Analysis of the Bearing Capacity of Pile Foundations with the Meyerhoff Method in the New Terminal Building at Haji Hasan Aroeboesman Ende Airport

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ABSTRACT

Pile foundation is a type of foundation that has the function of transmitting structural loads to the soil layer, with high bearing capacity at a certain depth. The purpose of this analysis is to calculate the bearing capacity of single pile, the bearing capacity of pile group and to calculate settlement of single pile and pile group from Sondir and Standard Penetration Test (SPT). In this calculation the Meyerhoff method is used.

The new terminal construction project at Haji Hasan Aroeboesman Ende Airport uses pile foundations. The location of the new terminal building is located at the coordinates of 8°50'51" S 121°39'54" E, the location is quite close to the beach with sandy soil types, a pile foundation is suitable for use.

Based on acquired sondir and SPT data, foundation bearing capacity at two test points, Qult sondir data: 404,637 tons and 412,177 tons. SPT data obtained by Qult: 887,112 tons and 928,158 tons. The results of the bearing capacity of group 4 piles on the survey data: 338,120 tons and 342,300 tons. While SPT data: 983,630 tons and 1,029,142 tons. The results of the group 3 data group capacity survey: 253,590 tons and 256,725 tons. While SPT data: 737,723 tons and 772,069 tons. Results of data group capacity survey from group 2: 240,221 tons and 243,191 tons. While SPT data: 698,831 tons and 713,363 tons. Calculation results of single settlement and pile group 4: 20,439mm and 90,749mm. Calculation results of single settlement and pile group 3: 27.123mm and 120,428mm. Calculation results of single settlement and pile group 2: 40,297mm and 179,920mm. In this computational analysis, the bearing capacity of single pile and group pile is declared safe and meets the requirements of standard SNI 8460: 2017 from the results of the specified calculation should not exceed 190 mm.

Keywords: pile, bearing capacity, meyerhoff, sondir, SPT.

INTRODUCTION

Haji Hasan Aroeboesman Ende Airport is one of the Class II UPBU Airports in Indonesia. The distance from the airport to the city center is only 2 km. Haji Hasan Aroeboesman Ende Airport is in the construction stage of a new terminal with PT. Anugerah Bangun Kencana and consultant PT. Multi Konsulindo Mandiri. Regarding planning, the building is designed to have two floors with a total area of 4.320 m^2. The new terminal development project at Haji Hasan Aroeboesman Ende Airport uses pile foundations.

This research tries to focus on foundation problems, namely by calculating the bearing capacity of the soil using pile foundations from field data in the form of survey data and standard penetration test (SPT) experimental data using the Meyerhoff method. The method used is the Meyerhoff method, this method is used because it is more realistic. Apart from that, the advantage of the Meyerhoff method compared to other methods is that the calculations obtain many results such as bearing capacity, single pile settlement, group pile settlement.

Haji Hasan Aroeboesman Ende Airport is in the construction stage of a new terminal with PT. Anugerah Bangun Kencana and consultant PT. Multi Konsulindo Mandiri. Regarding planning, the building is designed as two floors with a total area of 4.320 m^2, where on the first floor there is a check-in counter and arrival terminal, while on the second floor there is a waiting room and a food court equipped with supporting facilities such as escalators and lifts.

In the research conducted by Ayu Fithrosyam Sulistia who took the title Analysis of Soil Bearing Capacity of Pile Foundations with the Meyerhoff Method, this research was conducted on a panda bridge construction project in Bima Regency, NTB. The purpose of this study is to calculate the bearing capacity of the piles from the results of Sonidr, SPT and soil shear strength parameters, to compare the results of the pile bearing capacities carried out with the Meyerhoff method. Based on the calculations, the following data is obtained: bearing capacity of the pile foundation at two test points, for Qult sondir data = 300.57 tons and 111.714 tons, SPT data obtained Qult = 59.283 tons and 41.867 tons from the soil shear parameter data obtained Qult = 43.238 tonnes and 43,647 tonnes. The single pile settlement is 22.597 mm and the pile group settlement is 8.382 mm.

Furthermore, the research was carried out by I Gusti Ngurah Putu Dharmayasa with the title Analysis of Dangal Foundation Carrying Capacity on Soft Soils in Areas with Shallow Groundwater. This case study was carried out in the Suwung Kauh area. To find out the characteristics of the soil is done by testing in the laboratory, namely testing the physical and mechanical properties. Testing the physical properties of the soil, namely testing for water content (Wc), specific gravity (Gs), Aterberg limits and soil unit weight as well as mechanical testing of the UU triaxial test. From the calculations using the Terzhagi method, the lowest soil bearing capacity at a depth of 1 meter is 54.09 kN/m^2. At a depth of 2 meters it is 57.37 kN/m^2 and at a depth of 4 meters it is 57.37 kN/m^2.

