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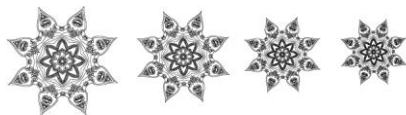
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Field Study on Undrained Shear Strength of Soft Soil around Micropiles

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ABSTRACT

Micropile (Cerucuk) is widely used to increase the bearing capacity of soft soil in South Kalimantan. Some researchers have reported that the use of micropile can increase the bearing capacity of soft soil. However, most studies were conducted in the laboratory. This paper discusses the influence of micropile on undrained shear strength in the soft soil around the piles. The study was performed in the field.

In this study, cerucuk used was Galam (*Melaleuca Leucadendron*) that have a nature-lined leather-wrapped stick, hard and dense. Galam has a diameter (D) of 0.10 m and a length of two meters. The piles were penetrated with different spacing (i.e., 2D, 3D, and 4D). Shear strength was measured directly in the field using the field vane shear. Considering time effect, measurements were made before installation, and 1, 7, 14, and 28 days after installation. The results show that the closer pile, the greater the soil shear strength. The piles affect the soil shear strength at a distance up to 0.20 m. Soil shear strength increases by time up to 14 days.

Keywords

Cerucuk, micropile, undrained shear strength, field vane shear test, pile distance, time effect.

1. INTRODUCTION

Micropile (cerucuk) is widely used in South Kalimantan to increase bearing capacity of soft soil. It can be proved theoretically as in [1] using NAVFAC DM-7 [2] based on the assumption of piles loaded laterally. However, based on laboratory model, Reference [3] reported that bearing capacity resulted in an experiment was higher than that of theoretical calculation. Reference [3] also stated that the use of micropile increases the shear strength of soft soil. However, the conclusion was based on laboratory model.

References [4] and [5] reported experiments on piles in the field. According to [4], the use of micropile resulted in increasing the bearing capacity of soft soil. It increases with increasing time. At the age of 4 days, bearing capacity increased by approximately 45%. The increase has reached 97% after the age of 15 days. According to [5], the distance of pile influenced the bearing capacity of a pile in the field. For the same length of pile, the shorter the distance, the greater bearing capacity of group piles. The study did not address changes in the shear strength of the soil around the pile. In fact, this information is important for the engineers in the calculation.

Reference [6] reported an effect of pile installation on the shear strength parameter of soil. The test was conducted in a triaxial apparatus. It was found that the cohesion and internal friction angle change due to the installation of the pile. It results in increasing soil strength and reducing settlement. The result was also concluded based on a laboratory test. A field test to support the theoretical and experimental results is required. This paper discusses the changes in the shear strength of soil around the pile. Distance and time of pile installation were considered in this study.

2. MATERIAL USED AND EXPERIMENTAL TECHNIQUES

2.1 Material Used

Micropile utilized in this study was the type of wood called Galam (*Melaleuca Leucadendron*). This kind of timber is often used as a foundation or soil reinforcement in Kalimantan especially in South Kalimantan. The unique property of this material is its strength maintained if submerged in water continuously. The pile used has a diameter of 10 cm and length of 200 cm.

2.2 Soil Properties

A laboratory test was performed to the soil. The soil properties of soft soil are summarized in Table 1. According to Table 1, the soil has very high water content, fine content, and compression index, and slight coarse grain, shear strength, and coefficient of consolidation. Table 1 also shows that the soil properties from the depth of 0.5 to 3.0 m are similar.

Table 1: Summary of soil properties

Soil properties		Depth (m)	
		0.5-1.0	2.5-3.0
Specific gravity		2.6	2.6
Water content	%	96.8	101
Volumetric weight	Mg/m ³	1.53	1.52
Grain size distribution			
Gravel	%	1.0	1.6
Coarse sand (0.6-2.0 mm)	%	0.7	1.7
Medium sand (0.2-0.6 mm)	%	0.8	1.4
Fine sand (0.05-0.2 mm)	%	4.5	3.9
Silt	%	41.7	22.7
Clay	%	51.3	68.7
Liquid limit	%	55	54
Plastic limit	%	43	46
Plasticity Index	%	12	8
Unconfined compression test			
q _u	kg/cm ²	0.07	0.16
q _f	kg/cm ²	0.03	0.7
s _t		2.13	2.34
Consolidation test			
c _c		0.82	0.55
c _s		0.09	0.14
c _v	cm ² /s	0.02	0.01

