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Experimental test of concrete plate deflection on soft soil improved by prefabricated vertical drain

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Abstract. The low permeability of soft soils results in slow water flows from the consolidation and the low bearing capacity. The soil improvement that can be used is Prefabricated Vertical Drain (PVD). The use of PVD significantly reduces the length of the soil pore drainage pathway, so that it can increase the bearing capacity of the soil due to the compaction process from the release of pore water from the soil. Experimental testing in the laboratory was carried out using a steel box measuring 1000 mm x 1000 mm x 1000 mm. There are three samples, soil without PVD and soil with PVD triangular patterns of distances of 100 mm and 150 mm. Preloading is carried out before loading on the concrete plate. Concrete plates measuring 700 mm x 100 mm x 30 mm and load media are proving rings with a capacity of 10 kN. The load placed in the center, the end, and the edge of the plate. The loading test results on a concrete plate on soil with PVD can reduce deflection that occurs compared to soil without PVD. Deflection reduction is more effective for PVD with a distance of 100 mm.

1. Introduction

Soft soils are problematic and challenging issue because, under load, they can produce large settlements in a very long time [1,2]. The settlement that occurs is because of permeability, which controls the rate of the expelling water out of the soil and consequently the rate of settlement at the desired time and the compressibility, which controls the process of excess pore pressures. Installation of the prefabricated vertical drain can reduce soil permeability, affect the process of soil consolidation [3], and significantly reduces the length of the pore drainage path and hasten the dissipation process of excess pore water pressure [4–8]. PVD is a sheet made from a combination of the core material and spun non-bonding geotextile as a wrapping. This research discusses the effect of soil improvement using the prefabricated vertical drain on concrete plate with experimental testing in laboratory.

2. Method

The soil used in this experimental test is from Gedebage, Bandung City. The soil used in this study has a moisture content of 63%, and it is a type of soft clay. The density of the soil is 2,49, and the weight of the content is 1,62 gram/cm^3. The liquid limit is 72%, and the plasticity limit is 35.57%, and the plasticity index is 36,43% and has high plasticity. Grain size analysis obtained percentage of clay 88,16%; silt 7,56%; and 4,28% sand. Based on grain size analysis, soils can be classified A-7-5 (41) according to the AASHTO and CH groups (non-organic clays with high plasticity) according to USCS.

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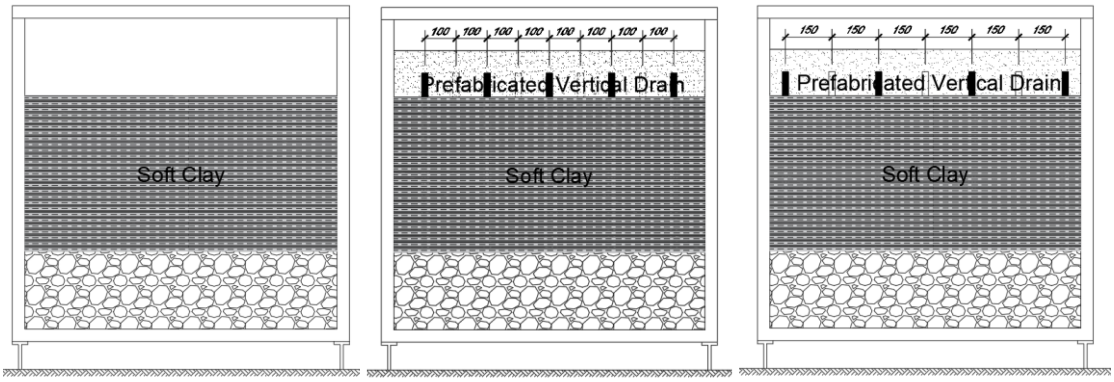
To find out the effectiveness of using prefabricated vertical drain in soil improvement is necessary to do field testing, but it creates some difficulties in its implementation. Therefore, testing in laboratory use as an alternative method [9].

The experimental test uses a laboratory model scale with a steel box of 1000 mm × 1000 mm × 1000 mm. Tests were carried out on three samples, soil without PVD and soil with PVD triangular patterns of distances of 100 mm and 150 mm that can see in Figure 1. PVD is planting into a 500 mm deep soil layer. Then the layer of sand is placed on the soil, which was previously coated by geotextile non-woven to separate the sand and soil layers from mixing.

