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ANALYSIS OF THE EFFECT OF SMEAR ZONE ON CONSOLIDATION DECLINE IN THE TEBING TINGGI-KISARAN TOLL ROAD PROJECT (PHASE 1) TEBING TINGGI – INDRAPURA STA 102+700 TOLL ROAD PROJECT WITH 3D PLAXIS MODELING

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Abstract

Repairing soft clay Embankment loading method with PVD is a soil improvement system consisting of Embankment loading work, installation PVD, installation PHD, and geotechnical instruments. Preload serves to compress the subgrade. PVD serves to speed up the process of soil compaction. Horizontal drains drain pore water taken from the PVD in a horizontal direction to the improved outside of the location. Geotechnical instruments monitor and record the process and determine the performance of the result, improving soil that has been carried out. Embankment loading and PVD (Prefabricated Vertical Drain) are often used in the construction world to increase shear strength and speed up the consolidation time of soft soils. However, using a mandrel can affect the surrounding soil during the installation of PVD, causing the soil to become disturbed. The disturbed area is called the Smear zone. Due to the presence of a smear area, analysis and calculations are needed to obtain a consolidation time under field conditions. This analysis aims to compare the decrease of displacement in the settlement plate (SP-124) with modeling in PLAXIS 3D, using with or without considering the smear zone. The method used in this thesis is the analytical method using Terzaghi theory and the finite element method using PLAXIS 3D. From the results obtained analytically, the magnitude of the decrease is 15.252 cm.

The results from the PLAXIS 3D analysis without the effect of the smear zone are 15.15 cm. With the effect of the smear zone being 2 times the dimensions of the mandrel, the results obtained are 15.131 cm, 15.133 cm and 15.134 cm. With 3 times the dimensions of the mandrel, the results obtained are 15,142 cm, 15,141 cm and 15,14 cm, and with 4 times the dimensions of the mandrel, the results obtained are 15,144 cm, 15,143 cm and 15,143 cm. The decrease in the settlement plate 124 in the field is 15.10 cm. So it can be concluded that the calculation of consolidation decrease using analytical theory is relatively close to the decrease in actual results in the field with a percentage difference of 1% decrease. There are differences in settlement due to laboratory data not representing the entire soil layer. Due to the decrease that occurred at 15.10 cm, the result of the effect of the smear effect 2 times the mandrel dimension and half of the coefficient of permeability of the original soil with a reduction ratio of 0.2% is the result that is closest to the results of field observations compared to without a smear effect of 0.331%.

Keywords: Consolidations; PVD; PLAXIS 3D; smear zone

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Introduction

Indonesia has been active in infrastructure development for the last 5 years, while infrastructure is currently under construction and has been completed, such as roads, bridges, dams, airports, MRT and LRT. North Sumatra is one of the areas that have the opportunity to develop infrastructure, especially toll roads whose distances will be extended so that all people can benefit from it. However, most people only pay attention to its aesthetic value, without paying attention to how long an infrastructure will last if it is subjected to loads, shocks, and is affected by the weather. In infrastructure development, geotechnical problems are important issues that must be considered. Many problems in the structure occur due to a lack of attention in assessing soil conditions in the field. Soil is the supporting foundation of a building or the construction material of the building itself, so land is considered very important in starting construction work.

Soft soil in construction is often a problem. This is due to the low bearing capacity of the soil. One of the factors that cause soft soil to have a low bearing capacity is its high water content. Low carrying capacity can cause losses, ranging from increasingly expensive construction costs to the threat to construction safety, namely structures that are unable to stand stably and can collapse. Soft soils are soils that, if not recognized and investigated carefully, can cause instability and long-term settlement that cannot be tolerated. These soils have low shear strength and high compressibility (Iskandar, 2018). In addition, the high level of compressibility in soft soils is caused by the high void ratio. If the soil is given a load, then the water and air that fills the pores will come out, resulting in soil compression, indicating a decrease in the soil. So that if it is used as a building or road foundation, stabilization or improvement of the soft soil must first be carried out so that it is feasible and meets the requirements as a foundation layer or subgrade layer for road construction. To overcome these problems, soil improvement work is needed.

Various methods have been used to overcome this problem by construction experts and academics. However, in the last two decades, the use of PVD as a repair method has been recognized as one of the effective and efficient methods of assisting preloading in locations with soft and thick soil deposits (Holtz, RD, Jamiolkowski, MB, Lancellotta, R. and Pedroni, 1991).

