



vol. 17 / 2023



The 7th International Conference on Science Technology

organized by
Faculty of Social Science and
Law Universitas Negeri Manado and
Consortium of International Conference
on Science and Technology

The Innovation Breakthrough in Digital and Disruptive Era

Geotextile Reinforcement Model Laboratory Test on Silt Soil

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Abstract. Merauke Regency is a lowland area that has soft soil which predominates. One of the methods to overcome the subsidence in silt soil, it is necessary to strengthen it by using geotextiles. The function of the geotextile is to hold the soil surface so that there is no subsidence in the soil. This study aims to determine the carrying capacity of silt soil before and after being given geotextile reinforcement. The study used an experimental method using the addition of Geotextile (non-woven type TS600) to strengthen the carrying capacity of silt soil. The silt soil carrying capacity test was divided into several variations, namely without using geotextile reinforcement and reinforced with 1 layer, 2 layers, and 3 layers of geotextile at a depth of 10 cm, 20 cm and 30 cm. The results of research conducted in the laboratory, the use of geotextile materials to increase the carrying capacity of silt soil has increased compared to the initial conditions. Soil without using geotextiles has a greater decrease, namely at a load of 5 kN there is a settlement of 20.3 mm. By using a single layer geotextile reinforcement material at a load of 5 kN there was a decrease of 10.97 mm, while using a two layer geotextile reinforcement material at a load of 5 kN there was a decrease of 8.09 mm, and using a three layer geotextile reinforcement material with a load of 5 kN there was a decrease of 6.01 mm. It can be concluded that the use of geotextile reinforcement can reduce the settlement of silt soil.

Keyword: Silt soil, reinforcement, geotextile.

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1 Introduction

The lowland region of Merauke Regency, where soft soil conditions are prevalent, urgently needs to be stabilized. With a grain size range of 0.05 to 0.002 mm and noted for having particles that are significantly smaller than sand and larger than clay, silt soil falls under the category of fine-grained soil. Soft soil is common in Merauke Regency, but because of its undesirable characteristics, it does not match the technical specifications required for a construction project. Low carrying capacity, high compressibility, significant volume fluctuations, and difficulties performing compaction work are examples of these qualities. The stability of the soil using cement is one approach to solving these issues [1][2].

To overcome the decline in silt soil, it is necessary to provide reinforcement or modeling of the soil, one of which is by using geotextile reinforcement. The function of the geotextile is to hold the soil surface so that there is no significant subsidence in the soil. If the soil layer is loaded, the soil will experience strain or decrease.

The strain that occurs in the soil is caused by changes in the composition of the soil as well as by a reduction in the pore/water cavities in the soil. The reason for the occurrence of landslides is due to the insufficient shear strength of the soil to resist the downward movement of the landslide, in the landslide field [3][4][5].

There are several types of geosynthetic materials that are often used in the geotechnical field, one of which is geotextile. There are two factors in the selection of geotextiles, namely internal and external. These two factors are related to the tensile strength of the geotextile and the type of backfill material used to interact with the geotextile. In this research, a test will be carried out on the silt soil reinforcement model using geotextiles on a laboratory scale [7][8].

2 Research Methods

2.1 Type of Research

This type of research is experimental research, by testing geotextile materials on silt soil reinforcement models.

2.2 Location and Sampling

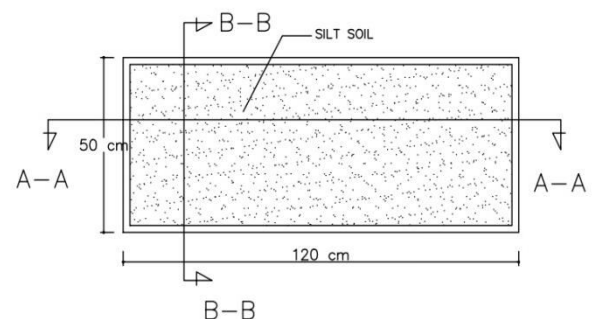
The soil samples used came from the Kurik V area, Kurik District, Merauke Regency. The geotextile material used is type TS600 non-woven. The research was conducted at the Laboratory of the Department of Civil Engineering, Faculty of Engineering, Musamus University

