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The Effect of Using Wooden Pile and Cast Concrete Reinforcement on Soft Soil Settlement in Graha Lentera Holtekamp Housing, Jayapura, Papua

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ABSTRACT

Low shear strength in soil can lead to issues such as low bearing capacity, excessive settlement, and soil compressibility, affecting the stability of structures. To mitigate these challenges, soil improvement and reinforcement techniques are applied to enhance soil stability and meet construction requirements. This study investigates the effects of reinforcement techniques on bearing capacity and settlement using wooden piles and cast-concrete piles. The experiment tested unreinforced soil, which exhibited a bearing capacity of 950.00 kPa with a *qijin* of 380.00 kN and a settlement of 1.861 mm (4.0%). Soil reinforcement using wooden piles (CK 8 I) improved the bearing capacity, resulting in a maximum load of 25.10 kN and a settlement of 5.90 mm (11.80%). Reinforced cast-concrete piles showed a maximum load of 23.50 kN and a settlement of 4.50 mm (9.00%). The findings indicate that reinforced soil demonstrates superior load-bearing behavior, with significant improvements in stability and reduced settlement compared to unreinforced soil. This research underscores the effectiveness of reinforcement techniques, such as wooden piles and cast-concrete piles, in improving soil stability for construction projects.

Keywords: *Lowering, soil improvement, wood piles, cast concrete*

INTRODUCTION

Jayapura is one of the cities at the eastern tip of Indonesia and is the capital of Papua Province, which is beginning to develop in line with the progress of this era. One aspect of this development is the opening of several areas for residential purposes through the construction of buildings, shops, and the creation of new access routes such as roads and bridges. With the inauguration of the *Youtefa* Red Bridge by President Joko Widodo on October 10, 2019, which connects *Hamadi* and the *Youtefa* Bay Area, regions that were once isolated have become accessible. People who previously lived in urban areas and their surroundings are now interested in finding new locations in the suburbs to settle (Haryanto & Rachman, 2020; Kusuma & Junaidi, 2018; H. Santoso & Wijaya, 2021; M. Wijaya & Hadi, 2020). Some developers are taking advantage of this opportunity by clearing land and constructing various buildings, such as housing and other facilities. For example, one private company has begun to establish several residential complexes, which will later serve as the location and site for the author's research (I. Wijaya & Santoso, 2019).

The main challenges faced, especially in *Holtekamp* and its surroundings, relate to the type of soil, which is generally less stable and consists of soft soil that requires improvement using various reinforcement methods (Nurimah & Martini, 2021; D. E. Wibowo et al., 2021;

Widianti, 2012). The bearing capacity of the soil is greatly influenced by the shear strength of each soil type. Low shear strength results in low bearing capacity and significant settlement, or even excessive settlement, while the compressibility of the soil affects shrinkage due to groundwater levels, ultimately impacting the stability of buildings constructed on it. The elasticity of the existing soil influences its density under load, which in turn significantly affects the stability of structures on the land, both in the short and long term (E. Santoso & Nugroho, 2021; Sholihah & Wijayanto, 2020; Sugiarto & Subroto, 2021; M. Wibowo & Wijayanto, 2020; Yuliana & Adi, 2022).

Previous studies have explored the impact of soil instability and reinforcement techniques on construction, particularly in areas with soft soil (Amsyar & Rosyidi, 2021; Azis & Nurhadi, 2020; Fauzi & Muladi, 2019; Lestari & Susilo, 2022; Rahman & Yanto, 2020). One study by Wijaya et al. (2019) analyzed the effects of soil improvement on bearing capacity and settlement in Jakarta, focusing on the use of soil stabilization methods such as chemical treatments and deep soil mixing. Their results showed significant improvement in bearing capacity but lacked a comprehensive comparison between various reinforcement techniques, such as wooden and cast-concrete piles. Another study by Haryanto et al. (2020) investigated the impact of pile foundations on the settlement and stability of buildings in areas with weak soil in Surabaya. While their study demonstrated the effectiveness of piles in increasing bearing capacity, it did not delve into the type of piles that may provide the best results in terms of cost-effectiveness and long-term performance.

This research aims to investigate the effectiveness of wooden piles and cast-concrete piles in improving the bearing capacity and reducing settlement of soft soil in Jayapura's *Holtekamp* area. By comparing these two techniques, the study seeks to provide practical recommendations for developers working in areas with weak soil conditions. The benefits of this research include enhancing the understanding of soil improvement methods in Papua and contributing to more stable and sustainable construction practices. Additionally, it offers developers cost-effective and efficient solutions for building on unstable soil, thus ensuring the long-term stability of structures in the region.

