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Experimental Study on Bearing Capacity of Micro Grid Galam Wood Pile on Soft Soil

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Abstract*— Construction on soft soil raises several issues. The low bearing capacity, high compressibility and the low permeability of the soft clay caused the problems both design and construction. While galam wood (Melaleuca leucadendra) have been used for many years as micro pile due to their durability and bearing capacity improvement, limited knowledge is available on performance of micro grid galam wood pile. The experimental study was conducted to analyze its bearing capacity and settlement of soft soil supported by micro grid galam wood pile. The study conducted on 2.00 x 3.00 x 2.00-meter concrete box container. Then the loading test on soft soil using two grid models such as square model and triangle model. The result shows that the use of grid modelled pile has significant role in increasing bearing capacity of soft soil. It increased approximately 500% of bearing capacity of soft soil. It is not significant bearing capacity improvement difference between square model and triangle model, however triangle model is better square grid model.

Keywords*— bearing capacity, settlement, micro grid pile, compressibility, loading test

I. INTRODUCTION

Construction on soft clay soil generally encountered some problems associated with bearing capacity, differential settlementl, lateral pressure, and the instability of structure. This happens due to weak bearing capacity of soft soil and has a high level of compressibility which resulted in settlement, either total settlement and differential settlement. It would also require long time consolidation [1]. To overcome soft soil problems, the use of local materials is more interesting and economical option. The use of cerucuk/micro wood pile on soft soil can increase bearing capacity of soft soil. Micro pile provides a considerable contribution to the soft soil, obtained about 2.2 times the bearing capacity of soft soil without fitted micropile [4]. Suroso [4] found that in the use of ceucuk, the larger the diameter of cerucuk, the more effective of bearing capacity. Similarly, the longer cerucuk provides increased bearing capacity effectively. The improvement is most effective from the long cerucuk length 18cm to 20cm in diameter 0,5cm with increased carrying capacity by 62.1%. According to research Wibowo AT [5], the use of cerucuk on silty sand increased in shear strength (ø ') and decreased in the value of cohesion (c'). The use of cerucuk will also increase the modulus of elasticity (E) of soft soil, an increase in the modulus of elasticity (E) is proportional to the large cross-sectional area cerucuk used. Some use of grid form floating pile has been applied to increase the carrying capacity of the soil. In this case may be used of friction pile, such as floating piles. The use of cerucuk aims to:

- *Increase the bearing capacity of soft soil.*
- *Reducing foundation settlement*
- *Avoiding the sliding, because micro wood pile can withstand shear forces greater than soil, besides cerucuk as reinforcement so that it will be able to withstand the movements,*

The experimental study from Marto A [2], the result showed that the diamond pattern of grid mat produced higher bearing capacity and a better settlement characteristic compared to that of the other patterns of grid mat models of the same sizes.

II. METHOD AND MATERIALS

Soil containing silt, clay and organic with a low level of plasticity. Soil sample has a small permeability value (1.77 x 10-4 cm /sec). Soil sample parameter as can be seen in table Tabel 1 below.

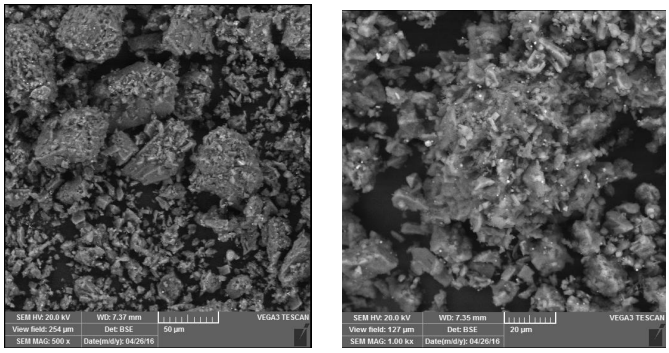

Fig.1 Scanning eletron microscope (sem) photo of soil sample with 20 µm and 50 µm

TABLE I
SOIL PARAMETER

PARAMETERS		VALUE
NATURAL MOISTURE CONTENT (Wn) (%)		49
UNIT WEIGHT OF SOIL (gr/cm^2)		1.40
WET DENSITY (gr/cm^2)		1.40
DRY DENSITY (gr/cm^2)		0.94
SPECIFIC GRAVITY (Gs)		2.69
ATTERBERG LIMIT (LL, PL, PI)	LL (%)	34.76
	PL (%)	28.36
	PI (%)	.41
POROSITY %		64
TRIAXIAL UU	C (Kg/cm^2)	0.275
	Ø °	20.09

Fig. 1 shows SEM (Scanning Electron Microscope) photo of soil sample. Soil sample particles' consists of fine and coarse grains. The test results SEM image is reinforced by the results of sieve analysis testing (grading) where there is a 48% particulate soil composed of sand and gravel, as well as 52% silt and clay.