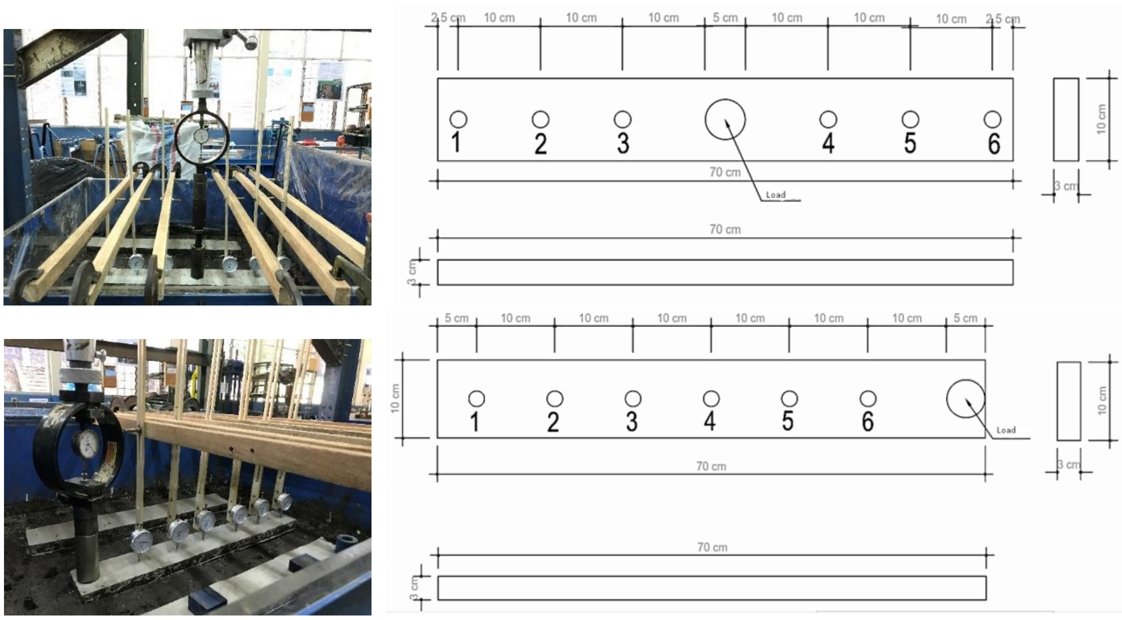


Soil without PVD Soil with PVD 100 mm Soil with PVD 150 mm

Figure 1. Experimental test.

Before the test is carried out, a preloading process is carried out first, which aims to help the water get out faster through PVD. Preloading is carried out using 10 mm thick steel plate media, which is then pressuring until the soil dropped when a 50% consolidation degree reached.

Concrete plates measuring 700 mm x 100 mm x 30 mm and load media are proving rings with a capacity of 10 kN. The load placed in the center, the end, and the edge of the plate can see in Figure 2. The loading test results on a concrete plate on soil with PVD can reduce deflection that occurs compared to soil without PVD.



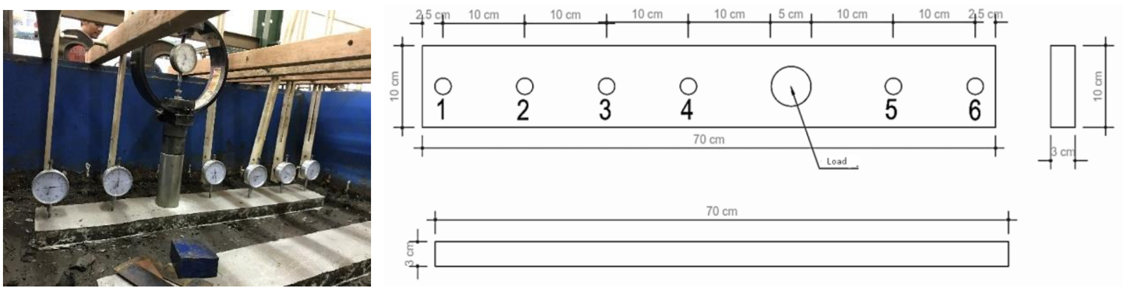


Figure 2. The load position.

3. Results and discussion

The results of the concrete plate load test are pressure and deflection. The results for the loading of the center, end, and edge can see in Table 1, Table 2, and Table 3.

Based on these tables, then made into a graphical form between pressure and deflection for each load position that can see in Figure 3, Figure 4, and Figure 5.

Table 1. Center load results.

	Deflection (mm)					
	Dial 1	Dial 2	Dial 3	Dial 4	Dial 5	Dial 6
Without PVD	-0,400	-0,500	-0,900	-0,880	-0,490	-0,400
With PVD 100 mm	-0,150	-0,290	-0,430	-0,420	-0,280	-0,150
With PVD 150 mm	-0,200	-0,350	-0,680	-0,680	-0,340	-0,210

