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CAPACITY ANALYSIS OF SINGLE PILE BEARING CAPACITY BASED ON STATIC METHOD AND N-SPT TEST ON PILE DRIVING ANALYZER TEST (CASE STUDY OF PT. ASAHI FORGE INDONESIA PHASE II PROJECT)

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ABSTRACT

Soil investigation has an important role before building a building. The carrying capacity of the soil obtained from the results of soil investigations is very influential on the shape and dimensions of the foundation itself. In the PT.Asahi Forge Indonesia Project, the SPT test data is out of sync with the actual piling results related to embedded pile penetration. The design plan for piles with a length of 7 m based on the N-SPT test turned out that in the field, the piles achieved a bearing capacity at a depth of 9 meters. The final project aims to analyze and compare the carrying capacity of a single pile based on static methods and N-SPT test on the Pile Driving Analyzer. The method used in this research is the study method of laboratory test results and N-SPT. Work steps include; preparation, literature study, data collection, carrying capacity analysis, and comparison of analysis results. The results of the analysis of the carrying capacity of the piles based on the static method by the λ (Vijayvergiya & Focht, 1974) method amounted to 549,201 kN; The α (McClelland, 1974) Method of 426,292 kN; The U.S Army Corps Method is 459,545 kN and the Tomlinson (1977) Method is 474,191 kN. While the results of N-SPT were bearing piles bearing capacity with the Mayerhof (1956) method of 738,645 kN and the Schmertmann (1967) Method of 451,327 kN. Based on these results, the N-SPT test based on the Mayerhof (1956) Method of 738,645 kN was the closest to the PDA test results of 755,116 kN. The comparison of the results of the analysis between the static test, N-SPT and PDA test is 19: 24: 30. This means that the carrying capacity of the static pile and PDA test has a difference of 37% while between the N-SPT and PDA test has a difference of 20%.

Keywords: soil investigation, pole penetration, carrying capacity, document studies, case studies

INRODUCTION

The foundation is part of an engineering system that sustains the burden and passes on its own burden and weight to and into the soil and rocks located below (Bowles, 1997). One type of deep foundation is the pile foundation. Soil investigation has an important role before building a building. Soil investigation aims to obtain the necessary information about the soil and find out the technical properties of the soil such as the characteristics of strength, soil weight, carrying capacity, or seepage ability, as well as ground water level. Soil carrying capacity is very influential on the shape and dimensions of the foundation in order to obtain optimal planning. So that soil samples need laboratory testing. While testing in the field is obtained from the N-SPT Test Results. In the PT. Asahi Forge Indonesia Phase II Project. N-SPT test results in the field explained that the soil with a depth of 7 meters has reached a value of 50, meaning that the soil layer has reached the hard soil layer (boring log no. BH-28). So that the pile is designed in length (length) 7 m. However, during the erection, the pile reached hard soil at a depth of 9 meters. The lack of synchronization between design and implementation makes the need for deeper analysis.

Based on the background of the problem above, identification of problems, namely:

a. The design of the pile construction does not match the results of the pile in this case the length of the pile used.
b. N-SPT test results in the PT. Asahi Forge Indonesia Phase II shows that soil with a depth of 7 meters has reached a value of 50 (hard soil layer). However, during the erection, the pile reached hard soil at a depth of 9 meters.

The objectives of this research are :

a. To get the carrying capacity analysis of piles based on static methods, N-SPT Test and pile driving analyzer test.
b. To compare the carrying capacity of the pile between the static method, the N-SPT test and the pile driving analyzer test.

LITERATURE

Pile foundation is a foundation construction that is able to withstand orthogonal force to the pile axis by absorbing bending. The pile foundation is made into a monolithic unit by uniting the base of the drill pole under construction, with the foundation footing (Nakazawa, 2000). Pile foundations are used to support buildings when the soil layer is very deep. This type of foundation can also be used to support buildings that hold upward force, especially in high-rise buildings that are affected by wind-rolling forces. Poles are also used to support the pier building (Hardiyatmo, 2018 : 145).