Experimental setup consists of a soil container, soft soil and loading equipment. The vertical load was applied to the soft soil using loading equipment. The loading equipment is using hydraulic jack with maximum capacity 500 kN. A load cell and a linear variable displacement transducers (LVDT) were used for measuring load displacement. The load applied to the model of soft soil was measured by load cell and displacement was measured by LVDT. Laboratory load test conducted by using loading plate with 70 x 70 cm^2 placed in the middle of the surface layer of soft soil. The soft clay of the original condition is stirred before inserted into concrete container of 200 cm x 300 cm width, and 150 cm height (Fig.2). For homogeneity of soil to pre loading (preloading) for 7 x24 hours with a load evenly. The vertical load was applied to the model using loading equipment, at a constant rate of vertical displacement. The compression machine with maximum capacity of 500 kN was connected to a portable data logger. Loads were applied to loading plate through hydraulic jack.

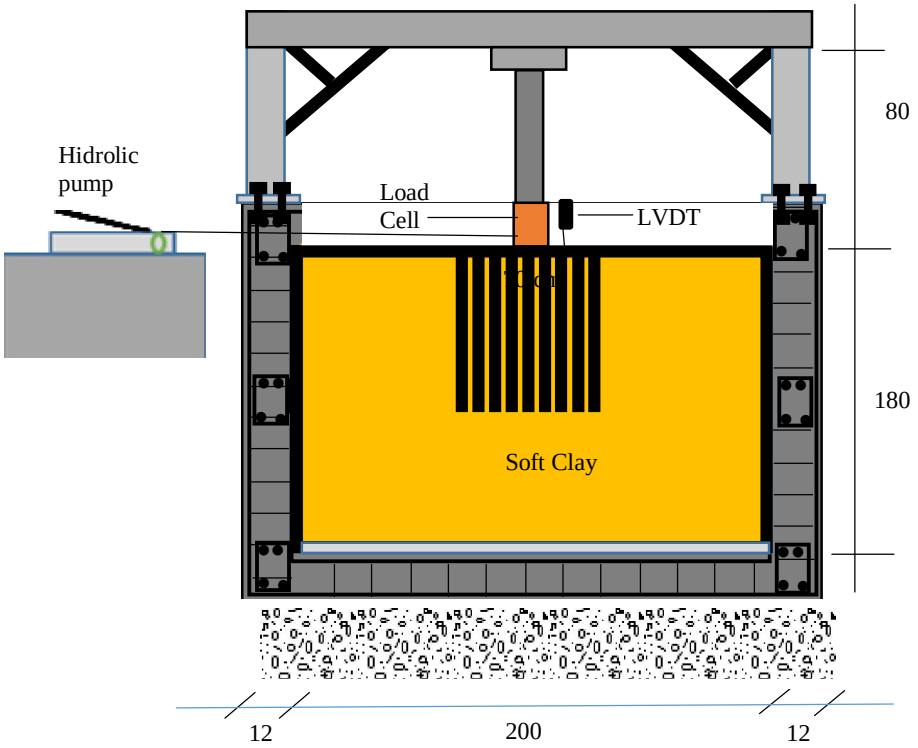

Fig. 2 Axial loading test model

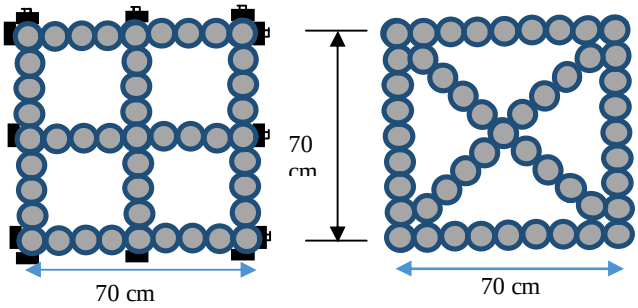

Fig. 3 Grid Pile Model

Fig. 4 Axial loading test of soil

III. RESULT AND DISCUSSION

In loading test of soft soil sample without grid pile model , the more increased loading, the settlement generated greater. When the load increased until 3:00 kN, its settlement reaches 10:00 mm. Then settlement is increasing dramatically to 19:00 mm when the load increased to 3.4 kN. At the time of loading of 2.47 kN, settlement reaches 6.00 mm at the center point of loading plate. While the surrounding area decreased gradually from 6.00 mm up to an increase of only + 2:00 mm at a distance of 80 cm from loading plate center of soft soil sample. At the time of load is 3.2 kN, the settlement reaches 20.00 mm in the central pressure point, and settlement slowly increase to 3.00 mm at a distance of 80 cm from the center point of loading plate.

