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THE CHANGES OF FRICTION CAPACITY OF THE PILE TO SUPPORT SLAB PAVEMENT DUE TO LATERAL LOADS

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ABSTRACT

Soft soils become one of the obstacles in building roads, where the carrying capacity of soft soils is very low and can make the pavement unstable on soft soils. There are several types of pavement that can be built on soft soil, one of which is rigid pavement that is added to the pile as an anchor under the slab pavement, and it is hoped that the pile will be able to support the slab of pavement so that the pavement is not damaged.

Lateral loading is one of the important things that must be calculated in the design of road pavement, especially rigid pavement or slab pavement with piles. From this study the effect of lateral loading can reduce the carrying capacity of the pile so that it is feared that it will reduce the performance of rigid pavement, which can result in failure of the pavement structure.

From the results of this study, the carrying capacity of piles decreased by 28%, especially the carrying capacity of pile friction due to gap changes, so the coefficient factor in the formulation of carrying capacity for shallow foundations must be multiplied by 78%.

Keywords: Gap, pile deformation, slab of pavement

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1. INTRODUCTION

Soft soil in Indonesia according to Satibi [2] around 30%, this is a particular challenge for building planners, especially roads where soft land has decreased so much when under burden

Rigid Pavement with nailed slab system is expected as an alternative to several foundation choices in improving the performance of the rigid pavement layers as described above, which can be used as an alternative solution to improve road pavement performance on soft soils. This pavement is expected to reduce damage to the pavement plates due to soft subgrade which is likely to continue to decline in the future, so that with the use of piles it is expected that the load will be channeled to the underground. But rigid pavement with glued plate system is not a function to improve soft subgrade, but one alternative method in improving the performance of rigid pavement on soft soil.

In this study rigid pavement with a glued plate system consists of thin plates with a thickness of about 0.1 m - 0.15 m supported by a small pile having a length of 1m -1.5 m and a pile diameter of 0.15 m - 0.20 m, although in other studies such as those conducted by Hardiyatmo [1] who examined the application of the ratio of pile length to diameter (L / D) of at least 7 or pile length of 0.70 m with diameter of 0.10 m, with monolithic installation between piles with pavement plates.

This study will analyze how the behavior of the pile when receiving latearl load that can affect the carrying capacity of friction because the gap caused will reduce the area of friction.

2. METHODE OF RESEARCH

This research is an experimental research, where the data collection system is carried out from the results of experiments or small-scale experimental methods in the laboratory by making a prototype of a rigid pavement with a glued plate system that is placed on soft soil. The prototype in rigid pavement research will be placed in a tub or container and in the transparent front made of fiber in which filled with soft soil that has been compacted in accordance with the level of density of soft soil in the field. Strain pavement and rig will be installed with strain gauge at certain points that will be connected to the data logger and connected to the computer so that any deflection changes that occur on the pile or deflection on the pavement can be recorded when receiving vertical or lateral loads.

The test is done by applying a lateral loading made from a motor that has been modified with a certain acceleration that is set through the dial gauge and connected to the inverter as a speed regulator to then connect with electrical power. The amount of load on the dial gauge will be adjusted to the needs of the study (Figure 1). In addition, the camera will be installed in front of the test tank to find out in detail the evolution of the movement of the pile and the amount of the gap between the pile with the ground around the pile caused by lateral loading of the magnitude as needed.

The soil used in the test box is soil with characteristics as soft soil, as can be seen from the results of soil testing in Table 1. This soft soil will be used into the test box and compacted according to the level of density in the field, the stages in compaction in the test box are 20 cm per layer. Compaction is carried out to achieve the desired consolidation as in the research by Pratikso [3]

The maximum lateral movement capacity of the engine is 4 kN with a frequency of 50 Hz or 50 cycles in one second. To get a lateral load of 2 kN the frequency is reduced to 25 Hz, while to get a lateral load of 1 kN the frequency is reduced to 12.5 Hz