According to Hardiyatmo, 2002, End Bearing Pile is a pole whose carrying capacity is determined by the end resistance of the pole. Generally the end bearing poles are in soft soil zones which are above hard soil. The poles are piled until they reach the bedrock or other hard layers that can support the burden that is not expected to cause excessive decline. Friction pile is a pole whose carrying capacity is more determined by the friction resistance between the pile wall and the surrounding soil (Figure 2-4). The friction resistance and the effect of the consolidation of the underlying soil layers are taken into account in the calculation of pile capacity (Hardiyatmo, 2018 : 95).

Analysis of bearing capacity of piles based on static methods using the Terzaghi method (1943) for the carrying capacity of the tip (Qp). As for the frictional carrying capacity (Qs) using the λ (Vijayvergiya, 1974) method, the α (McClelland, 1974) method, the U.S Army Corps Method and the Tomlinson (1977) Method. In contrast, for the analysis of bearing capacity based on N-SPT results using the Mayerhof (1956) method and the Schmertmann (1967) Method for maximum carrying capacity (Qu).

RESEARCH METHODOLOGY

The research methodology used in this study is the document study method. The research instrument used in the form of document quality control record piling (piling) work and Quality pile driving record based on ISO 9001: 2008. While the research data source in the form of laboratory data for soil samples, N-SPT test data, PDA results data, plan drawings and pile foundation technical specifications. The sample to be analyzed consists of 3 samples, namely the point of bore hole 6 (BH-6), point of bore hole 8 (BH-8) and point of bore hole 9 (BH-9). From the study of documents, secondary data will be obtained which will be used to analyze the carrying capacity of the pile.

In this study begins with the literature study stage. Literature study aims to critically analyze parts of journal articles through the process of summarizing, classifying and comparing with previous research. The process begins with searching for journals of the last five years related to the carrying capacity of the pile. Then each journal is made a resume or summary to get information about the results of the research conducted. Then clarify whether the journal answers research issues that will be raised or not. Capacity analysis of piles with a case study at PT. Asahi Forge Indonesia Phase II Project uses three secondary data in the form of laboratory test data, N-SPT test and pile driving analyzer test. Data from laboratory test results were analyzed in a static way by several existing methods including the λ (Vijayvergiya & Focht, 1972) Method, The α (McClelland, 1974) Method, The U.S Army Corps Method and The Tomlinson Method (1977). Carrying capacity of piles analyzed from N-SPT test results using the Mayerhof method, the Schmertmann method and the Brown method. Analysis Results in the form of carrying capacity of static stakes and N-SPT Test with several methods compared with the results of the pile driving analyzer test Comparison is done to find out which analysis method is the closest to the static method and N-SPT test on pile driving analyzer test.

RESULTS AND DISCUSSION

Analysis of Carrying Pile Capacity

The net ultimate resistance (Q_u) static way

The results of the analysis of the net ultimate resistance (Q_u) in the static way at the bore hole 9 can be seen in table 1 below.

$$W_p = L.A_p.W_c = 9x0,096x24 = 20,736 \text{ kN}$$

$$Q_p = A_p(1,3cN_c + p_b{}'N_q + 0,4\gamma dN_\gamma)$$

$$= 0,096(1,3x32x8,1 + 153x2 + 0,4x17x0,35x0,7) = 61,884 \text{ kN}$$

$$Q_s\, friction = \sum Q_{s1} + Q_{s2} = 11,409 + 72,103 = 83,512 \text{ kN}$$

Wall friction resistance of the cohesion component as follows.