2.3 Techniques and Procedures

The undrained shear strength of soil was measured using field vane shear test (FVST) apparatus. This test is the most widely used method for measuring the undrained shear strength of soil and is particularly appropriate for assessing very soft and sensitive clays, in the case where a sample for laboratory testing cannot be obtained. The vane has a diameter of 4 cm and height of 8 cm. The test procedures are described in ASTM Standard D-2573 [7]. The dimension effect on the s_u is included in the calculation as defined in [7].

Piles were installed with the configuration as shown in Figure 1. “s” is the distance of pile. Three different distance were used (i.e., 2d, 3d, and 4d, or 20, 30, and 40 cm, respectively) where d is pile diameter. FVSTs were performed in between the piles and also outside the group piles as shown in Figure 1.

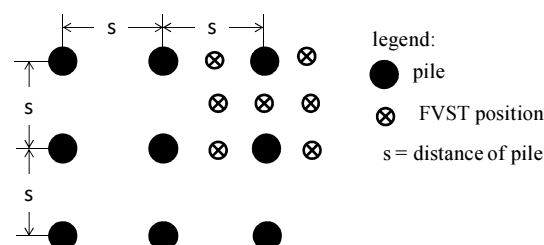


Figure 1: Configuration of pile installation and FVSTs positions

The distance of FVST is approximately 10 cm. For $s = 20$ cm, there was one FVST in between the piles. For $s = 30$ and 40 cm, there were 2 and 3, respectively (Figure 2). FVST were conducted after installation period of 1, 7, 14, and 28 days. To ensure that the soil is not disturbed, the test were performed to different group piles for various installation period. For the vertical distance, FVST was carried out each 20 cm to a depth of 200 cm as shown in Figure 2. Field procedures and calculation were performed based on ASTM standard [7].

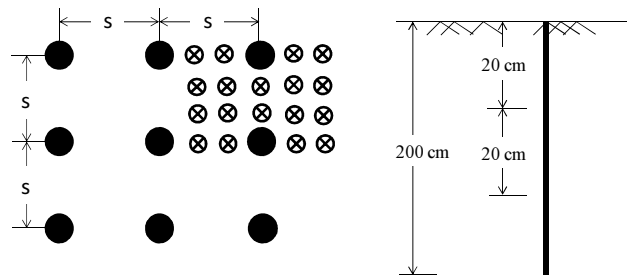


Figure 2: Configuration of pile installation, FVSTs positions, and vertical distance of FVST

3. RESULT AND DISCUSSION

Figure 3 shows representative undrained shear strength (s_u) in kPa obtained from FVST per 20 cm. Sketch of nine FVSTs positions is displayed on the right side of the figure. An independent measurement of FVST was performed before pile installation to obtain initial s_u . As shown in the figure, the initial s_u of the soil is approximately 1.8 to 2.0 kPa.

There are two primary positions discussed in this study, i.e., inside and outside group piles. Points placed in between the piles are 2, 4, 5, and 6, and the points outside are 1, 3, 7, and 8. Points 1 and 3 are placed about 10 cm from piles, whereas points 7 and 8 are placed about 20 cm from the piles. According to Figure 3, s_u at points 7 and 8 is similar to the initial s_u . The s_u at points 1 and 3 is higher than that of the initial value. It can be concluded that piles affect the soil at a distance of less than 20 cm. Similar result was obtained for $s = 30$ and 40 cm. Figure 3 also shows that s_u at points 2, 4, 5, and 6 increases due to pile installation. Pile affects the undrained shear strength of soil inside and outside the group.

Figure 4 shows a change of s_u due to the installation of piles after 14 days. As shown in the figure, that s_u of soil is affected by time. Except for s_u at the points of 7 and 8, the values are not changed. This result supports the earlier statement that piles affect the soil at a distance of less than 20 cm.