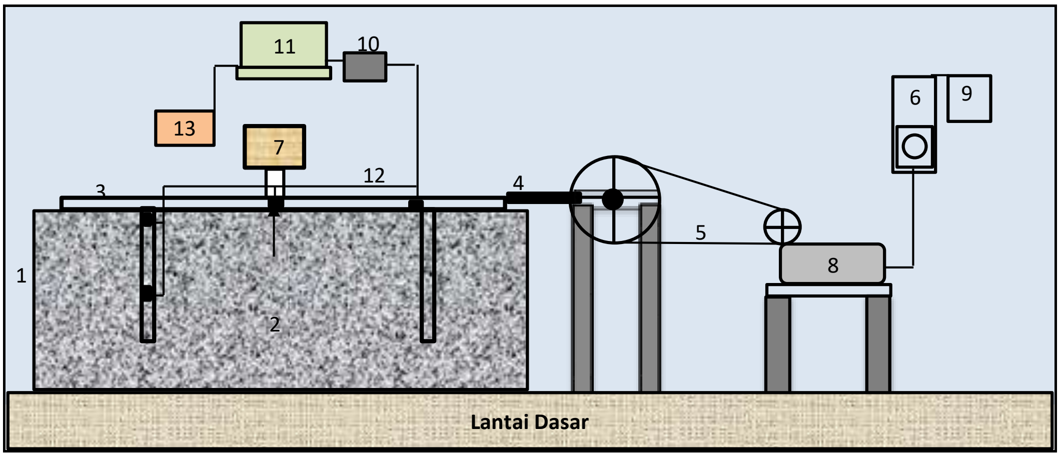

Figure 1: Schematic of experiment test

The description from schematic of experiment test is numbers 1 to 3 are prototypes, numbers 4 to 9 are motorcycle instruments and numbers 10 to 13 are instrument monitoring

3. RESULT AND DISCUSSION

3.1. Gap Analysis

Analysis of the gap length and the depth of the gap between the pile and the ground around the pile is done using the camera, the camera is placed at the end of the anchor pile that leads to the bottom of the pile. To find out the depth of the gap on the pile is done by placing pieces of length measuring devices up to the depth of the anchor pile.

Observations are made by monitoring through the results of the video that has been directly recorded into the computer. The following is an illustration of the gap changes in each lateral loading which is depicted manually through the recorded video.

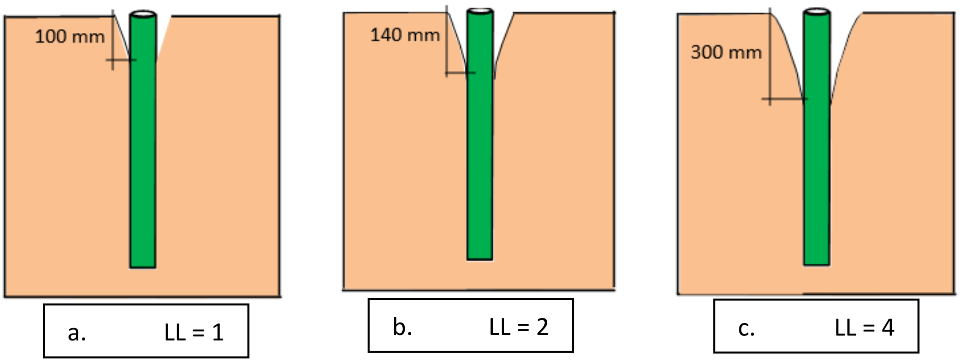

Figure 2. Gap Illustration

Figure 2 shows that there is a gap change that occurs in every lateral loading change, where the greater lateral loading will cause a greater gap, both in gap width and distance, for lateral load 1 kN the gap is 100 mm, for lateral load 2 kN the gap is 140 mm and for lateral load 4 kN the gap is 300 mm.

3.2. Pile Displacement with Friction Capability

From the monitoring results of the pile deformation for lateral loading of 1 kN produces deformation at the "back" of the pile around 0.82 mm and the largest at the end of the pile and 0.11 mm at the center of the pile, this value is smaller compared to the lateral loading of 2 kN which is 0.94 mm at the end of the pile or increased by 15%, while in the middle of the pile was deformed by 0.14 mm or an increase of about 27% when compared to the loading of 1 kN. For lateral loading of 4 kN there is an increase of about 50% when compared to the lateral loading of 1 kN which is 1.23 mm at the end of the pile and has an increase of 55% in the center of the pile by Situmorang, A. [4].

Gap analysis between the pile and the soil around the pile is carried out to determine the depth of the gap and the width of the gap between the pile and the soil. The results of the monitoring gap are shown in Table 4.11. From these results it was concluded that the tendency for the addition of the gap width and the depth of the gap along with the increase in lateral loading. For lateral loading of 4 kN the depth of the gap is 300 mm and the gap width of 9 mm is greater when compared to the lateral loading of 1 kN the depth of the gap is 100 mm and the width of the gap is 3 mm. As for the loading of 2 kN the gap width that occurs is 5 mm and the depth of the gap is 140 mm.

From the results of the measurement of the gap concluded that the width and depth of the gap is strongly influenced by lateral loading, and the size of this gap will affect the interaction between the pile and the ground. The results of this study are consistent with research by Kyle M. Rollins [5] that the existence of a gap around the pile with the ground will result in reduced interaction between the pile with the ground thereby reducing the carrying capacity of a friction pile.

The following is a graphic analysis of the gap between the pile and the ground for different lateral loading.