2.3 Method of Implementation

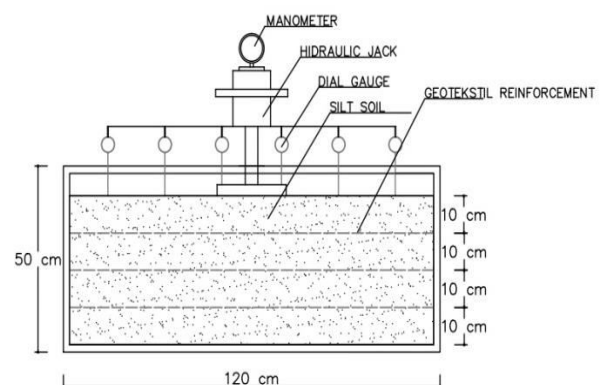
a. Investigation of soil properties

- Soil density testing is modified for SNI. Hot plates, picnometers, ovens, electric scales, and spatulas are among the equipment utilized.
- Water content testing is modified to SNI. The equipment includes electric scales, cups, and ovens.
- Grain analysis testing is modified for SNI. Sieve filters, brushes, electric scales, water hoses, and cups are among the equipment utilized.
- Devices for Atterberg boundary testing have been SNI-adjusted. The test apparatus includes a casagrande, a cup, a glass measuring 0.9 cm by 45 cm by 45 cm, a spatula, and an oven.
- SNI-adjusted equipment for compaction tests. The equipment used includes jacks, electric scales, standard proctors, standard hammer proctors, and ovens.
- This study compares silt soil reinforced with one, two, or three layers of geotextile to silt soil reinforced without geotextile reinforcement in terms of bearing capacity.

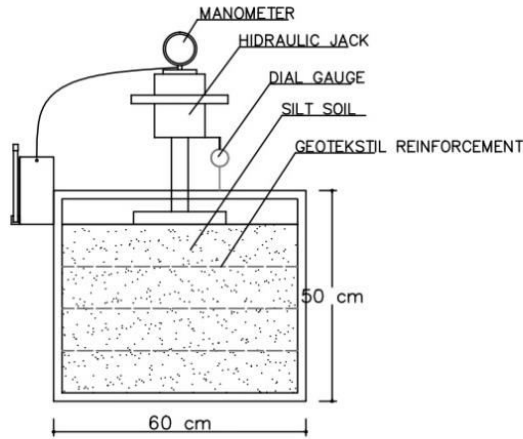
The modeling schematic designs for the use of geotextile materials for reinforcing silt soils, which is illustrated in Figure below.



(a)



(b)



(c)

Fig. 1. Modeling scheme design (a) modeling plan (b) section A-A (c) section B-B

3 Results and Discussion

3.1 Laboratory Test Results

The results of testing the physical characteristics of the soil taken from the Sumber Mulya Village area, Kurik District, Merauke Regency, contained a moisture content of 55.85%, specific gravity of 1.79, liquid limit (LL) of 50.64%, plastic limit (PL) of 42, 06%, plasticity index (PI) 8.57%, unit weight 1.85 gr/cm³, maximum dry unit weight 1.675 gr/cm³, optimum moisture content 28.13%. For more details can be seen in table 1.

Table 1. Recapitulation of soil test results

Laboratory Test Results				
No	Test	Symbol	Results	Unit
1	Water content	Wc	55,85	%
2	Unit weight	γ	1,85	gr/cm ³
3	Atterberg Limit			
	Liquid Limit	LL	50,64	%
	Plastic Limit	PL	42,06	%
	Indeks Plasticity	IP	8,57	%
4	Specific gravity		1,79	-
5	Sieve analysis			
	Gravel		0,00	%
	Sand		9	%
	Silt		80	%
	Clay		11	%

3.2 Soil Modeling Test without Geotextile Reinforcement

From the results of the unreinforced silt settlement test in a 40 cm deep test tub with box dimensions of 120x60x50 cm, which was carried out at loading with load readings at 1.00 kN, 2.00 kN, 3.00 kN, 4.00 kN and 5, 00 kN, the results can be seen in table 2:

Table 2. Testing silt soil without geotextile reinforcement

Load (kN)	Settlement and Deformation readings				
	Dial 1 (mm)	Dial 2 (mm)	Settlement Dial (mm)	Dial 3 (mm)	Dial 4 (mm)
0	0	0	0	0	0
1	1,71	1,62	-8,83	1,95	1,43
2	1,95	2,48	-11,98	3,4	1,66
3	1,12	3,22	-15,74	4,5	1,19
4	1,28	3,86	-18,72	5,79	2,59
5	2,31	4,94	-20,3	5,81	2,72
Distance	0	30	60	90	120

From table 2 above it can be seen that unreinforced silt soil with a settlement of -8.83 mm the load received is 1.00 kN, for a settlement of -11.98 mm the load received is 2.00 kN, for a settlement of -15.74 mm the load received is 3.00 kN, for a decrease of -18.72 mm the load received is 4.00 kN, and for a decrease of -20.3 mm the load received is 5.00 kN. The decline that occurs can be seen in Figure 2.

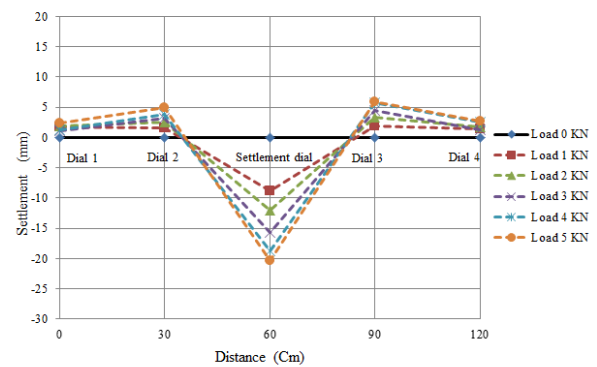


Fig. 2. Settlement graph of silt soil without geotextile reinforcement

From Figure 2 above it can be seen that the unreinforced silt soil with a load received of 1.00 kN, the settlement that occurred was -8.83 mm, and the deformation on dial 1 (one) was 1.71 mm, dial 2 (two) 1.62 mm, dial 3 (three) 1.95 mm and dial 4 (four) 1.43 mm. at a load of 2.00 kN, the settlement that occurs is -11.98 mm, and the deformation on dial 1 (one) is 1.95 mm, dial 2 (two) is 2.48 mm, dial 3 (three) is 3.4 mm and a 4 (four) 1.66 mm dial. at a load of 3.00 kN, the settlement that occurs is -15.74 mm, and the deformation on dial 1 (one) is 1.12 mm, dial 2 (two) is 3.22 mm, dial 3 (three) is 4.5 mm and dial 4 (four) 1.19 mm. at a load of 4.00 kN, the settlement that occurs is -18.72 mm, and the deformation on dial 1 (one) is 1.28 mm, dial 2 (two) is 3.86 mm, dial 3 (three) is 5.81 mm and dial 4 (four) 2.72 mm. and at a load of 5.00 kN, the drop that occurs is -20.3 mm. and deformation on dial 1 (one) 2.31 mm, dial 2 (two) 4.94 mm, dial 3 (three) 5.81 mm and dial 4 (four) 2.72 mm.

3.3 Testing Soil Modeling With single Layer Geotextile Reinforcement

From this second test sample, a test was carried out using one layer geotextile reinforcement, the soil was put into the test bath with a depth of 40 cm, at a depth of 30 cm the geotextile was placed as reinforcement then pressure was carried out with load readings every 1.00 kN, 2.00 kN, 3.00 kN, 4.00 kN, and 5.00 kN. The following is the reading of the settlement dial and silt load dial with single layer geotextile reinforcement, which can be seen in table 3 as follows:

Table 3. Soil testing with single layer geotextile reinforcement

Load (kN)	Settlement and Deformation readings				
	Dial 1 (mm)	Dial 2 (mm)	Settlement Dial (mm)	Dial 3 (mm)	Dial 4 (mm)
0	0	0	0	0	0
1	0,02	2,09	-5,56	1,3	1,06
2	0,04	2,18	-8,4	2,36	1,48
3	1,18	2,25	-9,68	3,52	1,73
4	1,46	3,02	-10,54	4,63	2,51
5	2,49	3,99	-10,97	4,85	2,67
Distance	0	30	60	90	120

From table 3 above it can be seen that silt soil with single layer geotextile reinforcement with a settlement of -5.56 mm the load received is 1.00 kN, for a settlement of -8.4 mm the load received is 2.00 kN, for a settlement of -9.68 mm the load received is 3.00 kN, for a decrease of -10.54 mm the load received is 4.00 kN, and for a decrease of -10.97 mm the load received is 5.00 kN. The decline that occurs can be seen in Figure 3.

