COMPRESSIVE CAPACITY OF HELICAL PILE FOUNDATION ON PEAT WITH VARIATION OF HELICAL PLATE DIAMETER

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ABSTRACT

The use of helical foundations to support structures on peat soil is still a new method. Research is needed to develop this foundation. There are 6 types of helical foundation tested on peat soil. To study the effect of helical plate diameter, plate diameters were varied with sizes 25 cm (M), 35 cm (L), and 45 cm (G). Plate positions (1, 2, 3 plates) are designed at 300 mm spacing. The axial compression bearing capacity test is carried out based on the constant rate of penetration procedure. At the beginning of loading, the load increases significantly. At a certain descent, the load begins to decrease slowly. The load-settlement curve shows that the larger the plate diameter, the greater the load it can withstand. The largest bearing capacity is produced by the GGG 30 foundation (3 plates dia. 45 cm), which is 10.83 kN. LLL 30 helical foundation (3 plates dia. 30 cm) provides a bearing capacity of 7.14 kN. These results clearly explain that the increase in plate diameter is directly proportional to the increase in the axial compression bearing capacity.

Keywords: helical foundation; slab diameter; peat; bearing capacity.

INTRODUCTION

Helical foundations are foundations made of steel or concrete and equipped with helical plates in a certain number and spacing. This foundation has long been used to support structural stability against compressive, lifting, and lateral forces (D&B Engineering Contractors Inc, 2009). The use of helical foundations as structural supports on peat soils is still a new method.

Designing a foundation on peat soil requires extra effort and precision. Helical foundations are a good choice for supporting structures. Research is urgently needed to apply this method to peat soils.

In this study, a study was conducted on the behavior of the effect of helical plate diameter variations on the bearing capacity of helical foundations on peat soils. The background of the research is to determine the effect of plate diameter variations, so as to design the compressive bearing capacity of helical foundations on peat soils appropriately and efficiently.

Helical foundation

The helical foundation was discovered by an English inventor named Alexander Mitchell in 1833. At that time helical foundations were used to support light buildings in the area around the river (Sprince, 2010).

Based on the mechanism, the bearing capacity of the helical foundation is determined by two methods, namely individual bearing and cylindrical shear (Perko, 2009). Individual bearing assumes the carrying capacity of the helical pile consists of two resistances, namely the bearing capacity of the soil under each plate and adhesion (skin friction). While the cylindrical shear method is a combination of the bearing capacity of the tip under the most basic plate, the shear strength formed by the soil cylinder with the soil, and adhesion.

Research on helical foundations has been carried out by several experts. Rao et al. (1991) conducted tests on cohesive soils. The results of research by Rao (1991) show that the bearing capacity of the helical foundation increases as the slab diameter increases

In addition, Sprince (2010) conducted helical foundation testing on 4 types of soil. The soils used are sandy, hard loam, floating loam, and find sand. The test results show that the bearing capacity of the helical foundation has increased due to the increase in the diameter of the slab.

In planning the structure of the most important building is the foundation. Planning of building foundations must go through a calculation process with aspects of subgrade conditions and sondir results must be considered so that the deep foundation can withstand its own load and the load on it including structural loads and earthquake loads. (Mubarak AA, 2014; Putranto FR, et.al, 2019; Taqwa FM, et.al, 2017; Marwahyudi M, 2019; Lutfi M, Mulyadi EB, 2021; Lutfi M, Maulana A, 2020; Artiwi NP, Rosdiyani T, 2021; Paikun P, et..al, 2021). This condition must consider precise calculations in order to get results that can be measured precisely and accurately. A strong foundation supports the above structure with a planned load that has been calculated. Calculation of subgrade and soil bearing capacity will get perfect results (Syaiful S, 2020; Syaiful S, 2021; Bagio TH, et.al, 2021; Priastiwi YA, et.al, 2021).