- The λ Method, Q_s = 424,541 kN
- the α Method, Q_s = 301,632 kN
- the U.S. Army Corps method, Q_s = 334,885 kN
- the Tomlinson method, Q_s = 349,531 kN

- $Q_u = Q_p + Q_s\, friction + Q_s cohesion - W_p$
- $Q_{u1} = 61,884 + 83,512 + 424,541 - 20,736 = 549,201$ kN
- $Q_{u2} = 61,884 + 83,512 + 301,632 - 20,736 = 426,292$ kN
- $Q_{u3} = 61,884 + 83,512 + 334,885 - 20,736 = 459,545$ kN
- $Q_{u4} = 61,884 + 83,512 + 349,531 - 20,736 = 474,191$ kN

Table 1. the net ultimate resistance (Q_u) at Bore Hole-9 static way

No	Point	Method	Q_p (kN)	Q_s friction (kN)	Q_s cohesion (kN)	Q_u (kN)
1	Bore Hole-9	λ	61,884	83,512	424,541	549,201
2	Bore Hole-9	α	61,884	83,512	301,632	426,292
3	Bore Hole-9	U.S. Army Corps	61,884	83,512	334,885	459,545
4	Bore Hole-9	Tomlinson	61,884	83,512	349,531	474,191

(Source: author's analysis)

The results of the analysis of the net ultimate resistance (Q_u) in the static way at the bore hole 6 can be seen in table 2 below.

$$W_p = L.A_p.W_c = 7x0,096x24 = 16,128 \text{ kN}$$

$Q_p = A_p.(N_c.c_u)$ = 0,096 x 9 x 55,9 = 48,298 kN

$Q_u = Q_p + Q_s - W_p$

$Q_{u1} = Q_p + Q_{s1} - W_p = 48,298 + 423,198 - 16,128 = 455,368$ kN

$Q_{u2} = Q_p + Q_{s2} - W_p = 48,298 + 286,396 - 16,128 = 318,566$ kN

$Q_{u3} = Q_p + Q_{s3} - W_p = 48,298 + 317,751 - 16,128 = 349,921$ kN

$Q_{u4} = Q_p + Q_{s4} - W_p = 48,298 + 369,445 - 16,128 = 401,615$ kN

Table 2. The net ultimate resistance (Q_u) at Bore Hole-6 static way

No	Point	Method	Q_p (kN)	Q_s (kN)	Q_u (kN)
1	Bore Hole-6	λ	48,298	423,198	455,368
2	Bore Hole-6	α	48,298	286,396	318,566
3	Bore Hole-6	U.S. Army Corps	48,298	317,751	349,921
4	Bore Hole-6	Tomlinson	48,298	369,445	401,615

(Source: author's analysis)

The results of the analysis of the net ultimate resistance (Q_u) in the static way at the bore hole 8 can be seen in table 3 below.

$W_p = L.A_p.W_c = 6x0,096x24 = 13,824$ kN

$Q_p = A_p(1,3cN_c + p_b{}'N_q + 0,4\gamma dN_\gamma)$

$= 0,096(1,3x42x8,9 + 90x2,4 + 0,4x15x0,35x1) = 67,588$ kN

$Q_s\, friction = \sum Q_{s1} + Q_{s2} = 8,4 + 32,35 = 40,75$ kN

Wall friction resistance of the cohesion component as follows.

- The λ method, Q_s cohesion = 326,849 kN
- The α method, Q_s cohesion = 225,256 kN
- The U.S. Army Corps method, Q_s cohesion= 256,134 kN
- The Tomlinson method, Q_s cohesion = 288,398 kN