Repair of soft clay preloading method with PVD is a soil improvement system consisting of preload work, PVD, horizontal drain and geotechnical instruments. Preload serves to compress the subgrade. PVD serves to speed up the process of soil compaction. A horizontal drain serves to drain pore water from the PVD in a horizontal direction to the outside of the preload pile. Geotechnical instruments function to monitor the process and determine the performance of the results of soil improvements that have been carried out.

Prefabricated vertical drain (PVD) is a geocomposite material consisting of a core layer of polypropylene/polyethylene and a filter layer of geotextile. The function of PVD is to overcome the problem of embankment construction on soft soil by speeding up the consolidation process time. PVD technology has been widely recognized as a soil improvement technology that aims to increase the shear strength of the soil, reduce soil compressibility/compression, minimize settlement, increase bearing capacity and prevent possible damage/collapse in building structures on soft soil. The shorter the vertical drain path, the higher the vertical hydraulic conductivity, and the greater the resistance of the well from the PVD, the smaller the error that will occur (Chai, Shen, Miura, & Bergado, 2001).

Compared to the consolidation process using PVD and without PVD, the consolidation process for soft clay occurs relatively quickly if PVD is installed. This shows that the flow process occurs in vertical and horizontal directions. Without using PVD, the consolidation process occurs very slowly, and there has never been a decrease in consolidation as expected in the installation of PVD (Aspara & Fitriani, 2016).

A large consolidation settlement that occurs over a long period is a major problem in the case of stockpiling. With low clay soil permeability, the time for soil subsidence until consolidation is complete is predicted to reach 10 years. Soil improvement is needed to speed up consolidation settlement time. One way that can be applied to speed up consolidation settlement time is pre-fabricated vertical drain and pre-loading. However, when installing PVD, the tool used (mandrel) can damage the surrounding soil so that it affects the horizontal permeability coefficient of the soil, which can reduce the rate of water entering the PVD. This event is called the smear zone effect. For this reason, it is necessary to study the effect of the smear zone on the decrease in soil consolidation.

Apriyani, Ikhya, and Hamdhan (2016) concluded that the mesh size did not affect the magnitude of the decline and the time of consolidation that occurred. However, the smear zone affects the consolidation time of the soil due to the smaller permeability coefficient.

Measuring moisture content from field measurements is also good according to the value calculated from the consolidation settlement. The results of the scale study confirm that the amount of consolidation settlement increases as the PVD distance decreases over a certain period. The final results also proved the effectiveness of PVD for Bangkok clay enhancement (Bergado, Balasubramaniam, Fannin, & Holtz, 2002).

Meiwa, Ikhya, and Hamdan (2015) performed a consolidation analysis with PVD for axisymmetric conditions and several plane strane equivalence methods using the finite element method. It was found that the Indraratna method has the closest axisymmetric results because this method, in addition to modeling the PVD point, also models the smear zone in its modeling so that the modeling is more detailed and the analysis results are more accurate. Although the Hird method does not model the smear zone, it has a fairly close axisymmetric analysis result.

Hayati's (2019) calculation of the reduction and consolidation time using PLAXIS 3D modeling by considering the effect of the smear zone gives results that are close to the situation in the field. The time needed in the consolidation process using PLAXIS modeling by taking into account the effect of the smear zone is longer than that without taking into account the effect of the smear zone.

Surbakti (2020) The decrease in consolidation using PLAXIS 3D modeling gives results closer to the decrease in observations in the field than PLAXIS 2D modeling.

In this thesis, an analysis of the effect of the smear zone on the consolidation of soft soil will be carried out. The analysis was carried out using the finite element method with the help of the PLAXIS 3D (three-dimensional) program.

Method

To support this research, the authors obtained data from the contractor, PT. Hutama Karya (Persero). The data obtained are:

1. The layout of road work
2. Boring Log BH-39
3. Specifications PVD
4. Geotechnical instrument (settlement plate)

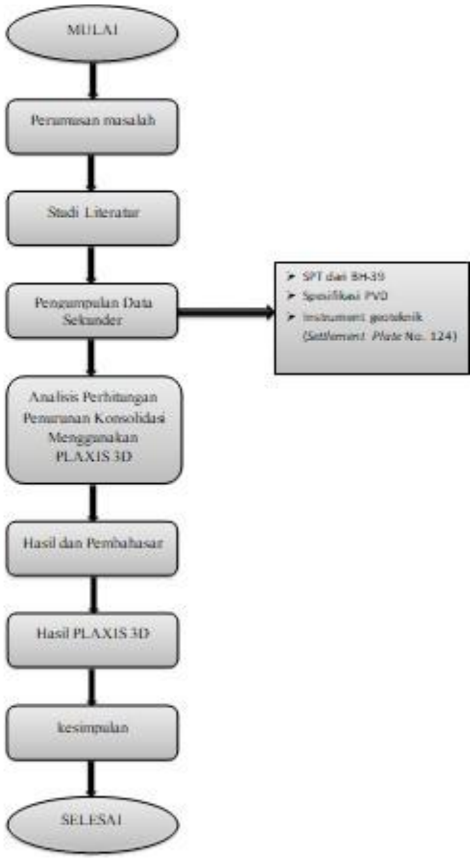

Figure 1
Research Flowchart

Results and Discussion

1. Based on the results of analytical calculations and 3D PLAXIS modeling with and without the effect of the smear zone, a large reduction can be occurred, according to Table 1.

Table 1
The results of the decrease that occurred based on analytical calculations and PLAXIS 3D

Modeling	Smear zone characteristics s'	Kh	Decreased (cm)
smearzone effects	2	2	15,131
		3	15,133
		4	15,134
	3	2	15,142
		3	15,141
		4	15,140
	4	2	15,144
		3	15,143
		4	15,143
Without smearzone effects			15,15
Analytical			15,252
Settlement plate 124			15,10

2. After analysis using 3D modeling with a time of 215 days, the depth of PVD erection was 17.4 meters with different characteristics of the smear zone, and the results are shown in Table 1. The table shows that the smaller the value of k with the value of s' constant, the closer the calculation results are getting closer to decreasing actual results in the field. The smaller the value of s' with a constant k value, the closer the calculation results are to the actual decline in the field. From all experiments, the value of s'=2 and k=2 is closest to the actual conditions in the field.
3. Close results are obtained with the same characteristics of the smear zone but with different permeability coefficient values using PLAXIS 3D, which can be seen in Figures 2 to 5.
4. The graph of the relationship between the magnitude of settlement and consolidation time from the results of the PLAXIS 3D modeling without and with the smear zone, which is close to the field results, as well as the field results from the settlement plate 124, can be seen in Figure 1.

Figure 2
The pattern of settlement and soil consolidation time 2 times the dimension of the mandrel

Figure 3
The pattern of settlement and consolidation time of soil 3 times the dimension of the mandrel

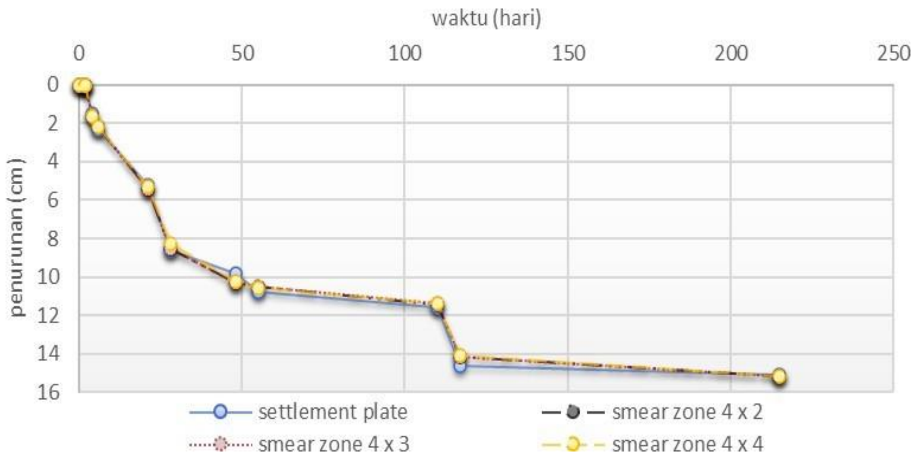

Figure 4
The pattern of settlement and soil consolidation time 4 times the mandrel