RESEARCH METHODS

Tools and materials

The peat soil was taken from the Rimbo Panjang area, Kampar Regency. The test was carried out at the Faculty of Civil Engineering Laboratory, Riau University. The series of testing tools are shown in table 1, figure 1 and figure 2 below

Table 1. Test Equipment

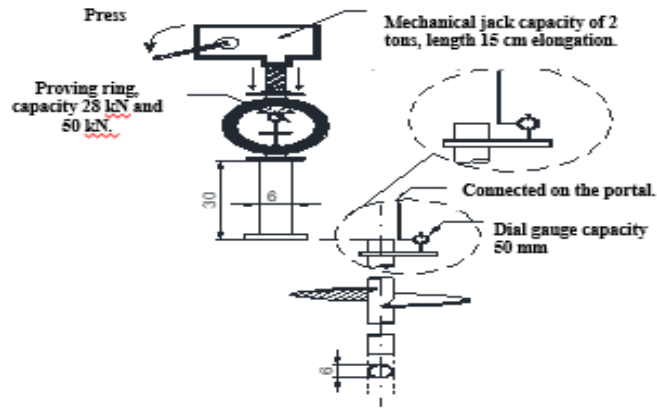|	
Mechanical jack	Kapacity 5 ton
Proving ring	Kapa**city** 28 and 50 kN
Dial gauge	Kapa**city** 50 mm
Modeling tub	Size 3 x 6 m, peat soil thickness 2.8 m
Vane shear	Propeller 25.4 x 50 mm
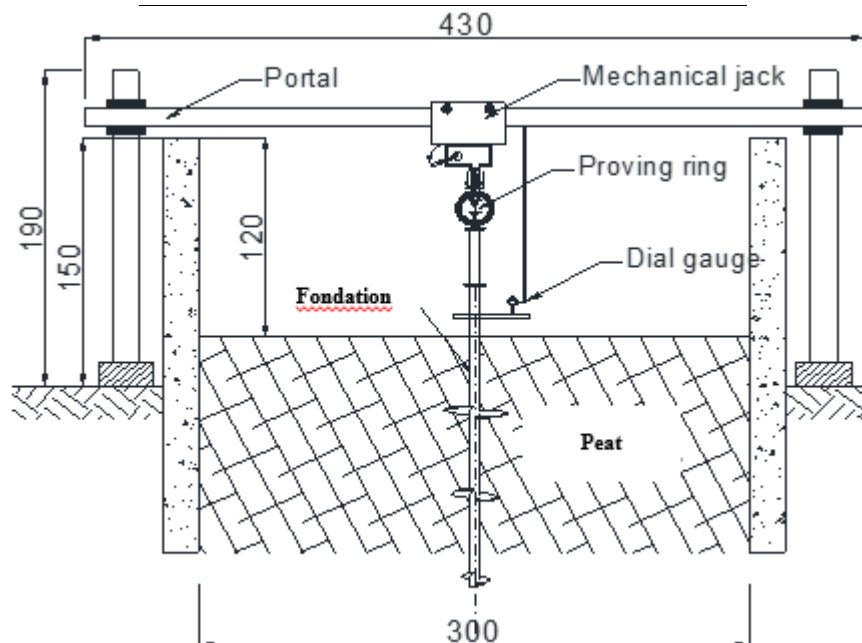
Figure 1. Tool Arrangement