METHOD

The methodology of this study began with the formulation of the research problem, identifying the issue to be solved. Next, both primary and secondary data were collected. The primary data included soil property data, which involved collecting detailed information about the soil's physical properties and modeling the strength of the soil based on these properties. The secondary data involved reviewing existing literature and gathering field testing data relevant to the research topic.

Following data collection, load and settlement testing was performed on the soil. This included testing soil without reinforcement, soil reinforced with cement, and soil reinforced with concrete piles to assess their load-bearing and settlement characteristics. The data were then analyzed to examine the relationship between the load and settlement of the soil with and without reinforcement, as well as to determine the maximum load that could be applied to both reinforced and non-reinforced soils.

The results from these tests were analyzed, and a comparison was made to draw conclusions about the effectiveness of the soil reinforcement techniques. Finally, the study concluded with a discussion of the findings and provided recommendations for future improvements or implementations in the field of soil reinforcement and construction practices.

RESULTS AND DISCUSSION

Sondir Test Results

With Sondir testing, it can be classified the type of soil that can be seen from the qc and fr values. Namely at a depth of 0 – 2.20 m including firm soil types, depths of 2.40 – 7.00 m very soft soil types, depths of 7.20 – 16.40 firm soil types, depths of 16.60 – 21.80 m rigid soil types, depths of 22.00 – 27.00 m very rigid soil types and at a depth of 27.20 – 28.00 m hard soil types. When viewed from the qc and fr values, it is concluded that the type of soil in the residential area of Graha Lentera Holtekamp is a type of sandy clay soil and silt.

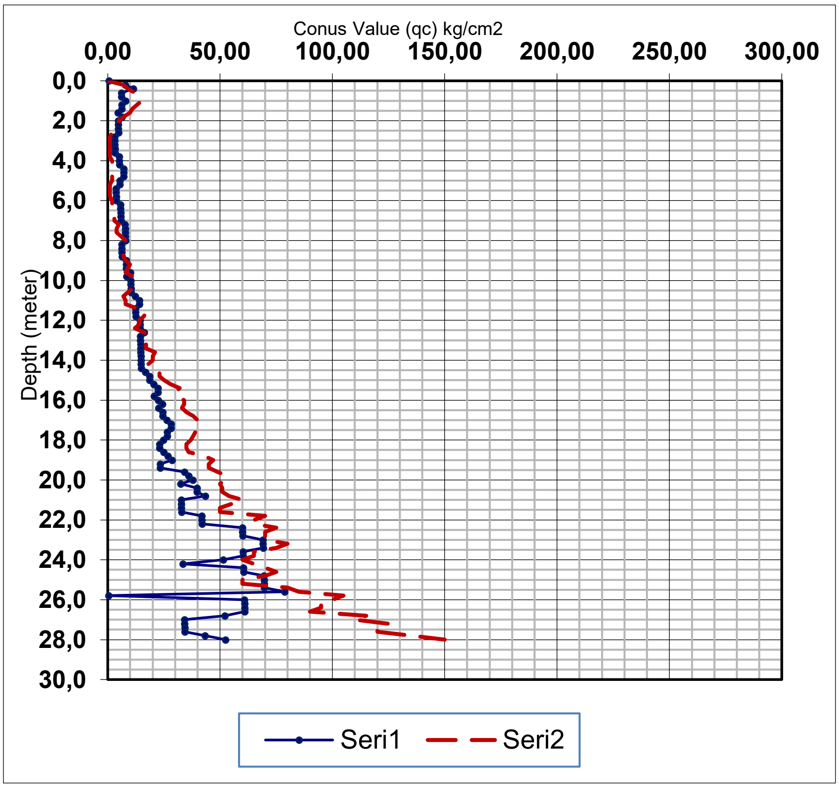

Figure 1. SPT Test Results Chart

Hand Drill Testing Results

Hand Drill Testing is carried out at 1 point with a depth of 0.00-2.50 m. From the results of the hand drill, different types of soil were obtained, namely at a depth of 0.00 – 1.50 m of clay soil, light brown color, medium to high plasticity, and at a depth of 2.00 – 2.50 m of clay clay soil, light blue, with high plasticity. SPT testing is carried out to obtain an N SPT value and is used to measure soil density and can provide information about soil type, strength and bearing capacity. Based on the depth, it can be seen on the tax return chart as in the borlog.