Figure 5 shows the effect of the distance and the time on the s_u of soil. The data in Figure 5(a) is the average of several measurements at the same position (i.e., in between two piles) and placed 10 cm from the pile (e.g., Points 2 and 4 as shown in Figure 3). As shown in Figure 5(a), s_u slightly increases with depth. At this position, the s_u of soil is similar to different distance of the piles. It seems that the installation affects surrounding soil. The distance does not give significant effect at least up to a distance of 4d (i.e., 40 cm) used in this study.

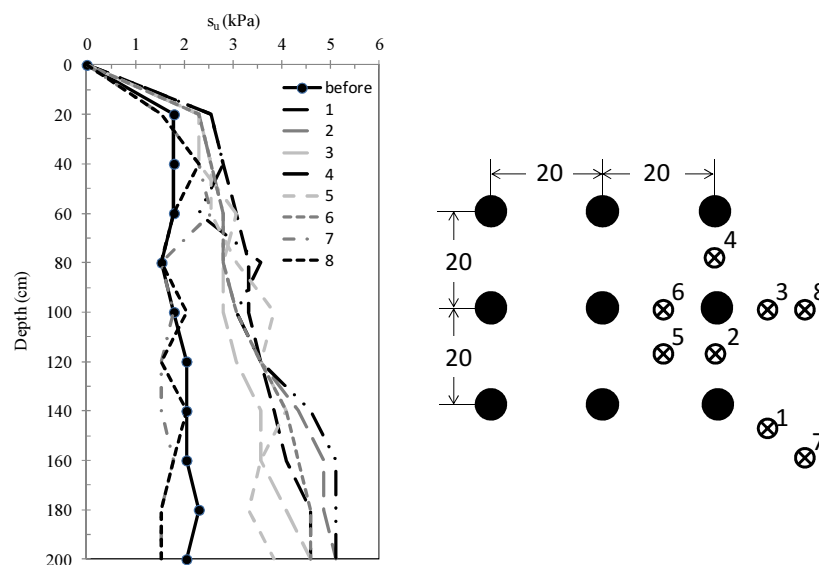


Figure 3: Undrained shear strength of soil by depth for $s=20\text{cm}$ after 7 days

Figure 5(b) shows s_u of soil at the same position as data in Figure 5(a) performed at a different time. After one day installation, s_u of soil is about 2 kPa. This value is almost the same as the initial s_u without pile. The s_u increases to 3 kPa and 4-5 kPa after 7 and 14 days installation, respectively. After 28 days, s_u is about 4-5 kPa. The results show that s_u of soil increases due to pile installation and time dependent. The addition of s_u is not significant after 14 days installation.

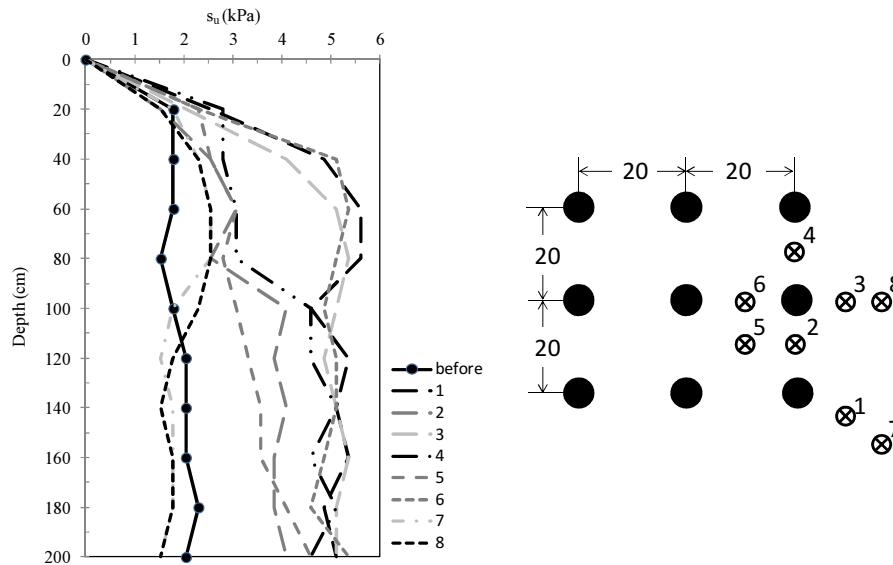


Figure 4: Undrained shear strength of soil by depth for $s=20\text{cm}$ after 14 days