Figure 2. Toolkit

Foundation Naming

The helical pile is made of steel with a pile diameter of 6 cm and a plate spacing of 30 cm. The diameters of the helical plates used are 25, 35, and 45 cm. The number of plates designed is 1, 2, and 3 plates. Tables 2 and 3 show the names and details for each variation of the foundation.
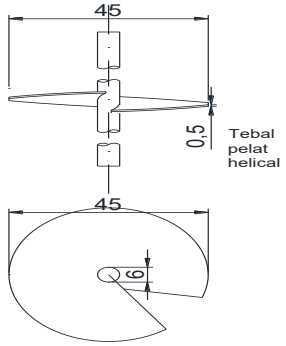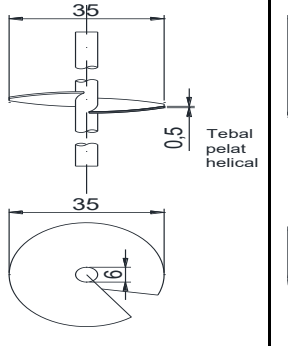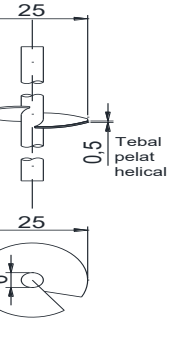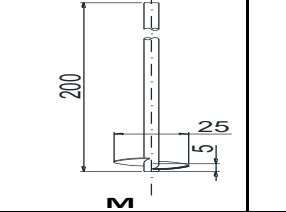
Table 2. Helical Plate Code
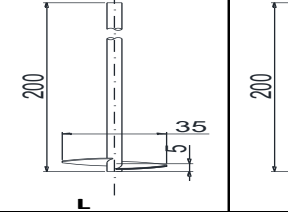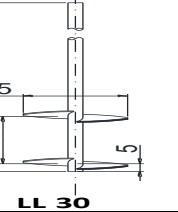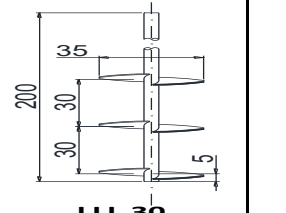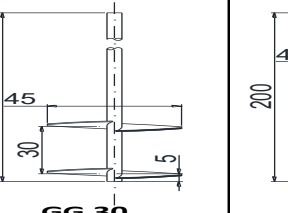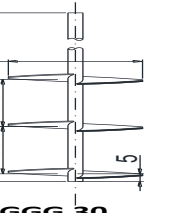
Pelat Helical			
Kode	G (Great) dia. 45 cm	L (Large) dia. 35 cm	M (Medium) dia. 25 cm

Table 3. Helical Foundation

Pondasi Helical			
Kode	M	L	LL 30
Pondasi Helical			
Kode	LLL 30	GG 30	GGG 30

Testing Procedure

The testing procedure is carried out in several stages. The foundation is planted to a depth of 1.5 m. Prior to the compression test, the peat soil was tested by field vane shear at a depth of 50, 100, and 150 cm. The Su value of vane shear is corrected with a peat soil correction factor of 0.50 (Golebiewska, 1983 in Thilakasari, 2006). A series of tools for testing the carrying capacity of the constant rate of penetration procedure such as mechanical jacks, proving rings, and dial gauges are installed as one unit and connected to the foundation (ASTM 1143-81). The average penetration rate is 1 mm per 30 seconds (2 mm/minute). In the test, recorded the amount of load given to make the foundation descend every 1 mm. The test is completed when the recorded load has lowered the foundation with an accumulated settlement of 45 mm.

RESULTS AND DISCUSSION

Soil Test Results

Peat is placed in a test pond measuring 3 x 6 m. The thickness of the peat soil is 2.8 m. Soil samples were taken at a depth of 50-100 and 100-150 cm. The properties of peat soil in this study were water content, volume weight, specific gravity, ash content, and fiber content, as shown in Table 4.

Table 4. Peat Soil Properties

Characteristics		Depth (cm)	
		50 - 100	100 - 150
Water content	%	190.949	236.837
Dry volume weight	gr/cm^3	0.273	0.236
Specific gravity	-	1.355	1.480
Ash content	%	35.544	54.463
Fiber content	%	5.281	6.114

