

1880 TECHNICAL STUDY OF SPUN PILE CONSTRUCTION SLAB ON PILE KATARAJA TOLL ROAD PROJECT ZONE 1

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ABSTRACT

Slab on pile is one of the bridge structures consisting of slab, pile head, and spun pile used in the Kataraja Toll Road Project zone 1. The piles on the slab on pile bridge on the Kataraja Toll Road Project are five in one pile head which has a spacing of 1 meters. Piling in slab on pile construction with pile foundations with a diameter of 60 cm. During the piling process, some data is generated, including the number of strokes and the final set of calendering results. In this paper the analysis of the bearing capacity of the piles will use several methods, namely the Meyerhof 1976 method which is a static method using SPT data then for data from calendering results it is used in the dynamic method, namely Modified ENR, Danish formula, Janbu's formula, and Michigan State Highway formula Commission. There is also a PDA test and Allpile Program, which is one of the technical tests for the feasibility of the pile, where this test aims to determine the axial bearing capacity of the pile, the integrity of the pile and the energy efficiency transferred. The data from the results of the PDA test will later be used to check or validate the bearing capacity of the piles. The technical study of slab on pile construction with spun pile foundations in zone 1 of the Kamal - Teluk Naga - Rajeg (Kataraja) toll road aims to ensure that the pile foundations can be said to be safe and efficient in terms of spun pile depth and spun pile bearing capacity.

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1. INTRODUCTION

The foundation is an important structure of a building. Foundation as the basis for bearing the basic load of a construction. Roads, buildings, bridges, dams, and other civil constructions without a strong foundation will inevitably suffer from construction failure. In field applications often override the analysis of the carrying capacity of the right foundation. Foundation design is only based on personal experience, so the author considers this to be necessary because the foundation is the most important foundation of success in civil buildings.

As an element of the lower structure of the building and the lowest part of a building, the foundation is directly related to the ground. Among the types of foundations available, pile foundations are one of the best and strongest types that are often chosen. This foundation consists of an arrangement of poles that are plugged into the ground at a certain depth using a mounting machine. With pile foundations, the structural part of a building divides the gravitational pressure evenly on the ground. As a result, this makes buildings that are under construction can be strong and stand firmly.

One of the toll road construction is supported by a foundation that can withstand the weight of the road itself and the load of vehicles passing through the road. One of the Kataraja toll road project sites in the Tangerang area was chosen to use a pile foundation with a diameter of 0.6 m.

The implementation of making the foundation for Katara toll road infrastructure in Tangerang has several factors that need to be considered such as environmental factors, social factors, and also cost factors. These factors are very likely to be able to change the design that has been determined from the beginning, where the changes that occur are in the change of the erection system that was originally without a preboring system to a preboring system, the depth of the pile, the number of hammer blows which ultimately affect the carrying capacity of a single pole.

These changes make it necessary to conduct a technical study of the number of blows to the depth and value of N-SPT and analysis of the carrying capacity of piles based on research data. The land obtained in the field i.e. SPT data and calendaring/final set using methods suggested by experts as well as PDA tests and Allpile programs. The construction of pile slab foundation can be said to be safe if the bearing capacity

- W_r = Hammer weight
- h = Ram fall height (cm)
- s = Punch penetration per cm
- n = Coefficient of restitution between ram and pile
- W_p = Pole weight

Danish method

The following is the formula for calculating the axial carrying capacity of piles with the Danish method using calendaring data:

$$Q_u = \frac{e_h \times E_h}{s + C_1} \sqrt{\frac{e_h \times E_h \times L}{2 \times A_p \times E}}$$

Description :

- e_h = Hammer efficiency
- E_h = Hammer energy
- s = Punch penetration per cm
- L = Pole length
- E = Pole modulus of elasticity
- A_p = Cross-sectional area of the pole

Janbu's method

The following is the formula for calculating the axial carrying capacity of piles with Janbu's method which uses calendaring result data:

$$Q_u = \frac{e_h E_h}{K'_{u,s}}$$

Where $K'_{u,s} = C_d \left(1 + \sqrt{1 + \frac{\lambda'}{C_d}} \right)$

$$C_d = 0.75 + 0.14 \left(\frac{W_p}{W_r} \right)$$

$$\lambda' = \frac{e_h E_h L}{A_p E s^2}$$

Remarks :