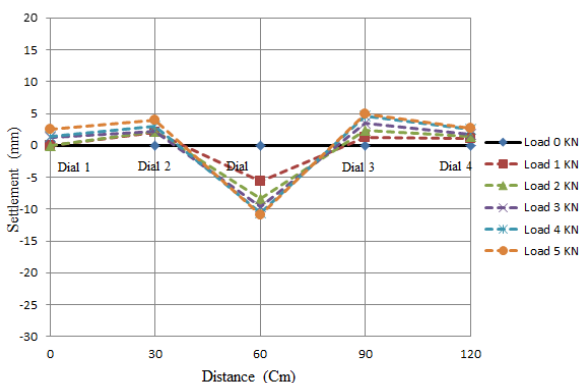


Fig. 3. Settlement graph of silt soil with single geotextile reinforcement

From Figure 3 above it can be seen that the silt soil with reinforcement at the received load is 1.00 kN, the settlement that occurs is -5.56 mm, and the deformation on dial 1 is 0.02 mm, dial 2 is 2.09 mm, dial 3 (three) 1.3 mm and dial 4 1.06 mm. for the received load of 2.00 kN, the settlement that occurs is -8.4 mm, and the deformation on dial 1 is 0.04 mm, dial 2 is 2.18 mm, dial 3 is 2.36 mm and dial 4 is 1.48 mm. for the received load of 3.00 kN, the settlement that

occurs is -9.68 mm, and the deformation on dial 1 is 1.18 mm, dial 2 is 2.25 mm, dial 3 is 3.52 mm and dial 4 is 1.73mm. for the received load of 4.00 kN, the settlement that occurred was -10.54 mm, and the deformation on dial 1 was 1.46 mm, dial 2 was 3.02 mm, dial 3 was 4.63 mm and dial 4 was 2.51mm. and for the received load of 5.00 kN the decrease that occurred was -10.97 mm. and the deformation on dial 1 is 2.49 mm, dial 2 is 3.99 mm, dial 3 is 4.85 mm and dial 4 is 2.67 mm.

3.4 Modeling Test of Silt Soil with Two-Layer Geotextile Reinforcement

From this third test sample, a test was carried out using two-layer geotextile reinforcement, the soil was put into the test box at a depth of 20 cm and 30 cm, then loading was carried out with load readings every 1.00 kN, 2.00 kN, 3.00 kN, 4.00 kN, and 5.00 kN. The following is the reading of the settlement dial and load dial of peat soil with geotextile reinforcement, which can be seen in table 4:

Table 3. Soil testing with two layer geotextile reinforcement

Load (kN)	Settlement and Deformation readings				
	Dial 1 (mm)	Dial 2 (mm)	Settlement Dial (mm)	Dial 3 (mm)	Dial 4 (mm)
0	0	0	0	0	0
1	0,7	1,76	-2,75	1,66	1,23
2	1,42	2,83	-4,93	3,27	1,54
3	1,75	2,99	-6,14	4,56	1,73
4	1,92	3,17	-6,98	4,89	1,98
5	1,98	4,75	-8,09	5,58	2,17
Distance	0	30	60	90	120

From table 4 above it can be seen that the silt soil with two-layer geotextile reinforcement with a settlement of -2.75 mm at a load reading of 1.00 kN, a settlement of -4.93 mm at a reading of 2.00 kN load, a settlement of -6.14 mm at a load reading of 3.00 kN, a decrease of -6.98 mm at a reading of 4.00 kN, and a decrease of -8.09 mm at a reading of 5.00 kN. The decline that occurs can be seen in Figure 4.