In loading test of soft soil sample with grid pile model A, the more increased loading, the settlement generated greater altough it is not as greater as the settlement of without grid pile model. When the load increased until 7:00 kN, its settelement reaches 9.00 mm. Then it is increasing dramatically to 36.00 mm when the load increased to 16 kN.

At the time of loading of 8.0 kN, settlement reaches -10.56 mm at the center point of loading plate. Settlement decreased gradually from 6.00 mm up to an increase of only + 3.00 mm at a distance of 80 cm from loading plate center of soft soil sample. When load is 16.5 kN, the settlement reaches -34 mm in the central pressure point, and settlement slowly increased to 3.00 mm at a distance of 80 cm from the center point of loading plate.

To determine the effect of galam grid pile on soil, then as a control, loading test carried out on soil without pile. Loading test is intended to determine the soil bearing capacity. Failure load is the maximum load that is received by the soil, when settlement continues to increase without any added load. Figure 5 shows bearing capacity vs settlement of each model (without pile, with triangular grid pile and with rectangular grid pile). It shows that settlement increases with an increase in loading up to the maximum load bearing capacity. Bearing capacity of soil increased significantly when grid piles are applied. On loading test without pile, when the load increases until 3:00 kN / m2, the settlement of soil is 2.2 mm. Then settlement is increasing dramatically to 19 mm when the load reached maximum load of 6.7 kN/m^2. This means that soil has the ability to accept a maximum load of 6.7 kN / m2. From Figure 5 is also shown that the ultimate bearing capacity of soil is 6.6 kN/m2. According to consistency of soil classification, soil is classified as very soft soil. Soft soil has low bearing capacity and high level of compressibility [4].

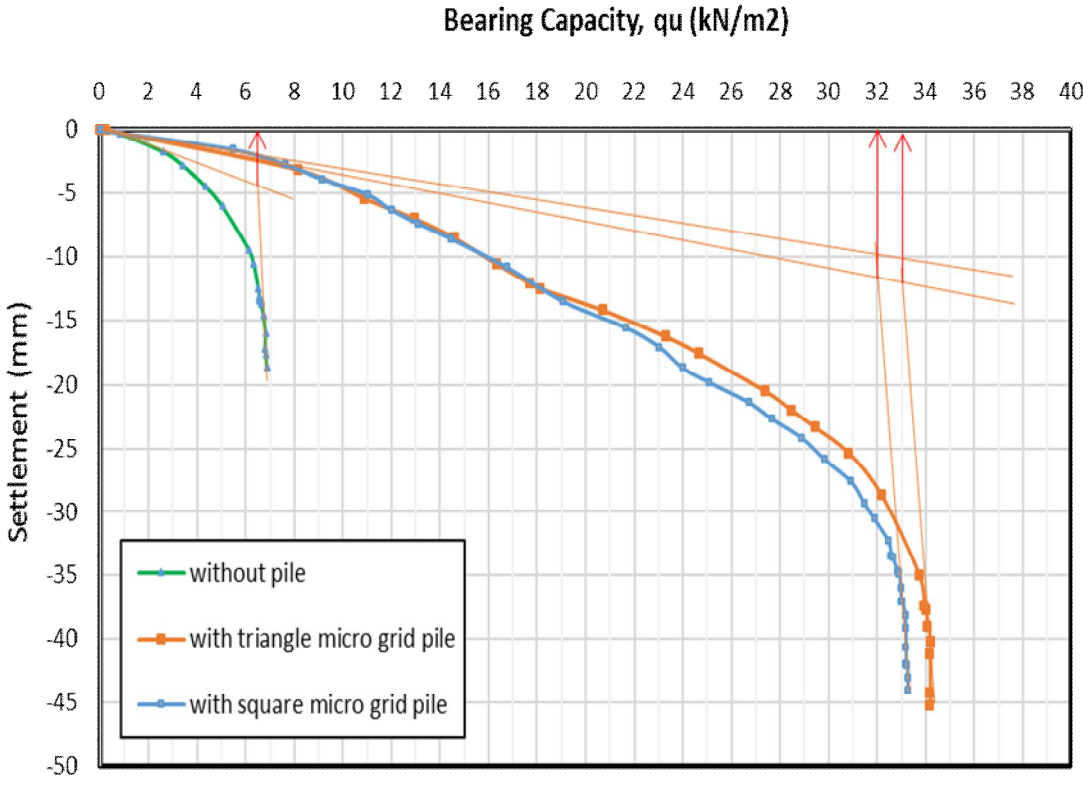

Fig. 5 Load – settlement relationship for soft soil with and without micro grid pile

