduce the value of cc (*compression index*) on the soil, where the smaller the value of cc (*compression index*) the smaller the ability of the soil to perform compression so that the reduction can be reduced. While the variation of lime and sand material combinations has not been able to minimize the value of soil settlement compared with the value of soil without the use of vertical drainage reinforcement.

Because, except the reinforcement using lime column, it can be observed that settlement value of any variations vertical drainage filler material still larger than soil without reinforcement it means that process of consolidation is still in progress. To know the real settlement value, the

process of giving a distributed load should waiting until the process of consolidation is over.

4. CONCLUSION AND SUGGESTION

4.1 CONCLUSION

1. Soil samples used based on the classification of USCS including into the CH non organic clay classification with high plasticity While according to AASHTO Classification the soil samples can be classified into types A-7-5 which means the soil is clay that has poor quality.
2. Soil settlement value in Troketon Village Pedan District of Klaten without using vertical drainage reinforcement due to distributed load is 2.87 mm
3. Soil settlement value in Troketon Village Pedan District of Klaten by using lime reinforcement as vertical drainage due to distributed load is 2,46 mm. Installation of lime columns can strengthen soft clay soil in Troketon Village Pedan District of Klaten. Installation of lime columns can reduce settlement compared to soil without using reinforcement.
4. Soil settlement value in Troketon Village Pedan District of Klaten by using sand reinforcement as vertical drainage due to distributed load is 5,15 mm, This indicates that the installation of sand columns can accelerate the soil settlement in Troketon Village Pedan District of Klaten because the water in the soil can be removed properly by sand.
5. Soil settlement value in Troketon Village Pedan District of Klaten by using mixture of sand and lime reinforcement as vertical drainage due to distributed load is 3,09 mm. This shows that the reinforcement of mixture sand and lime columns can not reduce soil settlement compared to soil without the using of vertical drainage reinforcement.
6. Soil settlement value in Troketon Village Pedan District of Klaten by using lime above sand reinforcement as vertical drainage due to

distributed load is 3,16 mm. Based on this data, the reinforcement of lime above sand is no better than soil without the use of vertical drainage reinforcement.

7. Soil settlement value in Troketon Village Pedan District of Klaten by using sand above lime reinforcement as vertical drainage due to distributed load is 3,05 mm. This variation is the best among the variations of sand and lime combination as reinforcement, although it has not been able to reduce settlements compared to soil without use of vertical drainage reinforcement.

4.2 SUGGESTION

1. Further research on soil reinforcement using vertical drainage needs other soil material types to be carried out in larger and more complex scale.
2. Need to check or care on laboratory equipment especially Dial Gauge for maximum results obtained

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