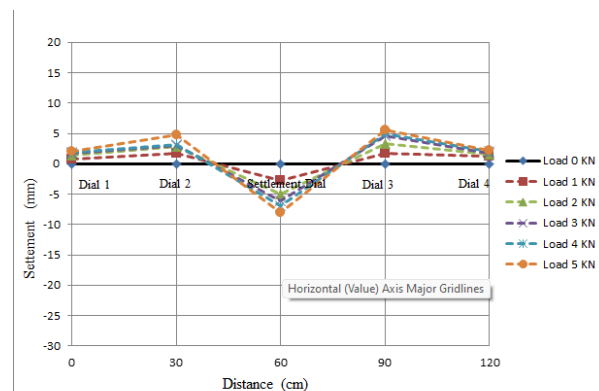


Fig. 4. Settlement graph of silt soil with two geotextile reinforcement

From Figure 4 above it can be seen that the silt soil with two layers of geotextile reinforcement with a load received of 1.00 kN, the settlement that occurred was -2.75 mm, and the deformation on dial 1 was 0.07 mm, dial 2 was 1.76 mm, dial 3 is 1.66 mm and dial 4 is 1.23 mm. for the received load of 2.00 kN, the settlement that occurred was -4.93 mm, and the deformation on dial 1 was 1.42 mm, dial 2 was 2.83 mm, dial 3 was 3.27 mm and dial 4 by 1.54mm. for the received load of 3.00 kN, the settlement that occurred was -6.14 mm, and the deformation on dial 1 was 1.75 mm, dial 2 was 2.99 mm, dial 3 was 4.56 mm and dial 4 was 1.73mm. for the received load of 4.00 kN, the settlement that occurred was -6.98 mm, and the deformation on dial 1 was 1.92 mm, dial 2 was 3.17 mm, dial 3 was 4.89 mm and dial 4 was 1.98mm. and for the received load of 5.00 kN, the decrease that occurs is -8.09 mm. and the deformation on dial 1 is 1.98 mm, dial 2 is 4.75 mm, dial 3 is 5.58 mm and dial 4 is 2.17 mm.

3.5 Soil Modeling Test with Three Layer Geotextile Reinforcement

From the fourth test sample, a test was carried out using three layers of geotextile reinforcement, the soil was put into the test model box, at a depth of 30, 20 and 10 cm each geotextile was placed as reinforcement in three layers, then the load was suppressed by reading the load every 1.00 kN , 2.00 kN, 3.00 kN, 4.00 kN, and 5.00 kN. The following is the reading of the settlement dial and load dial of peat soil with geotextile reinforcement, which can be seen in table 4.

Table 4. Soil testing with three layer geotextile reinforcement

Load (kN)	Settlement and Deformation readings				
	Dial 1 (mm)	Dial 2 (mm)	Settlement Dial (mm)	Dial 3 (mm)	Dial 4 (mm)
0	0	0	0	0	0
1	1,6	1,1	-1,54	1,45	0,5
2	1,62	1,5	-2,62	2,44	0,7
3	1,65	2,25	-4,05	3,42	0,8
4	1,7	2,55	-5,32	4,7	2,02
5	1,7	2,85	-6,01	4,78	2,27
Distance	0	30	60	90	120

From table 4 above it can be seen that the silt soil with percutaneous three layers has a settlement of -1.54 mm at 1.00 kN loading, -2.62 mm settlement occurs at 2.00 kN loading, for -4.05 settlement mm occurs at a loading of 3.00 kN, for a decrease of -5.32 mm at a loading of 4.00 kN, and for a decrease of -6.01 mm the load received is 5.00 kN. The decline that occurs can be seen in Figure 5 below.

