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Effect of eucalyptus pellita timber-pvd hybrid pile as a vertical drain on soft soil.

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Abstract The innovative technique of a hybrid PVD timber pile as a vertical drain can be implemented to reinforce and improve soft soil. In this case, the acceleration of pore water dissipation could increase shear strength. The at soil of this study is to investigate the effectiveness of a hybrid eucalyptus pellita-PVD timber pile as a vertical drain. The test method applied is a laboratory model test, consisting of the installation of a hybrid pile on soft soil in a rectangular pattern with a spacing of 10 cm. Then by a static loading test was subjected on soft soil with an initial load of 10 kg and subsequent loads of 20 kg and 40 kg. Daily dial monitoring of the increase in pore water dissipation was performed during the preloading test. The results show that the hybrid pile could accelerate the process of pore water dissipation to the surface compared to using timber piles alone. The increase of soil density before and after the loading indicated that the hybrid piles enhanced the density by 3.9%, whereas the reinforcement using only timber pile just increased by 2.4%.

Keywords: hybrid pile, eucalyptus pellita, vertical drain.

1. Introduction

As well as the expansion of the construction sector, the need for developing land will continue to rise. However, some regions are unable to avoid conditions in which building sector development must be conducted on soft soil. Soft soil has a poor bearing capacity, a high soil plasticity index, low permeability, and a prolonged subsidence process. These qualities pose the most significant challenges for designers who wish to construct a building atop it.
Construction on soft soil requires many solutions to the problems of limited bearing capacity and extended consolidation period. And this issue can be resolved by improving the carrying capacity of the soil through micropile installation. [1] [2] [3] [4] [5] [6] [7] and constructing one-way vertical drain might accelerate changes in soft soil water content and the process of land subsidence. [8] [9] As for the conductivity issue, PVD can be utilized to speed up the process of pore water dissipation caused by loading processes. [10] [11] [12].
In Indonesia, micro-piles are constructed with timber piles since indigenous materials are permitted in several regions, and the availability of these materials is relatively high, making this a viable option in areas where the soil conditions have a limited bearing capacity.
As a breakthrough in soil improvement and reinforcement engineering, hybrid Eucalyptus pellita-PVD timber piles are anticipated to raise the soil's bearing capacity and hasten the consolidation process. This study intends to assess the effect of constructing a rectangle pattern of Hybrid piles of eucalyptus pellita-PVD timber piles as vertical drain on the soft soil's water release.

2. Materials and Testing Methods

2.1. Materials

Based on the result of laboratory tests, which included testing the physical and mechanical properties of soft soil samples, test data on the characteristics of the eucalyptus pellita timber material, and test data on the characteristics of the Prefabricated Vertical Drain (PVD) material, the initial research data were gathered. This information is necessary to establish whether the type of material used corresponds to the required design and description for the intended model test. This study utilized a soft soil sample from the Turikale, Maros Regency sub-district. The eucalyptus pellita timber originates from the Muting District of the Merauke Regency in South Papua Province. As indicated in Figure 1, the little timber pile has a length of 33 centimeters and a width of 1 centimeter. As shown in Figure 2, the Prefabricated Vertical Drain (PVD) length is 33 cm, and the width is 1 cm. Based on the shape of the two materials, two reinforcement models are created, the first of which consists of three connected timber piles. The second type uses wire, composed of three piles and one PVD in the center, as depicted in Figure 3.

Figure 1. Mikro pile eucalyptus pellita

Figure 2. Prefabricated Vertical Drain (PVD),

Figure 3. Timber Pile and Timber pile+PVD (hybrid pile)

2.2. Testing Methods
The applied research design refers to the collected primary and secondary data. This study includes two test models: a one-way vertical drain test using a timber cone + PVD (Hybrid pile) and reinforcement using timber piles without PVD, installing a 10-cm-wide rectangular pattern. This layer will serve as a control point for the process of releasing water to the surface by evaluating the water content daily during the testing procedure, as depicted in Figures 4, 5, and 6. Subsequently, the preloading test was conducted with a progressive load, starting with 10 kg, followed by 20 kg, and finally 40 kilograms. By measuring the moisture content of the sand every day for 27 days, the process of water rising to the surface was observed and quantified. Figures 7 and 8 show that the test implementation model is shaped and sized according to the test dimensions.