- e_h = Hammer efficiency
- E_h = Hammer energy
- s = Punch penetration per cm
- W_r = Hammer weight
- W_p = Pole weight
- E = Pole modulus of elasticity
- A_p = Cross-sectional area of the pole

Michigan State Highway Cimission Method

The following is the formula for calculating the axial carrying capacity of piles with the Michigan State Highway Cimission method using calendaring data:

$$Q_u = \frac{1.25 e_h E_h}{s + C} \times \frac{W_r + n^2 W_p}{W_r + W_p}$$

Remarks :

- e_h = Hammer efficiency
- E_h = Hammer energy
- s = Punch penetration per cm
- W_r = Hammer weight
- W_p = Pole weight
- C = 0.1 in

3. METHODS

In this research, several stages were carried out starting with conducting literature studies through books, journals, and websites. Data collection is carried out after the literature study process where at this stage the data collected is based on the results of direct reviews in the field by making observations, recordings and interviews, the data includes SPT test result data, pole erection data, and data calendaring.

This stage is simplified in the form of a flow chart according to Figure 1. The flow chart is intended to facilitate the stages to be carried out in the research process.

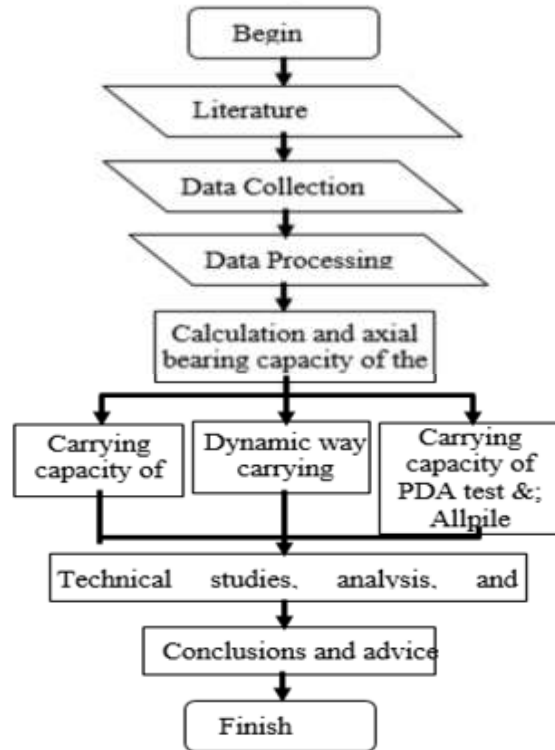


Figure 1. Research Flow Chart

4. RESULT AND DISCUSSION

Before a technical study was carried out to make it easier to analyze, the Kataraja Toll Road zone 1 project was divided into 4 ramps. Ramp is a lane or road connecting toll roads with public roads

Technical Study of the Number of Strokes

Ramp 1 : On the processed pole obtained the number of blows 350-400 to reach a depth of 21-22 meters with silt clay type, very high plasticity which has an average N-SPT value of 50 and obtained the number of strokes 250-300 strokes

Ramp 2 : The poles on ramp 2 are at a depth of 21-22 meters which are silt clay type, very high plasticity with an average N-SPT value of 60 resulting in a blow result of 300-350

Ramp 3: On the processed pole obtained the number of blows 300-400 to reach a depth of 21-22 meters with silt clay soil type, very high plasticity which has an average N-SPT value of 45 and obtained the number of strokes 200-350 strokes

Ramp 4 : The poles on ramp 4 are at a depth of 21-22 meters which are silt type sand clay which is very plastic and firm consistency with an average N-SPT value of 55 producing a blow result of 350-400

Analysis and Discussion of the Carrying Capacity of the Meyerhof Method 1976

Based on N-SPT zone 1 (ramp 1) data calculated by the meyerhof method obtained a carrying capacity of 122.6 tons at a depth of 19 meters, a carrying capacity of 127.2 tons was obtained at a depth of 20 meters, a carrying capacity of 135.3 tons at a depth of 21 meters, and a carrying capacity of 224.7 tons at a depth of 22 meters was obtained