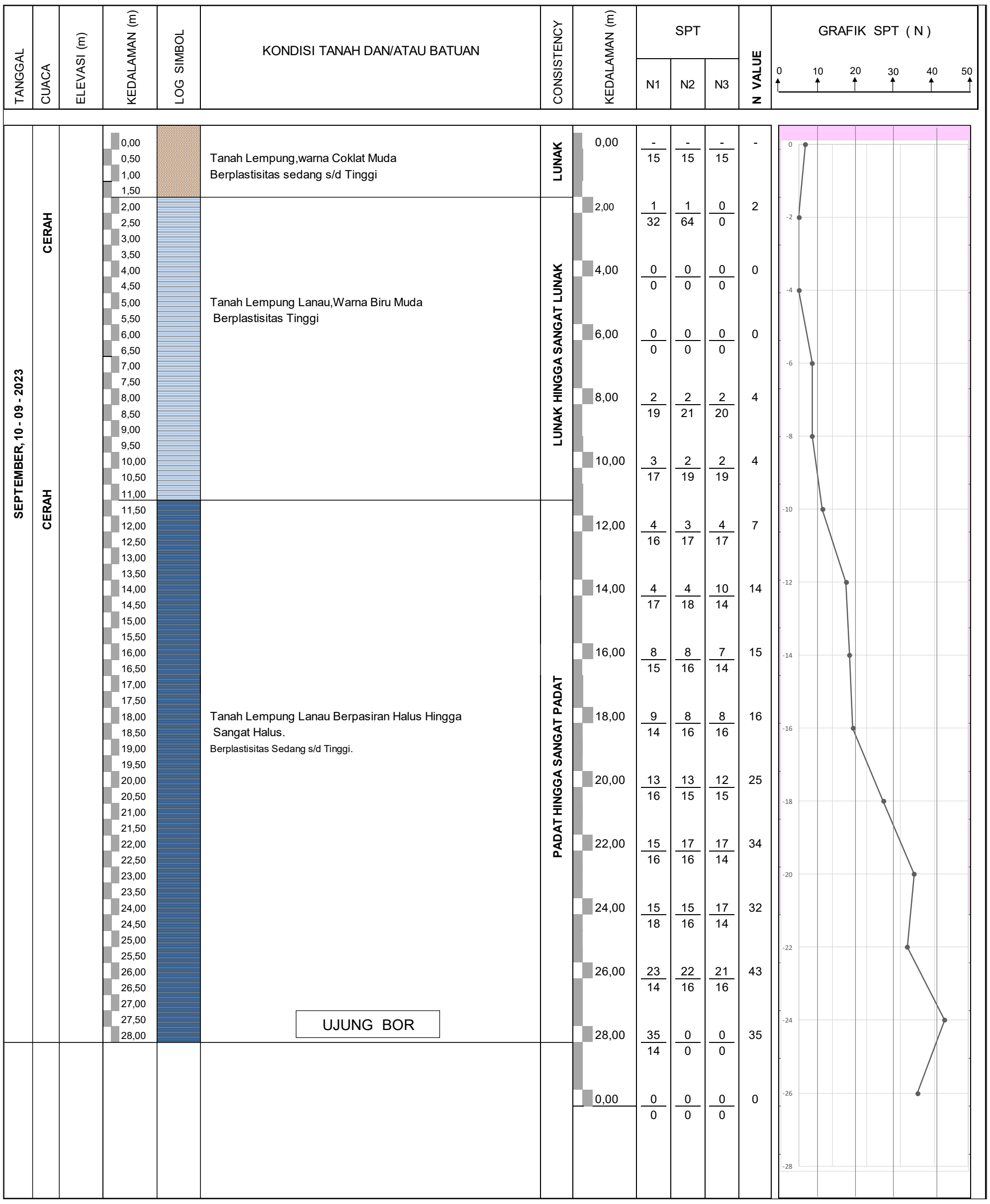

Figure 2. Tax Return (Standard Penetration Test) test results

Recapitulation of Test Results

The results of the tests of Moisture Content, Specific Gravity, Liquid Limit, Plastic Limit, Plastic Index, Cohesion, Deep Friction Angle, and Optimum Moisture Content can be seen in the following table.