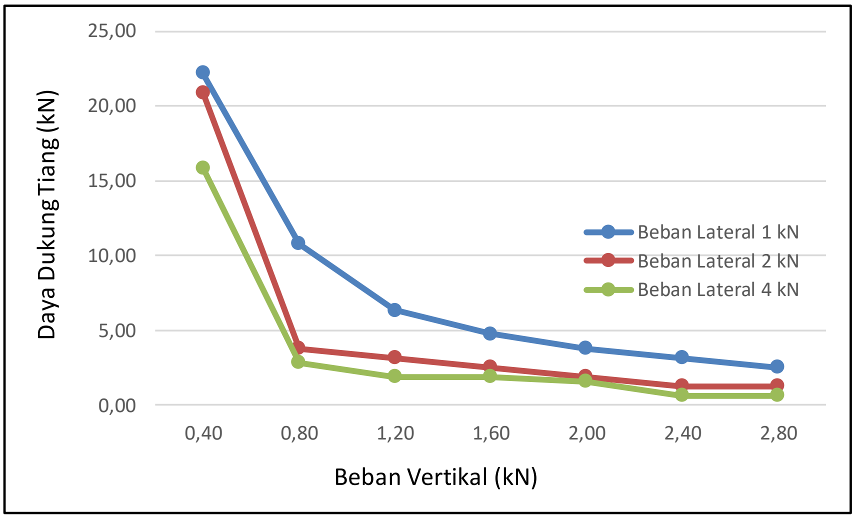

Figure 3. Bearing Capacity vs lateral load

From the results of the analysis above, the average percentage of reduction for each loading is made, where the largest average decrease is in lateral loading of 4 kN by 85% and the smallest is for 1 kN loading with an average decrease for each vertical loading variation with a decrease by 69%.

3.3. Pile Carrying Capacity Analysis

Analysis of the formulation of the bearing capacity of the pole is the result of the sum between the end capacity of the pile and the carrying capacity of friction, as in the equations below:

$$Q_u = Q_b + Q_s$$

Where:

Q_u = ultimate capacity

Q_b = end bearing capacity (assumtion $Q_b = 0$)

Q_s = friction capacity

$Q_u = Q_s = A_s \times f_s$

f_s = total friction (kPa)

A_s = area of pile (m^2)

Using the formula above, it is necessary to calculate the area around the pile subject to friction for each lateral loading according to the length of the pile as in Table 1.

Table 1. area of pile

LATERAL LOAD			
0 kN	1 kN	2 kN	4 kN
A_s (m^2)	A_s (m^2)	A_s (m^2)	A_s (m^2)
2.011	1.76	1.66	1.25

To calculate the friction factor along the pile with some supporting variables as formulated as follows:

$f_s = a_d\, c_u + p_o\, K_d \tan \varphi_d$

where :

$a_d = 1$

$c_u = 12.6$ kN/m^2

$p_o = 0.40$ kN

$K_d = 0.722$

$\varphi_d = 9.3$

With the variables above, the fs value and ultimate carrying capacity can be calculated, the full results of the ultimate carrying capacity calculation as in Table 2.

Table 2. Bearing Capacity of Pile

Description	Lateral Load			
	LL = 0 kN	LL = 1 kN	LL = 2 kN	LL = 4 kN
A_s *(m2)*	2.011	1,76	1,66	1,25
fs (kN/m)	126,6	126,6	126,6	126,6
$Q_u = Q_s = A_s\, x\, f_s$	254,6	222,8	210,1	158,2

From the results of the carrying capacity calculation above, there is a decrease in carrying capacity due to lateral loading, because when there is no lateral loading the bearing capacity of the pile is 254.60 kN and after experiencing loading 1 kN the carrying capacity decreases by 12.5%, when lateral loading is added to 2 kn carrying capacity decreased again by 17.5% and for lateral loading 4 kn decreased 37.8%, and if averaged the total reduction in lateral loading increased 100% is from 1 kN to 2 kN and to 4 kN there was a decrease in average average of 22%.

From the above explanation it can be concluded that the carrying capacity of the piles will decrease by about 22% due to lateral loading when compared to slab without lateral load. So that the formulation of the carrying capacity of the pile is adjusted to the large percentage of the decrease in carrying capacity as a coefficient factor, which can be formulated as follows:

Q_u

$= Q_s = n\ A_s \times f_s$

$= 0.78\ A_s \times f_s$

4. CONCLUSION

Lateral load has a very significant effect on the stability of the rigid pavement structure with the glued plate system, where the lateral loading will reduce the friction of the pile with the ground so that there will be a decrease in the carrying capacity of the pile. From the experimental results it was concluded that the application of 1 kN lateral load would provide a gap between the pile and the ground by 100 mm meaning it would reduce the 100 mm friction of the total length of the pile. For lateral loading 2 kN increases the gap depth to 140 mm, and increases again to 300 mm when the lateral loading is applied to 4 kN.

The results of this gap analysis will affect the formulation of the carrying capacity of the land in accordance with the calculation of the area of the pole that has friction. When 1 kN lateral load is applied it reduces the carrying capacity of the pile by 12.5% compared to without lateral loading. The same thing with lateral loading of 2 kN can reduce the carrying capacity of the pile by 17.5%, and for lateral loading 4 kN reduce the carrying capacity of the pile by 37.8%, so that the average total decrease in bearing capacity due to lateral load to 22% when compared without lateral load.

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