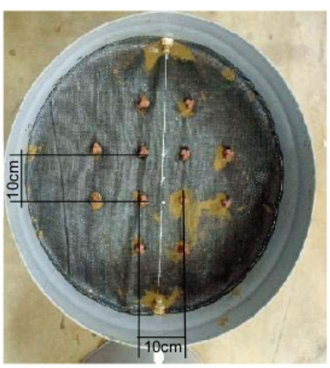

Figure 4. Installation position timber pile

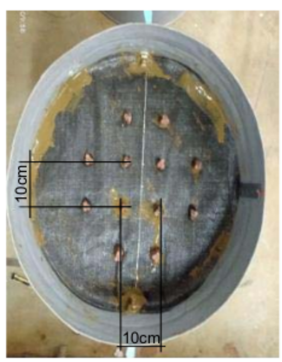

Figure 5. Installation position Hybrid pile

Figure 6. Water content sampling

Figure 7. Test equipment installation position

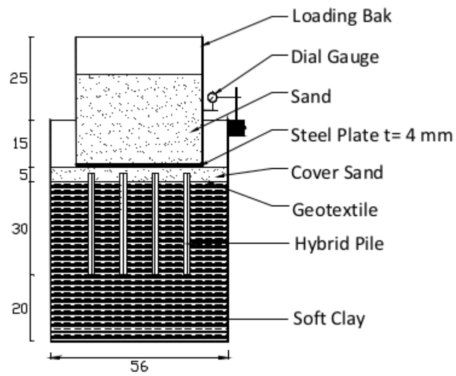

Figure 8. Model and size test dimensions

3. Result and Discussion

Based on the results of testing the soil characteristics, the type of soil utilized for model testing according to the USCS classification was high plasticity clay (CH), whereas the classification according to AASHTO was group A-7-6. The summary of the soil characteristics test may be found in Table 1.

Table 1*. Soil characteristics test results.*

No.	Kinds of Test	Unit	Test Result
Characteristic of Physical Properties			
1	Specific Gravity (Gs)	-	2,74
2	Water Content (w)	(%)	72.91
3	Atterberg Limit		
	shrinkage limit (S.L.)	(%)	13.88
	Plastic Limit (P.L.)	(%)	26.77
	Liquid Limit (L.L.)	(%)	82.75
	Plasticity Index (PI)	(%)	55.98
4	Grain size analysis		
	Gravel	(%)	0.00
	Sand	(%)	7.20
	Silt	(%)	25.50
	Clay	(%)	67.30
5	Permeability	(cm/s)	2.3×10^{-7}
Classification			
USCS			CH
AASHTO			A-7-6

Based on the outcomes of laboratory tests on Eucalyptus Pellita timber used as timber piles, this species is classified as a timber class I [13]. Based on the results of investigating the qualities of the timber material used

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for piles, the data presented in Table 2 were acquired. The characteristics of the Prefabricated Vertical Drain (PVD) material used in this investigation are of the CeTeau Drain CTD-812 type. This PVD has a permeability value of > 1 x 10-4 m/s, which is fairly high.

Table 2. *Eucalyptus Pellita test results*

No.	Kinds of Test	Unit	Test Result
1	Specific Gravity (Gs)	-	0,91
2	Water Content (w)	(%)	8.83
3	Flexural strength	Mpa	110.50
4	Compressive strength parallel to fiber	Mpa	60.15

Observations and testing of water content during the research period revealed that the use of a timber cone + PVD as a vertical drain on soft clay soils could accelerate the process of releasing surface water. At the initial time of loading, the increase in water content surface- cover sand and the graph repeats this pattern at the initial time of adding the second and third loads. Figure 9 depicts the graph of the relationship between the load and water content surface- cover sand.