Figure 3 shows the results of the vane shear test for each type of foundation. The graph is the result of the Su (shear undrained) value of the average correction from a depth of 50, 100, and 150 cm. Based on the graph, it can be seen that the value of Su is relatively not much different from each other, which ranges from 3.83 to 5.25 kPa. This makes the test situation the same for each foundation based on the shear strength of the soil.
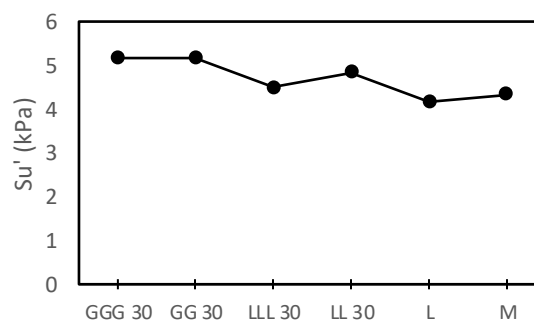
Figure 3. Vane Shear . Test Results

Helical Foundation Behavior

The behavior of the foundation can be seen through the relationship curve between load/settlement vs. load as shown in figure 4, figure 5, and figure 6, To simplify the analysis, helical foundations are grouped based on the number of slabs.

figure 4 shows the behavior of a group 3 plate helical foundation. The GGG 30 foundation has the largest plate diameter. At the beginning of loading, the curve increases. This identifies that, the GGG 30 foundation has an increase in load per unit mm. After passing the peak, the GGG 30 foundation began to experience a decrease in load every mm.
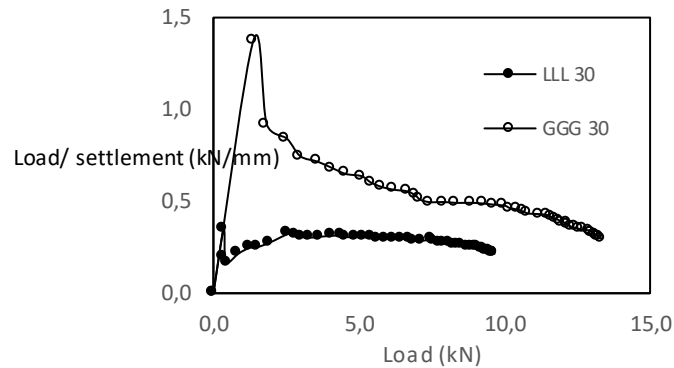
Figure 4. Behavior of LLL and GGG 30

The LLL 30 foundation showed the same behavior at the beginning of loading. After crossing the peak, the LLL 30 foundation begins to show a difference. The load begins to decrease per unit mm. However, in one condition, the load increases again, until the curve forms a straight line. At that time the load did not increase or decrease again. Figure 5 and Figure 6 show the behavior of the LL 30, GG 30, L, and M. foundations
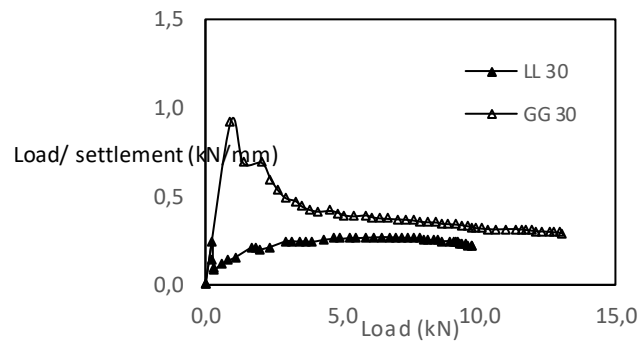
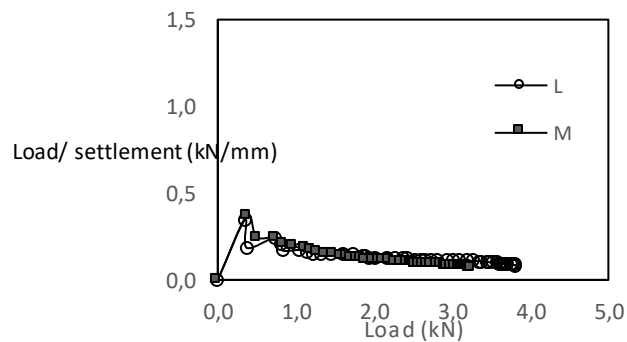**Figure 5**. Behavior of LL 30 and GG 30