Based on N-SPT zone 1 (ramp 2) data calculated using the meyerhof method and obtained a carrying capacity of 1.44. 1 ton at a depth of 19 meters, obtained carrying capacity of 1.51. 4 tons at a depth of 20 meters, obtained carrying capacity of 1.58. 9 tons at a depth of 21 meters, and obtained a carrying capacity of 2.47. 2 tons at a depth of 22 meters

Based on N-SPT zone 1 (ramp 3) data calculated by the meyerhof method and obtained a carrying capacity of 119.6 tons at a depth of 19 meters, a carrying capacity of 124.8 tons was obtained at a depth of 20 meters, a carrying capacity of 131.5 tons at a depth of 21 meters, and a carrying capacity of 235.6 tons at a depth of 22 meters was obtained

Based on N-SPT zone 1 (ramp 4) data calculated by the meyerhof method and obtained a carrying capacity of 137.5 tons at a depth of 19 meters, a carrying capacity of 142.5 tons was obtained at a depth of 20 meters, a carrying capacity of 156.9 tons at a depth of 21 meters, and a carrying capacity of 267.9 tons at a depth of 22 meters was obtained

Analysis and Discussion of the Carrying Capacity of the Modified ENR Method

The calculation with the Modified ENR method that uses calendaring data is as follows:

$$\begin{aligned}
 Q_u &= \frac{e_h W_r h (W_r + n^2 W_p)}{(s + 0.25)(W_r + W_p)} \\
 &= \frac{0.8 \times 5.5 \times 250 \times (5.5 + 0.4^2 \times 10.852)}{(1.833 + 0.25) \times (5.5 + 10.852)} \\
 &= 233.7 \text{ ton}
 \end{aligned}$$

Based on the calculation example above, it is known that the number of poles that meet the axial carrying capacity requirements are:

Table 1. Percentage of the number of poles that meet the axial carrying capacity requirements according to Modified ENR

Ramp	Number of Escape Poles (%)	Total Number of Masts in a zone
Ramp 1	99.3	584
Ramp 2	98.6	520
Ramp 3	100	508
Ramp 4	100	600

Analysis and Discussion of the Carrying Capacity of the Danish Formula Method

The calculation with the Danish Formula method that uses calendaring data is as follows:

$$\begin{aligned}
 C_1 &= \sqrt{\frac{e_h \times E_h \times L}{2 \times A \times E}} \\
 &= \sqrt{\frac{0.8 \times 13.75 \times 16}{2 \times 0.2826 \times 30 \times 10^5}} = 0.01018 \\
 Q_u &= \frac{e_h \times E_h}{s + C_1} \\
 &= \frac{0.8 \times 13.75}{0.01833 + 0.01018} = 385.7 \text{ ton}
 \end{aligned}$$

Based on the calculation example above, it is known that the number of poles that meet the axial carrying capacity requirements are:

Table 2. Percentage of the number of poles that meet the axial carrying capacity requirements according to the Danish Formula

Ramp	Number of Escape Poles (%)	Total Number of Masts in a zone
Ramp 1	100	584
Ramp 2	99.2	520
Ramp 3	100	508
Ramp 4	100	600

Analysis and Discussion of the Carrying Capacity of Janbu's Formula Method

The calculation with Janbu's Formula method that uses calendaring data is as follows:

$$C_d = 0.75 + 0.14 \left(\frac{W_p}{W_r} \right)$$

$$= 0.75 + 0.14 \left(\frac{10.852}{5.5} \right) = 1.026$$

$$\lambda' = \frac{e_h E_h L}{A_p E s^2}$$

$$= \frac{0.8 \times 13.75 \times 16}{0.2826 \times 30 \times 10^5 \times (1.833 \times 10^{-2})^2}$$

$$= 0.618 \text{ m}$$

$$K'_u = C_d \left(1 + \sqrt{1 + \frac{\lambda'}{C_d}} \right)$$

$$= \frac{0.8 \times 13.75}{2.325 \times (1.833 \times 10^{-2})} = 258.1 \text{ ton}$$

$$= 1.026 \left(1 + \sqrt{1 + \frac{0.618}{1.026}} \right) = 2.525$$

$$Q_u = \frac{e_h E_h}{K'_u s}$$

Based on the calculation example above, it is known that the number of poles that meet the axial carrying capacity requirements are:

Table 3. Percentage of the number of poles that meet the axial carrying capacity requirements according to Janbu's Formula

Ramp	Number of Escape Poles (%)	Total Number of Masts in a zone
Ramp 1	100	584
Ramp 2	98.4	520
Ramp 3	96.7	508
Ramp 4	100	600

Analysis and Discussion of the Carrying Capacity of the Michigan State Highway Cimission Method

The calculation with the Michigan State Highway Cimission method using calendaring data is as follows:

$$Q_u = \frac{1.25 e_h E_h}{s + C} \times \frac{W_r + n^2 W_p}{W_r + W_p}$$

$$= \frac{1.25 \times 0.8 \times 1375}{1.833 + 0.25} \times \frac{5.5 + 0.4^2 \times 10.852}{5.5 + 10.852}$$

$$= 292.1 \text{ ton}$$

Based on the calculation example above, it is known that the number of poles that meet the axial carrying capacity requirements are:

Table 4. Percentage of the number of poles that meet axial carrying capacity requirements according to Michigan State Highway Cimission

Ramp	Number of Escape Poles (%)	Total Number of Masts in a zone
Ramp 1	98.1	584
Ramp 2	100	520

Ramp 3	97.7	508
Ramp 4	100	600

Carrying Capacity Based on PDA Test Results (Pile Driving Analyzer Test)

The PDA test on the Kataraja toll road project was carried out on MR-PSL8 59 and MR-PSL8 60 poles. The following is a table of the carrying capacity of spun pile piles with a diameter of 60cm:

Table 5. PDA Test Results

Post	Q _{ultimate} (Ton)	Q _{all} Fs=2 (Ton)	Q _{all} Fs=2.5 (Ton)	Q _{all} Fs=3 (Ton)
PSL8 59	411	205.5	163.4	137
PSL8 60	432	216	172.8	144

Carrying Capacity Based on Allpile Program Data

The following is a table of data obtained based on the calculation results of the allpile program which will be used as calculation data for verification.

Table 6. Allpile Program Data

Ramp 1 (Zone 1)		Ramp 3 (Zone 1)	
Depth (m)	Qull (ton)	Depth (m)	Qull (ton)
18	167.3	18	117.9
19	182.2	19	138.2
20	198.7	20	142.7
21	223.6	21	289.9
22	241.9	22	306.7
Ramp 2 (Zone 1)		Ramp 4 (Zone 1)	
Depth (m)	Qull (ton)	Depth (m)	Qull (ton)
18	198.6	18	177.4
19	201.8	19	191.7
20	226.5	20	209.3
21	243.1	21	226.1
22	264.2	22	238.8

5. CONCLUSION

The bearing capacity (Qu) of a single pole foundation is calculated manually by several methods, namely: The carrying capacity (Qu) of a single pile foundation using the Modified ENR method obtained a value of 233.7 tons. The carrying capacity (Qu) of a single pile foundation using the Danish Formula method obtained a value of 385.7 tons. The carrying capacity (Qu) of a single pole foundation using Janbu's Formula method obtained a value of 258. 1 ton. The carrying capacity (Qu) of a single-mast foundation using the Michigan State Highway Cimmission method was 292. 1 ton.

The method closest to the PDA test results obtained in the field using soil data from the Standard Penetration Test (SPT) test is using the Danish Formula method.

Based on the number of differences and blows with N-SPT value and depth, 2,212 of the 2,840 poles on ramp 1, ramp 2, ramp 3, and ramp 4 in zone 1 have reached the hard soil layer or final set at depth 21-22 meters. Figure 2. Which shows the results of the study with N-SPT data using the Meyerhof method 1976 and the allpile program has results that differ greatly from the PDA test result data.

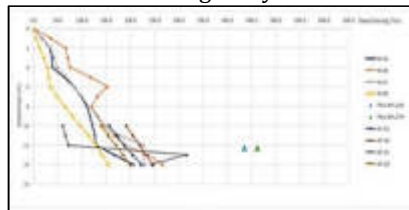


Figure 2. Results of Axial Carrying Capacity Calculation Using Meyerhof's Method 1976 PDA test, and Allpile

The process of erecting poles that are not supervised by supervisors or experts and also the unpredictable nature of the soil can cause data discrepancies

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