Subsequent research was carried out by Amris Azizi entitled Analysis of the Bearing Capacity and Reduction of Pile Foundations for the DPRD Building Project, Pemalang Regency. The research was conducted by analyzing data in the form of SPT test results and shop drawings, so that the foundation is categorized as safe (Qall > Pp). With a comparison of the largest load on type 1 foundation of 145.727 tons > 49.962 tons, type 2 foundation of 290.710 tons > 107.077 tons, type 3 foundation of 570.930 tons > 380.931 tons and type 4 foundation 727.396 tons > 489.773 tons. The settlement that occurs on the foundation is 0.029 m deep or smaller than the allowable reduction of 10% diameter.

The method used is the Meyerhoff method, this method is used because it is more realistic. Apart from that, the advantage of the Meyerhoff method compared to other methods is that the calculations obtain many results such as bearing capacity, single pile settlement, group pile settlement. So this method is considered more effective. Comparison of the bearing capacity of the foundation obtained by the dynamic formula in this method.

In this analysis soil data is needed in analyzing the bearing capacity of the pile before construction begins, in order to determine the ultimate bearing capacity of the pile. This analysis focuses on using the direct method only because of the large amount of sondir data. This direct method was put forward by several experts, including Meyerhoff.

METHOD

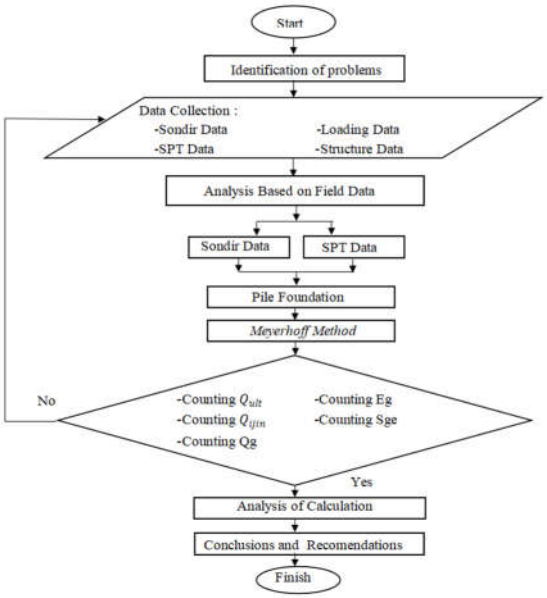

Figure 1.1 Diagram Alur Penelitian

Data collection

The construction of a new terminal at Haji Hasan Aroeboesman Ende Airport has technical data. Includes the following :

1.Building length	: 92 m
2.Building width	: 24 m
3.Building construction	: Concrete
4.Abutment	: Pilecap
5.Abutment Height	: 100 cm
6.Foundation type	: Spun pile
7.Number of piles	: 264 points
8.Length at stake	: 17 m
9.Diameter at the pile	: 40 cm
10.Concrete piles	: 500 kg/cm^2

Pile Foundation

Pile (Pile Foundation) is part of a wooden, concrete and steel foundation structure with a slender shape that is embedded in the ground to a certain depth with the function of carrying or transmitting the load from the superstructure through soft soil to hard soil layers. In this case, the pile foundation used is prefabricated reinforced concrete piles, namely reinforced concrete piles that are stamped and cast into a concrete mold, then after their strength is sufficient, they are also driven up.

Sondir Field Investigation

The sondir test is a pressure testing method that is carried out to analyze the carrying capacity of the soil as well as measure the depth of the hard soil layer or support which is commonly known as sondir soil. By knowing the depth of solid soil (sondir) that will be used as a pile or pile foundation, a contractor can design a foundation that meets safety to support the columns of a building. The Sondir tool is a cylindrical tool with a tapered tip. Cone strength and rod strength were measured at a depth of 20 cm once.

SPT Field Investigation

The Standard Penetration Test (SPT) method is a method of inserting a rod (with one lead) into the ground with a hammer and measuring the number of hammer blows per penetration depth. The results of the drilling work and the Standard Penetration Test (SPT) are then entered into the drill log sheet.

RESULT

Carrying Capacity of Sondir Data

Calculating the bearing capacity of piles from exploration data using the Meyerhoff method. From the attached sondir data, this data is used at the test point (TS) at point 04 and at point 05. This is because the soil at the test point tends to be soft and can be used to calculate how strong and sturdy the building is. At test point 05, the maximum depth reaches 13.20 meters, and is very relevant to the length of the piles to be used, namely 17.00 meters.