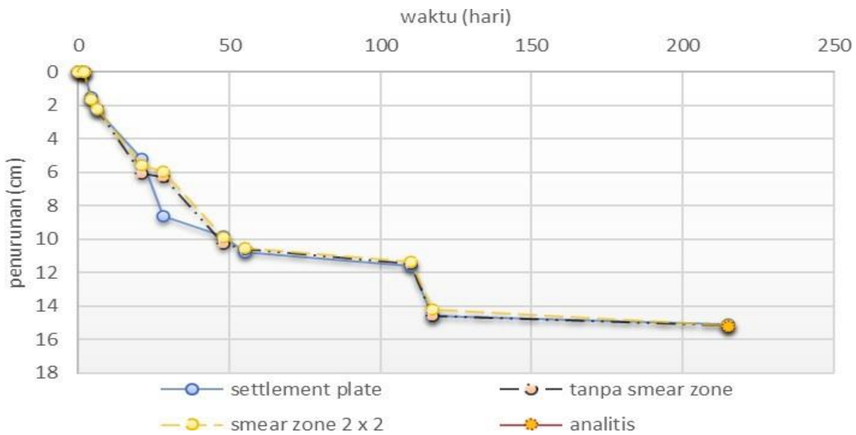

Figure 5
Comparison of settlement pattern and consolidation time for plate settlement, without smear zone, effect smear and with analytical results that are close to plate settlement

Conclusion

Calculating consolidation settlement using the Terzaghi 1-D analytical theory is relatively close to the decrease in actual results in the field, with a percentage difference of 15.252 cm. For numerical results using PLAXIS 3D modeling, the results are 15.15 cm without using any smear zone, with 2 times the dimensions of the mandrel, the results obtained are 15.131 cm, 15.133 cm and 15.134 cm, with 3 times the dimensions of the mandrel the results obtained are 15.142 cm, 15.141 cm and 15.14 cm. With 4 times the dimensions of the mandrel, the results are 15.144 cm, 15.143 cm and 15.143 cm, with a settlement plate value of 15.10 cm. There is a difference in settlement due to laboratory data not representing the entire soil layer in the field.

The effect of the smear zone on soil subsidence is different for each soil type. Where in this study, the value of 2 times the mandrel dimension and the permeability coefficient of the original soil as a result of 0.2% is closer to the results of field observations. This shows that the diameter of the smear zone is 2 times the dimension of the mandrel, where the original mandrel size is 5 x 12.5 to 10 x 25, and the soil permeability is 2 times less than the original soil permeability.

References

Apriyani, Ketut Devy, Ikhya, Ikhya, & Hamdhan, Indra Noer. (2016). Analisis

Konsolidasi Dengan Prefabricated Vertical Drain Untuk Beberapa Soil Model Menggunakan Metode Elemen Hingga. RekaRacana: Jurnal Teknil Sipil, 2(3), 17.

Aspara, Wimpie Agoeng Noegroho, & Fitriani, Eka Nur. (2016). Pengaruh Jarak Dan Pola Prefabricated Vertical Drain (Pvd) Pada Perbaikan Tanah Lempung Lunak= Effect Of Distance And Pattern Of Prefabricated Vertical Drain For Improvement Of Soft Clay Soil. Majalah Ilmiah Pengkajian Industri, 10(1), 41–50.

Bergado, Dennes T., Balasubramaniam, A. S., Fannin, R. Jonathan, & Holtz, Robert D. (2002). Prefabricated vertical drains (PVDs) in soft Bangkok clay: a case study of the new Bangkok International Airport project. Canadian Geotechnical Journal, 39(2), 304–315.

Chai, Jin Chun, Shen, Shui Long, Miura, Norihiko, & Bergado, Dennes T. (2001). A simple method of modeling PVD-improved subsoil. Journal of Geotechnical and Geoenvironmental Engineering, 127(11), 965–972.

Hayati, Titi. (2019). Analisis Pengaruh Smear Zone pada Penurunan dan Waktu Konsolidasi Proyek Reklamasi Belawan Fase II dengan Plaxis 2D dan 3D.

Holtz, R. D., Jamiolkowski, M. B., Lancellotta, R. dan Pedroni, R. (1991). Prefabricated Vertical Drain Design and Performance. Oxford, UK.

Iskandar, R. (2018). Teknik Perbaikan Tanah dengan Menggunakan PVD dan Preloading. USU Press. Medan.

Meiwa, S., Ikhya. Dan Hamdan, I. .. (2015). "Analisis Konsolidasi dengan PVD untuk Kondisi Axisymmetric dan Beberapa Metode Ekuivalensi Plane Strane Menggunakan Metode Elemen Hingga." Jurnal Institut Teknologi Nasional.

Surbakti, RUDIANTO. (2020). Analisis pengaruh SAND REPLACEMENT sebagai COUNTER WEIGHT pada proses konsolidasi di Reklamasi Belawan.