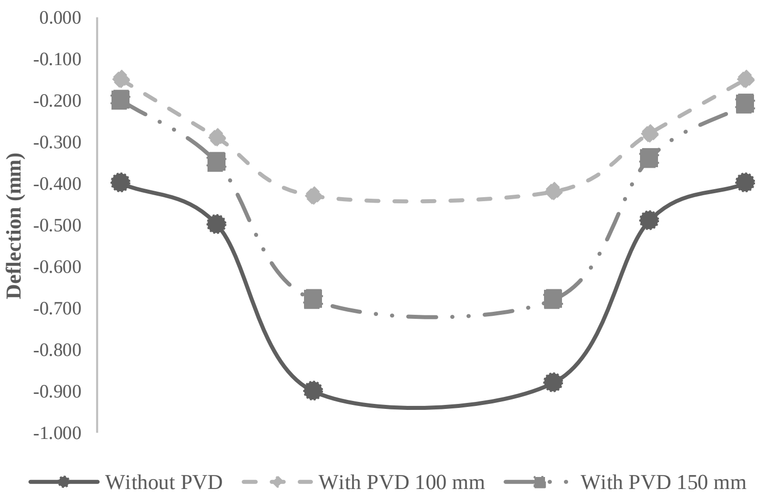


Figure 3. Center load results.

Table 2. End load results.

	Deflection (mm)					
	Dial 1	Dial 2	Dial 3	Dial 4	Dial 5	Dial 6
Without PVD	0,640	0,400	-0,003	-0,400	-1,000	-1,700
With PVD 100 mm	0,300	0,200	0,040	-0,170	-0,500	-1,000
With PVD 150 mm	0,500	0,300	0,100	-0,200	-0,620	-1,400

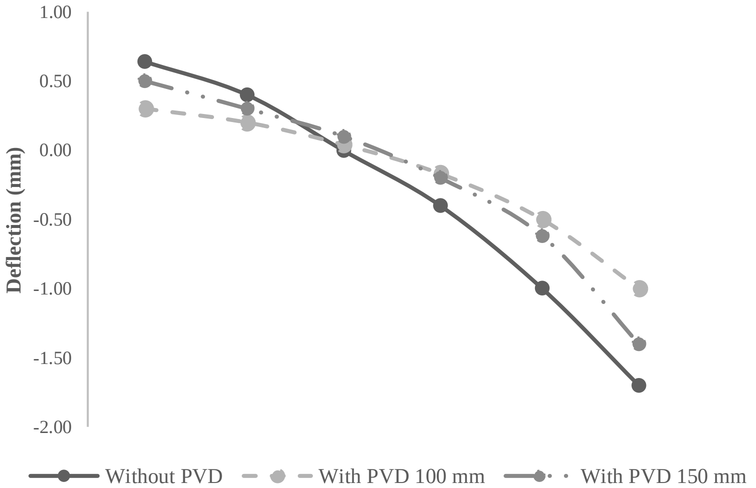


Figure 4. End load results.

Table 3. Edge load results.

	Deflection (mm)					
	Dial 1	Dial 2	Dial 3	Dial 4	Dial 5	Dial 6
Without PVD	-0,001	-0,220	-0,500	-0,700	-0,980	-0,970
With PVD 100 mm	0,040	-0,120	-0,300	-0,450	-0,550	-0,500
With PVD 150 mm	0,020	-0,170	-0,400	-0,550	-0,840	-0,800

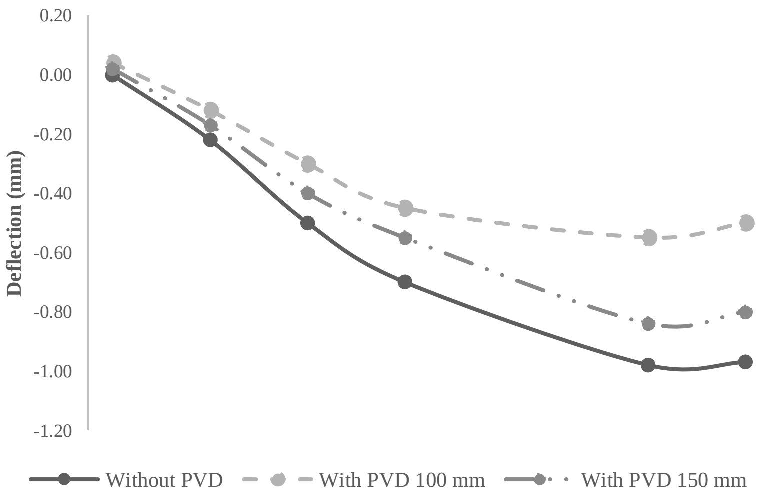


Figure 5. Edge load results.

Reduction of deflection for the center load between soil without PVD and soil with PVD 100 mm by an average of 52% while soil with PVD 150 mm by 34%.

Reduction of deflection for the end load between soil without PVD and soil with PVD 100 mm by an average of 50% while soil with PVD 150 mm by 31%.

Reduction of deflection for the edge load between soil without PVD and soil with PVD 100 mm by an average of 43% while soil with PVD 150 mm by 19%.

4. Conclusion

The results of loading tests on concrete slabs in soil with PVD can reduce deflection that occurs compared to soils without PVD. Deflection reduction is more effective for PVD with a distance of 100 mm. PVD distance affects the effectiveness of its use, the closer the PVD distance, the more significant the deflection reduction.

Acknowledgment

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