- Pole area (AP) $= (\frac{1}{4}) . \pi . d^2$
  $= 0{,}1256\ m^2$
- Around the pole (Kt) $= \pi$ x d
  $= 1{,}256$ m
- JHL on TS-04 $= 770$
- JHL on TS-05 $= 830$
- Qult $= (qc\ x\ Ap) + (JHL\ x\ Kt)$
- Qijin $= \frac{qc\ x\ Ap}{3} + \frac{JHL\ x\ Kt}{5}$

Table 1.1 Qult and Qijin in TS-04 and TS-05

Depth (Meter)	TS - 04		TS - 05	
	Qult (tons)	Qijin (tons)	Qult (tons)	Qijin (tons)
1.00	25,133	7,540	31,415	9,634
2.00	37,700	10,900	27,646	7,204
3.00	25,133	5,864	33,930	8,461
4.00	52,780	13,906	32,672	7,372
5.00	87,964	24,294	51,522	12,817
6.00	81,681	21,362	133,203	39,207
7.00	57,805	12,400	111,840	30,745
8.00	84,194	20,190	90,477	22,284
9.00	109,327	27,730	80,424	17,760
10.00	91,734	20,860	121,893	30,243
11.00	149,540	39,123	206,088	57,135
12.00	246,300	70,204	290,283	84,027
13.00	404,637	121,980	392,070	116,951
13.20	-	-	412,176	123,485

Carrying Capacity from SPT Data

Calculation of the bearing capacity of piles using SPT data using the Meyerhoff method. From the attached SPT data, measure at 2 points, namely point 01 (BH-01) and point 02 (BH-02). The attached SPT data is accurate enough for reference because it was tested at a depth of 30.00 meters.

- Pole diameter (d) $= 0{,}4$ m
- Pole area (AP) $= (\frac{1}{4}) . \pi . d^2$
  $= 0{,}1256\ m^2$
- Around the pole (Kt) $= \pi$ x d
  $= 1{,}256$ m
- Safety Factor $= 2{,}5$ (No Earthquake)
- NSPT on BH-01 $= 120$
- NSPT on BH-02 $= 120$
- Qp $= 40$ x NSPT x Ap
- Qs $= 0{,}2$ x NSPT x p x Li
- Qult $= Qp + Qs + Qs$
- Qijin $= \frac{Qult}{Safety\ Factor}$

Table 1.2 Qult and Qijin on BH-01 and BH-02

Carrying capacity	SPT data
Ultimit	887,112 tons
	928,158 tons
Ijin	354,845 tons
	371,263 tons

(1)

Pile Group Capacity Based on Group Efficiency

The calculation of the efficiency of the pile group starts with the pile groups numbering 4, 3 and 2. Next, calculate the capacity of the pile group, Pile group capacity (Qg). Declared safe in terms of Qg > Load of superstructure per column (to determine safety) the value is 1,970.456 kN or 197.0456 tons.

- θ = Arc tg d/s
  = Arc tg . 40/75
  = Arc tg . 0,53
  = 27,92 °
- n' = 2
- m = 2
- Eg = 1 -θ
  = 0,693
- Qg = Eg . n . Qijin

Table 1.3 Pile Group Capacity

Number of Pole Groups	Sondir	SPT
Pole Group 4	338,120 tons	983,630 tons
	342,300 tons	1.029,141 tons
Pole Group 3	253,590 tons	737,723 tons
	256,725 tons	772,069 tons
Pole Group 2	240,221 tons	698,831 tons
	243,191 tons	713,363 tons

Reduction of Single Pole, Reduction of Pole Group and Permit Reduction

In this case the calculation is divided into 3, namely the reduction in pile group 4, the reduction in group 3 and the reduction in group 2. To determine the safety of each reduction, it must be compared with the reduction requirements. In this case, using the SNI 8460: 2017 reduction requirements as a reference, the calculation results obtained a reduction requirement of 190 mm. So the calculation result must be smaller than the reduction requirement to be declared safe. Starting with the calculation of the settlement of a single pole:

- Qc value = 24.5000

The elastic modulus used for the type of sandy soil around the pile :

- Es = 3 x qc

Determine the modulus of elasticity used for the type of sandy soil at the base of the pile :

- Eb = 10 x Es

Determine the modulus of elasticity of the pile material:

- K Load = 500 kg/cm^2
- fc' = 49 MPa
- Ep = 4.700
  = 4.700
  = 4.700 . 7
  = 32.900 MPa
  = 32.900.000 kN/m^2

If there is no skin friction along the pile shaft, the pile load remains the same at all depths and elastic shortening. Due to skin friction [se(1)] :