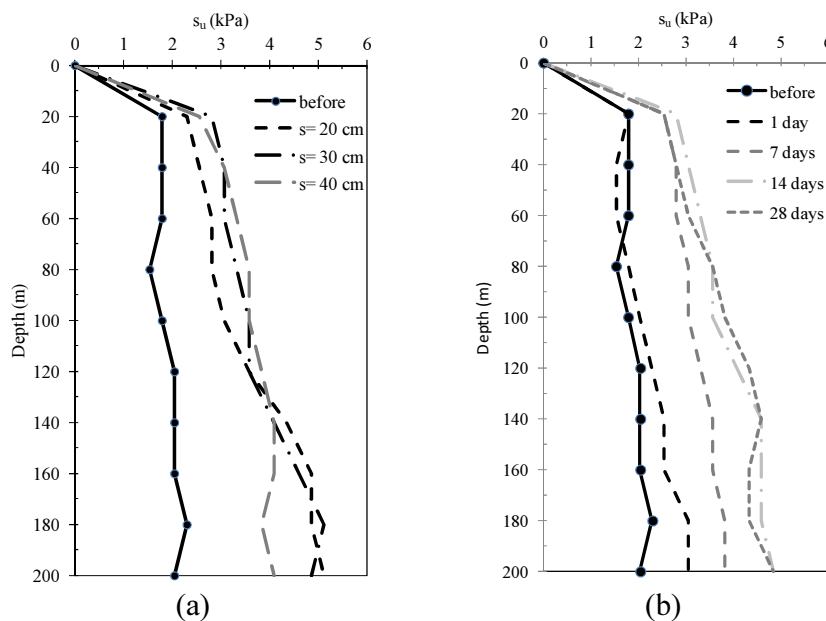


Figure 5: Undrained shear strength of soil (a) distance effect, and (b) time effect

Figure 6 shows s_u of soil as a function of time for the various distance of pile. Figures 6(a) and 6(b) show average data of s_u at the same depth (i.e., 200 cm) at points 1 and 3 and at points 2 and 4 as presented in Figure 3, respectively. Figure 6(a) shows clearly that s_u increases significantly up to 4.5-5 kPa or 250% (i.e., 2.5 times the initial s_u) up to 14 days. The similar phenomenon is shown in Figure 6(b). s_u increase significantly up to 5 kPa or 275% (i.e., 2.75 times the initial s_u) up to 14 days.