Table 1. Recapitulation of Test Results

No.	Parameter	Value	Unit
1	Moisture Content	52.076	%
2	Specific Gravity	2.544	-
3	Liquid Limit (LL)	76.55	%
4	Plastic Limit (PL)	18.57	%
5	Plasticity Index (PI)	57.98	%
6	Cohesion	2.3	kg/cm²

7	Internal Friction Angle (ϕ)	3	(°)
8	Dry Density	1.72	kg/cm³
9	Optimum Moisture Content	20.50	%

Reading Results of the Relationship Between Load and Decrease

From the results of modeling tests on unreinforced (TL) soils, the readings on the dial gauge of the decrease that occurred by making 3 experiments, can be seen in the following table.

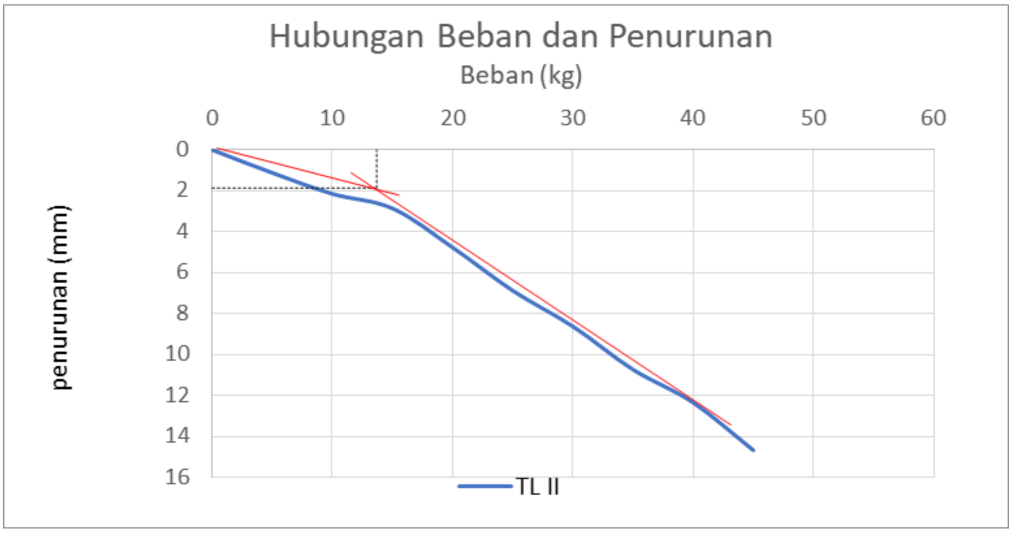

Figure 3 Graph of Unreinforced Modeling (TLII) results

Modeling results with reinforcement of wood piles

Here the modeling is carried out using reinforcement of wooden piles 2 cm in diameter with a depth of 8 cm and 16 cm, and the results can be seen in the following figure.