TABLE II
BEARING CAPACITY AND SETTLEMENT OF SOIL

NO	MODEL	BEARING CAPACITY (QU)	SETTLEMENT
1	WITHOUT PILE	6.6 kN/m2	19
2	WITH TRIANGLE MICRO GRID PILE	33 kN/m2	30
3	WITH SQUARE MICRO GRID PILE	32 kN/m2	37

Table II shows the ultimate bearing capacity of each model. It shown that the bearing capacity of soil increased 5 times from 6.6 kN/m^2 to 33 kN/m^2 and 32 kN/m^2 respectively of soil without grid pile and with grid pile (triangle grid pile and square grid pile). The results of this study reinforced by Marto A [2] that the foundation of the model grid has a high bearing capacity and diamond grid model produces a higher bearing capacity than other grid model in the same size. Chandrawansih [3] found that the use of skirt foundation increased significantly of soil bearing capacity.

In loading test of soft soil sample with triangle grid pile model, the trend of settlement is not too significant different compared to square grid pile mode. The more increased loading, the settlement generated greater altough it is not as greater as the settlement of without grid pile model. When the load increased until 7.00 kN, its settelement reaches -8.55 mm. Then it is increasing dramatically to 36.00 mm when the load increased to 16 kN.

At the time of loading of 8.0 kN, settlement reaches -10.8 mm at the center point of loading plate. Settlement decreased gradually from -10.80 mm up to an increase of only + 3.57 mm at a distance of 80 cm from loading plate center of soft soil sample. When load is 16.2 kN, the settlement reaches -37 mm in the central pressure point, and settlement slowly increased to 3.00 mm at a distance of 80 cm from the center point of loading plate.

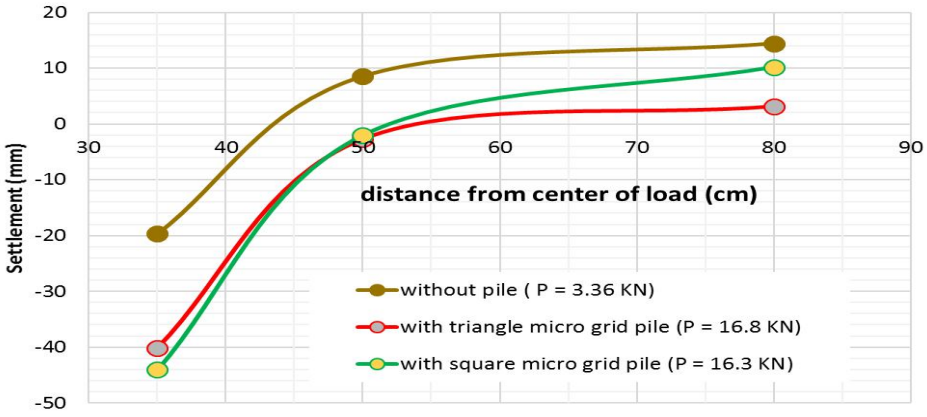

Fig. 6 Load – heaving relationship for soft soil with and without micro grid pile

TABLE III
UPIFT DEFORMATION

NO	MODEL	UPLIFT DEFORMATION		
		30 CM FROM LOAD CENTER	50 CM FROM LOAD CENTER	80 CM FROM LOAD CENTER
1	SOFT SOIL	-19 MM	+ 9 MM	+ 14 MM
2	WITH TRIANGLE GRID PILE	-40 MM	+2.7 MM	+3 MM
3	WITH SQUARE GRID PILE	-44 MM	+2.0 MM	+10 MM

Figure 6 shows that the increase of loading generated heaving around the loading plate. At the time of loading is 10.15 kN, the settlement of soil is 14 mm at the centre load point. While the surrounding area decreased gradually from 14 mm to an increase of only + 2:00 mm at a distance of 80 cm from the load centre of soft soil sample. At the time of loading of 16.74 kN, the settlement is 45.00 mm in the central loading point, and settlement of soil reduced to + 3 mm at a distance of 80 cm from the loading point.

And also the increase of loading, the strain generated around the plate getting higher. At the time of loading of 11 kN, the settlement is 16.50 mm at the centre point. While in the surrounding area decreased gradually from 16:50 mm to only + 2 mm. At the time of loading of 16 kN, the settlement is 44 mm, and slowly the settlement decreased to + 10 mm. From the result heaving, it is shows that, triangle grid pile model has lower heaving compare to square grid pile model.

IV. CONCLUSIONS

From the results of laboratory investigations on the effect of axially loaded modeled galam wood grid pile on soft soil, the following conclusions are drawn:

- *Soft soil settlement increases with increase in loading.*
- *The use of micro grid piles model increased significant bearing capacity of soft soil by approximately 500%.*
- *The trend of load vs settlement between square grid pile and triangle grid pile is not different significantly each other, however the bearing capacity of triangle grid pile model increased higher than square grid pile model.*
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