Figure 6. Behavior of L and M
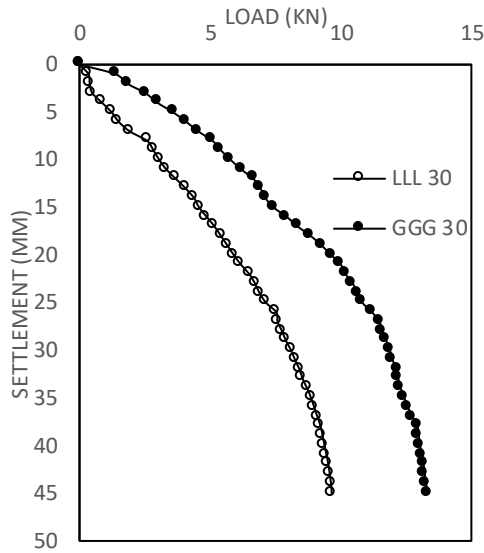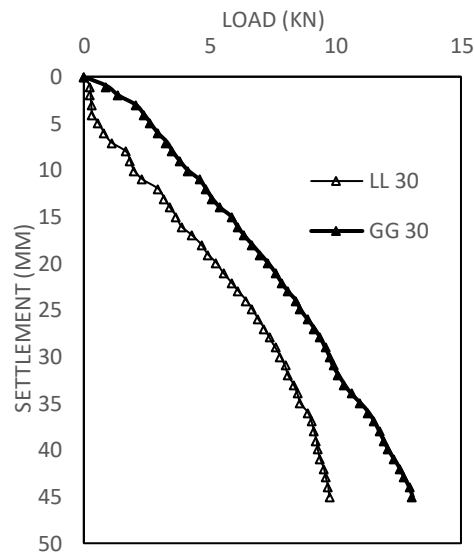
**Effect of Plate Diameter on Helical Foundation Bearing Capacity**

Testing the bearing capacity of the foundation produces a load vs settlement curve. The curve can show how much influence the slab diameter has on the bearing capacity of helical foundations on peat soils.

Figure 7. Load vs Decrease GGG 30 and LLL 30 . curves

**Figure 8.** Load vs Deduction Curve GG 30 and LL 30
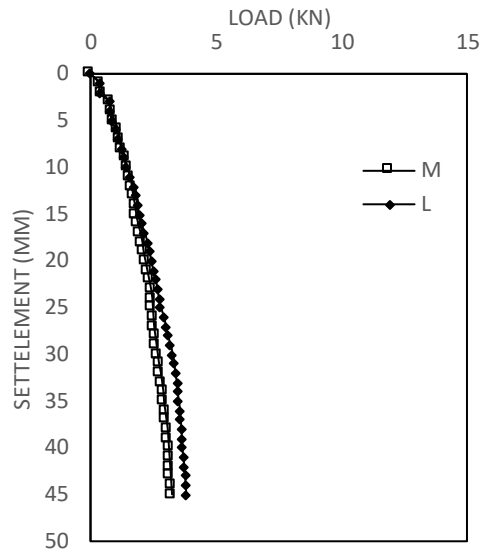
Figure 9. Load vs Drop Curves GG 30 and LL 30

Figure 7 shows the load vs. settlement curve of the GGG 30 and LLL 30 foundations. The GGG 30 foundation curve shows a greater load than the LLL 30 foundation at the same settlement. This is because the diameter of the GGG 30 plate is larger than that of the LLL 30. The foundation of GGG 30 uses 3 plates with a diameter of 45 cm. The LLL 30 foundation uses 3 plates with a smaller diameter of 35 cm. This behavior is also seen in foundations that use 2 slabs (GG 30, LL 30) and 1 slab (L, M). fig. 8 and 9 show load vs. settlement curves for 2 slab and 1 slab helical foundations.

So the larger the diameter of the helical plate, the greater the load it can withstand. Based on the analysis of the load vs. settlement curve, it can be concluded that the amount of load received by the helical foundation is influenced by the diameter of the helical plate.