- Se (1) $= \frac{(Qws + \xi\ Qws)\ L}{Ap\ .Ep}$

The fall of the column due to the load acting on the top of the column can be expressed as follows:

- Se (2) $= \frac{qwp\ .D}{Es}$ (1- μ_s^2) lwp
- Se (2) $= \frac{Qwp\ .Cp}{D.qp}$

The settlement of the pile caused by the load carried by the pile shaft is calculated as follows:

- Se (3) $= (\frac{Qws}{P\ .L})\ .\ \frac{D}{Es}$. (1- μ_s^2) lws
- Se (3) $= \frac{Qws\ .Cs}{L\ .qp}$

For the single pole drop Se (2) and Se (3 are taken as the largest :

- Se = Se (1) + Se (2) + Se (3)

Lower the pile group and degrade the license as follows

- Requirements for group reduction are Building Area = 4 cm
- Reduction Conditions SNI 8460:2017 = 190 mm
- Bg = 7.900 mm
- Sge $= \sqrt{\frac{Bg}{D}}$. Se
  = Decrease Results < 190 mm

Yield must be less than 190 mm to determine safe group pile settlement. Based on the calculation results, all group pile settlements are safe because they are less than 190mm.

Table 1.4 Single and Group Pile Drops

Number of Pole Groups	Single Pole Drop	Pile Group Lowering
Pole Group 4	20,439 mm	90,749 mm
Pole Group 3	27,123 mm	120,428 mm
Pole Group 2	40,297 mm	178,920 mm

CONCLUSION

Conclusion

Based on the results of calculations using the Meyerhoff method for the construction of a new terminal at Haji Hasan Aroeboesman Ende Airport, Qult should be greater than Qijin, because it is divided by the safety factor, it can be concluded that :

1. The results of the calculation of the bearing capacity of the piles from the sondir data using the Meyerhoff method are :

   a.TS-04 : Qult = 404,637 tons

   Qijin = 121,977 tons

   b.TS-05 : Qult = 412,177 tons

   Qijin = 123,485 tons

   The results of calculating the bearing capacity of piles from SPT data using the Meyerhoff method are :

   a.BH-01 : Qult = 887,112 tons

   Qijin = 354,845 tons

   b.BH-02 : Qult = 928,158 tons

   Qijin = 371,263 tons

2. The results of the calculation of the bearing capacity of the pile group are based on the performance of the group, in this case the calculation is divided into 3 pile groups namely pile group 4, pile group 3 and pile group 2. The results of all pile group calculations must be compared with the load on the superstructure per column, in the terminal building Recently the structural load was 1970,456 tons. So the result of the calculation must be less than the value of the load per column superstructure to be declared safe.

   a. Pole Group 4 : Sondir = 338,120 ton s

   342,300 tons

   SPT = 983,630 tons

   1.029,142 tons

   b. Pole Group 3 : Sondir = 253,590 tons

   256,725 tons

   SPT = 737,723 tons

   772,069 tons

   c. Group Tiang 2 : Sondir = 240,221 tons

   243,191 tons

   SPT = 698,831 tons

   713,363 tons

3. The next calculation is the reduction in single poles, groups of poles and the reduction in clearance. In this case the calculation is divided into 3, namely the reduction in pile group 4, the reduction in group 3 and the reduction in group 2. To determine the safety of each reduction, it must be compared with the reduction requirements. In this case, using the SNI 8460: 2017 reduction requirements as a reference, the calculation results obtained a reduction requirement of 190 mm. So the calculation result must be smaller than the reduction requirement to be declared safe.

   a.Pole Group 4 :

   Single drop = 20,439 mm

   Group decline = 90,749 mm (safety)

   b.Pole Group 3 :

   Single drop = 27,123 mm

   Group decline = 120,428 mm (safety)

   c.Pole Group :

   Single drop = 40,297 mm

   Group decline = 179,920 mm (safety)

Suggestion

Based on the results of calculations using the Meyerhoff method for the construction of a new terminal at Haji Hasan Aroeboesman Ende Airport, there are several suggestions as follows :

1. To determine the appropriate structure for foundation construction, it is necessary to study and examine not only the project soil data, but also emphasize the method of laying, the difficulties in its implementation. useful and useful for future researchers.

2. In further research, it is better to use sondir data, SPT and soil lab data. Another method that can be used to test the validity of the data is to use the Vesic method.

3. In reference to SNI 8460: 2017, sondir and SPT testing points for 2-story buildings with a width such as the new terminal building at Haji Hasan Aroeboesman Ende Airport are carried out at one point every 600 m^2. Figures and tables should be placed either at the top or bottom of the page and close to the text referring to them if possible.

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