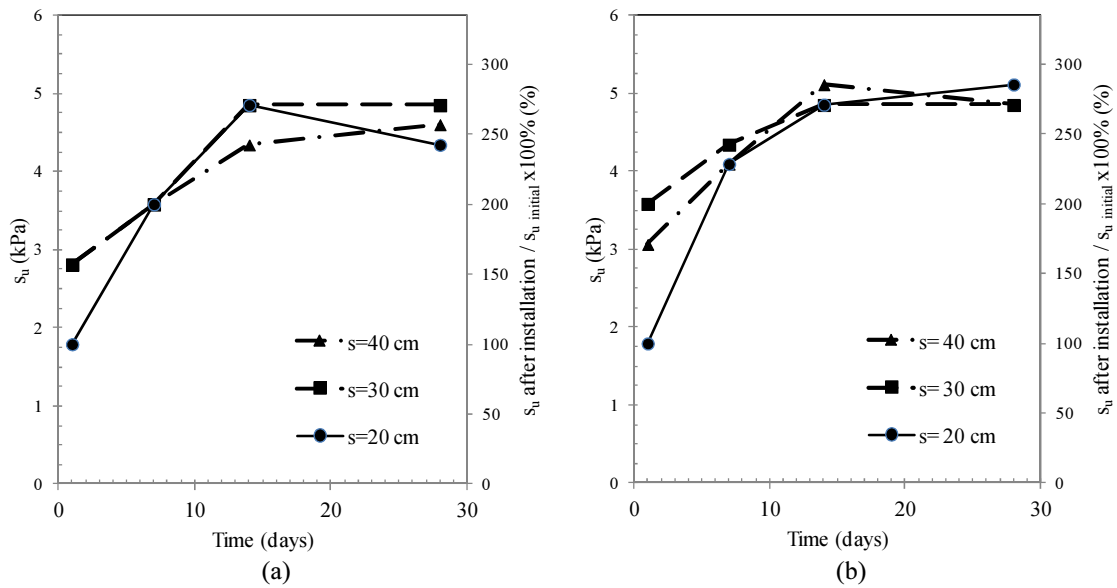


Figure 6: Undrained shear strength of soil (a) distance effect (b) time installation effect

Figures 7(a) and 7(b) shows the influences of position and pile distance on the s_u after 1 and 7 days pile installation, respectively. As shown in Figure 7(a), s_u of soil outside the group piles is less than those inside the group piles. The s_u of soil in between 2 piles (points 2, 4, and 6) is relative the same as s_u of soil in between four piles (points 5). The value is slightly influenced by the distance of piles. After 7 days, s_u increases and similar for all positions inside and outside of group piles. Similar results are obtained for 14 and 28 days after installation of piles.

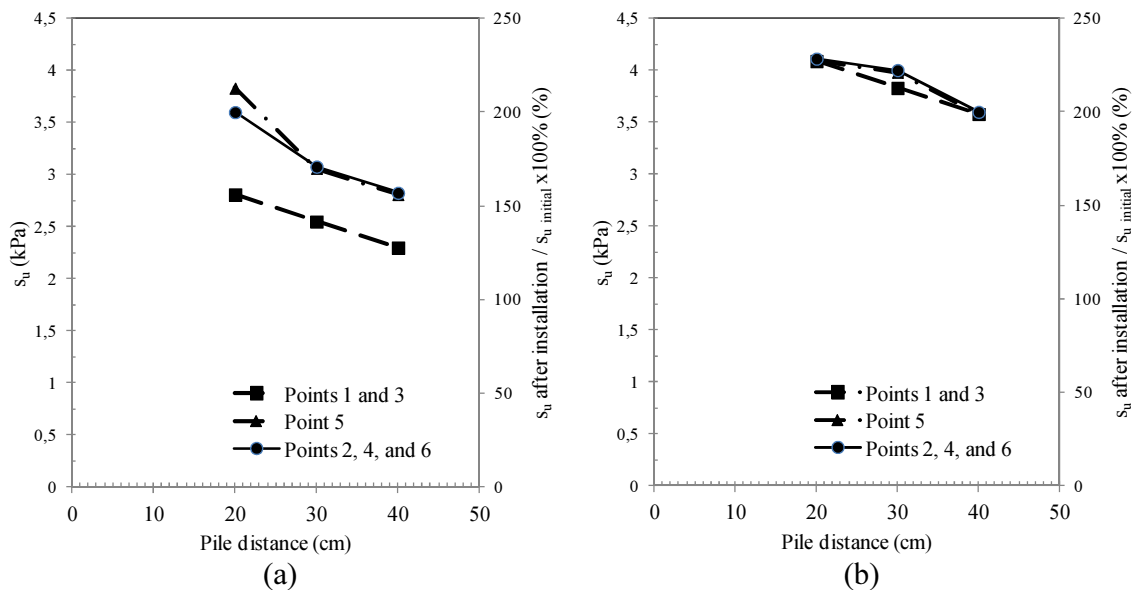


Figure 7: Effects of points position and pile distance (a) after 1 day, and (b) after 7 days installation

4. CONCLUSION

The results of a field test of micropiles effects on undrained shear strength of soil around the piles are presented. The distance and time effects are considered in this study. The results revealed that pile installation influenced the undrained shear strength of soil at a distance up to 20 cm outside the group. For soil inside the group piles, undrained shear strength increased from 2.5 to 2.75 times due to pile installation. The increase of shear strength was almost the same for different positions in the group. Pile distance influenced slightly on the values of shear strength. The closer the pile, the higher shear

strength of the soil. Time installation affected significantly on the undrained shear strength of soil around the pile. The shear strength increased significantly up to 14 days. There was no significant effect after 14 days installation.

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