Ultimate Carrying Capacity

The ultimate bearing capacity of the helical foundation is interpreted by the load method at a settlement of 25 mm. This corresponds to the standard settlement clearance of the foundation is 1 inch (25.4 mm, ASTM 1143-81). fig. 10 shows the use of the 25 mm settlement method for the M foundation.
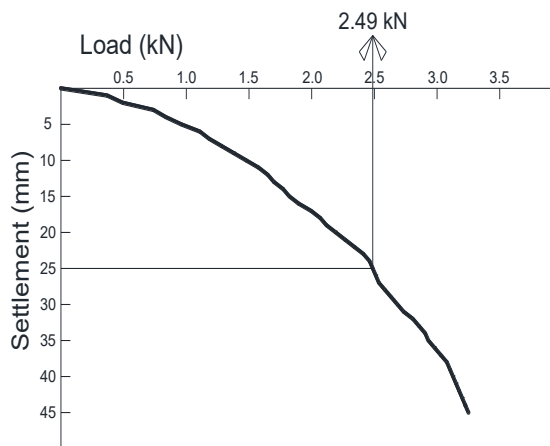

Figure 10. Bearing Capacity of M Foundation at 25 mm. Subsidence

Table 5 shows the ultimate bearing capacity of all types of helical foundations. The largest bearing capacity is produced by the GGG 30 foundation with a value of 10.83 kN. The lowest bearing capacity is produced by the M foundation with a value of 2.49 kN. Based on the value of the bearing capacity, it can be seen that the larger the diameter of the helical plate, the greater the bearing capacity of the foundation.

Table 5. Ultimate Carrying Capacity

Foundation Type	Ultimate Carrying Capacity (kN)
GGG 30	10,83
GG 30	8,63
LLL 30	7,14
LL 30	6,72
L	2,81
M	2,49
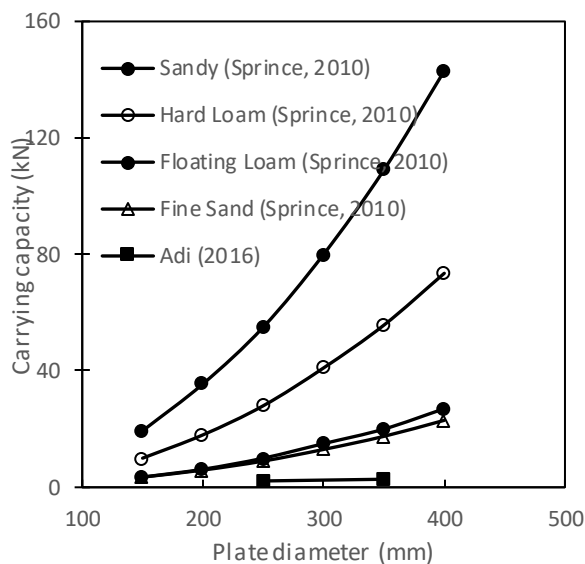
Figure 11. Comparison of Research

This study is also compared with previous research by Sprince (2010), as shown in figure 11. Sprince (2010) research shows that the larger the diameter of the helical plate, the greater the bearing capacity of the foundation. The increase in bearing capacity occurs significantly in sandy soils and hard loam mixtures. There was no big increase in the mixed soft clay (floating loam) and fine sand, when compared to the previous soil. This behavior also occurs in the peat soil tested in this study.

So based on the research comparison, it can be concluded that the helical foundation produces the smallest bearing capacity when planted on peat soil.

CONCLUSION

The conclusions that can be drawn from the results of this study are : The load vs settlement curve shows that the helical foundation load is affected by the diameter of the helical slab. The larger the diameter of the slab, the greater the load that can be received by the foundation. The ultimate bearing capacity results show that the helical foundation has increased bearing capacity as the slab diameter increases. The larger the diameter of the helical plate, the greater the ultimate bearing capacity of the foundation.

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