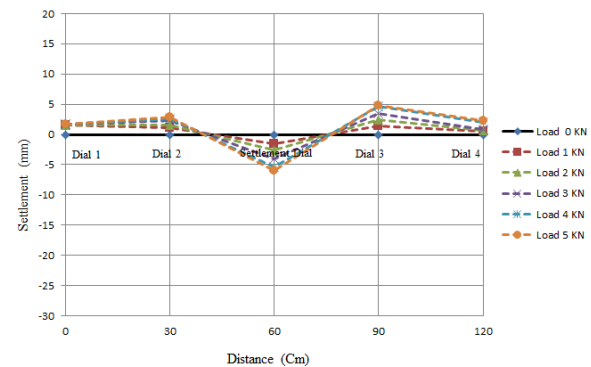


Fig. 5. Settlement graph of silt soil with three geotextile reinforcement

From Figure 5 above it can be seen that the silt soil with three-layer geotextile reinforcement with a loading received of 1.00 kN, the settlement that occurred was -1.54 mm, and the deformation on dial 1 was 1.6 mm, dial 2 was 1.1 mm, dial 3 is 1.45 mm and dial 4 is 0.5 mm. at a loading of 2.00 kN, the settlement that occurred was -2.62 mm, and the deformation on dial 1 was 1.62 mm, dial 2 was 1.5 mm, dial 3 was 2.44 mm and dial 4 was 0.7mm. at 3.00 kN loading, the settlement was -4.05 mm, and the deformation on dial 1 was 1.65 mm, dial 2 was 2.25 mm, dial 3 was 3.42 mm and dial 4 was 0.8 mm. at a loading of 4.00 kN, the settlement that occurred was -5.32 mm, and the deformation on dial 1 was 1.7 mm, dial 2 was 2.55 mm, dial 3 was 4.7 mm and dial 4 was 2.02 mm. and for the received load of 5.00 kN, the decrease that occurs is -6.01 mm. and the deformation on dial 1 is 1.7 mm, dial 2 is 2.85 mm, dial 3 is 4.78 mm and dial 4 is 2.27 mm.

3.6 Discussion

Based on the overall test results, it can be seen in the graph below that there has been an increase in the carrying capacity of the silt soil by using added geotextiles in each layer and an increase in the carrying capacity with each additional layer of geotextile. The following is a comparison of the settlement of each silt soil test sample without reinforcement and with geotextile reinforcement, which can be seen in table 5 below.

Table 5. Comparison settlement of geotextile reinforcement models on silt soils

Load (kN)	Settlement and Deformation readings			
	without reinforcement (mm)	single layer reinforcement (mm)	double layer reinforcement (mm)	three layer reinforcement (mm)
0	0	0	0	0
1	-8,83	-5,56	-2,75	-1,54
2	-11,98	-8,4	-4,93	-2,62
3	-15,74	-9,68	-6,14	-4,05

4	-18,72	-10,54	-6,98	-5,32
5	-20,3	-10,97	-8,09	-6,01
Distansi	0	30	60	90

From table 5 above it can be seen that the silt soil without geotextile reinforcement has a maximum settlement of -20.3 mm with an received load of 5.00 kN, for the reinforcement of one layer of geotextile there is a maximum settlement of -10.97 mm at a loading condition of 5.00 kN, for two-layer geotextile reinforcement there is a maximum settlement of -8.09 mm at a given loading of 5.00 kN, for three-layer reinforcement there is a maximum settlement of -6.01 mm at a given loading of 5.00 kN. The graph of the decline that occurs can be seen in Figure 6 below.

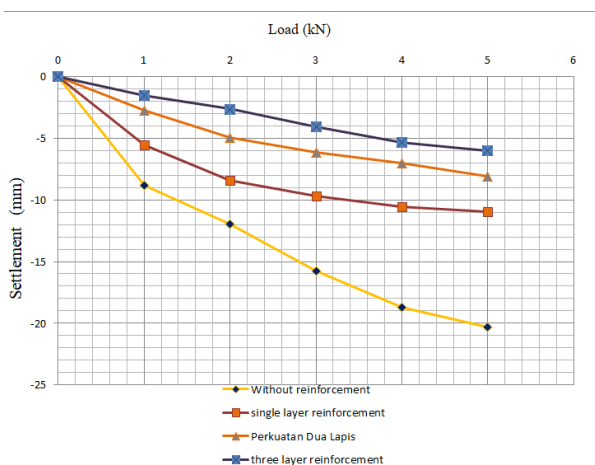


Fig. 5. Graph of soil settlement comparison of geotextile reinforcement model on silt soil

4 Conclusion

Based on the results of laboratory tests, it was concluded that the use of geotextile materials has an effect on efforts to increase the carrying capacity of silt soil. From the reinforcement model, it is known that silt soil without geotextile reinforcement has a greater decrease, namely at a loading of 5 kN, a decrease of 20.3 mm occurs compared to those using geotextile reinforcement materials.

While the results of tests in the laboratory using a single layer geotextile reinforcement material with a load of 5 kN decreased by 10.97 mm, on a two-layer geotextile reinforcement with a load of 5 kN there was a decrease of 8.09 mm, and on a three-layer geotextile reinforcement with a load of 5 kN decreased by 6.01 mm. Based on the test results it can be said that the use of geotextiles can reduce settlement. This can be seen from the smaller settlement value and larger bearing capacity ratio resulting from the combination of geotextile reinforcement.

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