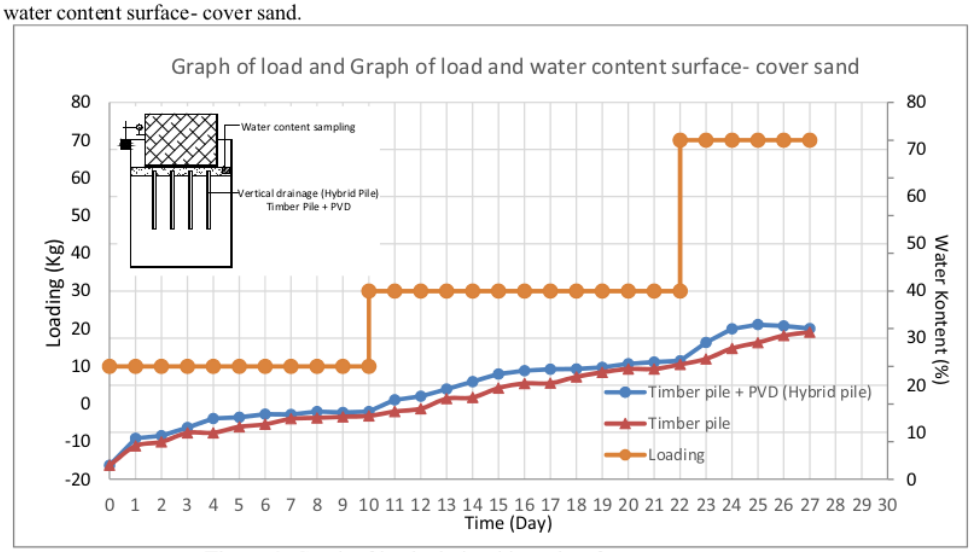

Figure 9. Graph of load relationship and surface water content.

Table 3. *The results of the water content and bulk density of the soil testing*

Test Model	Before loading			After Loading		
	γ_{wet} (gr/cm^3)	γ_{dry} (gr/cm^3)	W (%)	γ_{wet} (gr/cm^3)	γ_{dry} (gr/cm^3)	w (%)
Timber pile	1.49	0.82	82.69	1.51	0.84	81.07
Timber pile + PVD (hybrid pile)	1.49	0.82	82.20	1.53	0.85	79.93

Table 3 presents the results of a comparison between the soft soil test values with timber pile reinforcement and the soft soil test values with hybrid pile (PVD) reinforcement as vertical drain. The results of this preloading test indicate that the density of the soft soil has increased. The indicator for this rise in density is the change in the original value of dry density before loading and reinforcing system installation. The initial dry density value before loading was 0.82 kg/cm3 with a moisture content of 82%. However, following the application of timber pile reinforcement, the value increased to 0.84 kg/cm3 with a moisture content of 81.07%. Using a hybrid pile as vertical drain increased the soil's dry density to 0.85 kg/cm3 while decreasing the soil's water content to 79.93%.

This demonstrates that using timber piles and PVD (hybrid pile) can speed the soil compaction process. This situation emerges due to the PVD's function as a vertical drain system. Figure 10 depicts a comparison of the results of soil density tests. Figure 11 shows the variations in the moisture content of soft soil before and after loading. The results indicate that using Hybrid piles of Eucalyptus Pellita – PVD as vertical drain can enhance soil density by 3.9%, whereas the reinforcement that simply employs timber piles increases soil density by 2.4%.

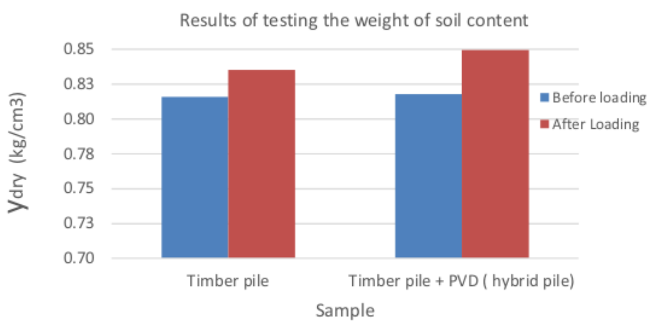

Figure 10. Dry density value before and after loading test

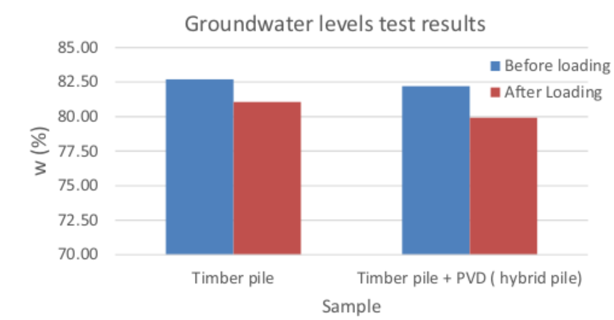

Figure 11. Comparing the results of water content tests

4. Conclusion

The conclusions that can be drawn from this research are:

1. Installation of vertical drain Hybrid piles of Eucalyptus Pellita – PVD timber piles are able to accelerate the process of removing water from the soil when compared to reinforcement that only uses timber cones.
2. The use of Hybrid pile piles of Eucalyptus Pellita – PVD as vertical drain was able to increase soil density by 3.9%, while the reinforcement that only used timber cones was 2.4%.

5. Suggestion

It is necessary to conduct further testing with different installation patterns and depth variations to obtain an effective design and depth used for the installation of hybrid piles as vertical drain.

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Acknowledgements

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