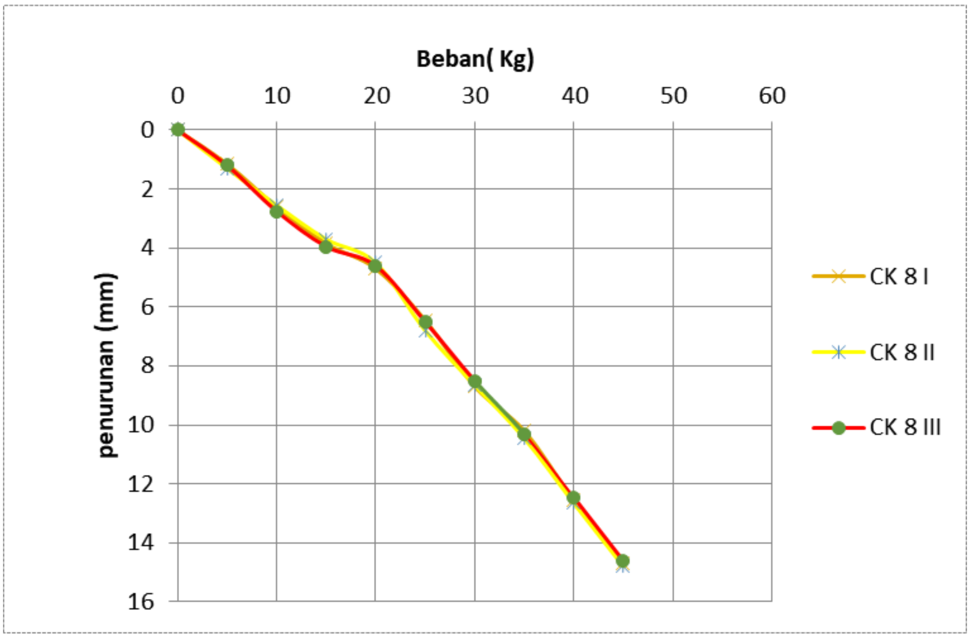

Figure 4. Graph of the reinforcement of wooden piles at a depth of 8 cm

Table 2. Results of reinforcement of wooden recesses at a depth of 8 cm

Model	Type	qijin **(kN)**	BCR **(Bearing Capacity Ratio)**
Original Soil	1	380.00	0%
Wooden stake	8 I	697.22	83%
Wooden stake	8 II	669.44	76%
Wooden stake	8 III	638.89	68%

Modeling results with cast concrete reinforcement

Here the modeling is carried out using reinforcement of cast concrete with a diameter of 2 cm with a depth of 8 cm and 16 cm, and the results can also be seen in the following table.

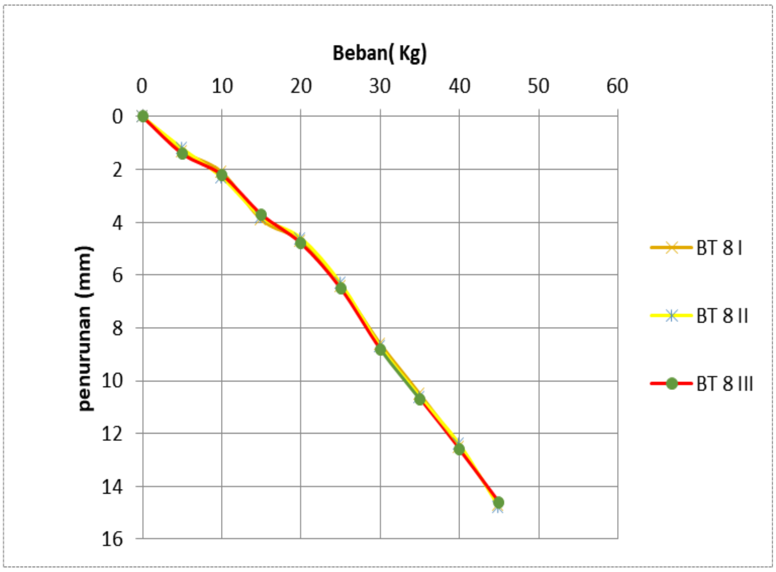

Figure 5. Results of reinforcement of cast concrete at a depth of 8 cm

Table 3. Modeling results with reinforcement of cast concrete at a depth of 8 cm

Model	Type	qijin **(kN)**	BCR **(Bearing Capacity Ratio)**
Original Soil	1	380.00	0%
Cast Concrete	8 I	652.78	72%
Cast Concrete	8 II	633.33	67%
Cast Concrete	8 III	638.89	68%

Table 3 presents the modeling results of soil bearing capacity reinforced with cast concrete at a depth of 8 cm. The original soil without any reinforcement has a bearing capacity (qijin) of 380.00 kN, which serves as the baseline with a Bearing Capacity Ratio (BCR) of 0%. When reinforced with cast concrete, significant improvements in bearing capacity are observed. The highest increase is seen in Type 8 I, reaching 652.78 kN with a BCR of 72%. Types 8 II and 8 III also show enhanced performance, with bearing capacities of 633.33 kN and 638.89 kN, respectively. These results indicate that cast concrete reinforcement can effectively improve soil bearing capacity, with Type 8 I offering the most optimal outcome among the tested configurations.

CONCLUSION

This study demonstrated that soil reinforcement techniques, specifically using wooden piles and cast concrete piles, significantly improved the bearing capacity and reduced settlement of soft soils compared to unreinforced soil. The unreinforced soil had a bearing capacity of 950.00 kPa with a *qijin* of 380.00 kN and a settlement of 1.861 mm (4.0%), while soil reinforced with wooden piles (CK 8 I) achieved a maximum load of 697.22 kN and a settlement of 5.90 mm (11.80%), and soil reinforced with cast concrete piles (BT 8 I) reached a maximum load of 652.78 kN with a settlement of 4.50 mm (9.00%). These results confirm that both reinforcement methods are effective in enhancing soil stability and load-bearing capacity. For future research, it is suggested to investigate the long-term performance of these techniques under varying environmental conditions, such as groundwater fluctuations and soil changes, as well as to compare the effectiveness of other reinforcement materials and methods to further optimize soil stabilization for diverse construction needs.

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