$Q_u = Q_p + Q_s\, friction + Q_s cohesion - W_p$

$Q_{u1} = 67,588 + 40,75 + 326,849 - 13,824 = 421,363$ kN

$Q_{u2} = 67,588 + 40,75 + 225,256 - 13,824 = 319,77$ kN

$Q_{u3} = 67,588 + 40,75 + 256,134 - 13,824 = 350,648$ kN

$Q_{u4} = 67,588 + 40,75 + 288,398 - 13,824 = 382,912$ kN

Table 3. The net ultimate resistance (Q_u) at Bore Hole-8 static way

No	Point	Method	Q_p (kN)	Q_s friction (kN)	Q_s cohesion (kN)	Q_u (kN)
1	Bore Hole-8	λ	67,588	40,75	326,849	421,363
2	Bore Hole-8	α	67,588	40,75	225,256	319,77
3	Bore Hole-8	U.S. Army Corps	67,588	40,75	256,134	350,648
4	Bore Hole-8	Tomlinson	67,588	40,75	288,398	382,912

(Source: author's analysis)

Information :
W_c = concrete volume weight (kN/m^3)
A_p = cross sectional area of the lower end pole (m^2)
L = pole length (m)
W_p = pole self wight (kN)
Q_u = net supporting capacity (kN)
Q_p = ultimate bottom end resistance (kN)
Q_s = ultimate friction resistance (kN)

Permit Support Capacity (Q_a) based on the N-SPT Test

The results analysis of the permit support capacity (Q_a) based N-SPT test in the bore hole-9 can be seen in table 4 below.

$$Q_a = \frac{Q_u}{F}$$

$$Q_{a1} = \frac{Q_{u1}}{F} = \frac{2215,936}{3} = 738,645 \text{ kN}$$

$$Q_{a2} = \frac{Q_{u2}}{F} = \frac{1353,982}{} = 451,327 \text{ kN}$$

Table 4. Permit support capacity (Q_a) based N-SPT test in the bore hole-9

No	Point	Method	F	Q_u (kN)	Q_a (kN)
1	Bore Hole-6	Mayerhof	2,5	2215,936	738,645
2	Bore Hole-6	Schmertmann	2,5	1353,982	451,327

(Source: author's analysis)

The results analysis of the permit support capacity (Q_a) based N-SPT test in the bore hole-6 can be seen in table 5 below.

$$Q_a = \frac{Q_u}{F}$$

$$Q_{a1} = \frac{Q_{u1}}{F} = \frac{2257{,}934}{3{,}5} = 645{,}124 \text{ kN}$$

$$Q_{a2} = \frac{Q_{u2}}{F} = \frac{1431{,}95}{3{,}5} = 409{,}129 \text{ kN}$$

Table 5. Permit support capacity (Q_a) based N-SPT test in the bore hole-6

No	Point	Method	F	Q_u (kN)	Q_a (kN)
1	Bore Hole-6	Mayerhof	3,5	2257,934	645,124
2	Bore Hole-6	Schmertmann	2,5	1431,95	409,129

(Source: author's analysis)

The results analysis of the permit support capacity (Q_a) based N-SPT test in the bore hole-8 can be seen in table 6 below.

$$Q_a = \frac{Q_u}{F}$$

$$Q_{a1} = \frac{Q_{u1}}{F} = \frac{2183{,}25}{4} = 545{,}813 \text{ kN}$$

$$Q_{a2} = \frac{Q_{u2}}{F} = \frac{1283{,}203}{4} = 320{,}8 \text{ kN}$$

Table 6. Permit support capacity (Q_a) based N-SPT test in the bore hole-8

No	Point	Method	F	Q_u (kN)	Q_a (kN)
1	Bore Hole-6	Mayerhof	4	2183,25	545,813
2	Bore Hole-6	Schmertmann	4	1283,203	320,8

(Source: author's analysis)

Keterangan :

Q_u = net supporting capacity (kN)

Q_a = permit support capacity (kN)

F = safe factor

Comparison of Bearing Piles Carrying Capacity

From the results of the comparative analysis of the carrying capacity of the pile at bore hole-9 static way and the results of the N-SPT test, the two methods are compared with the results of the PDA (Pile Driving Analyzer) Test as described in table 7. below .

Tabel 7. Comparison of Bearing Piles Carrying Capacity at Bore Hole-9

No	Way of analysis	Method	Pile length (m)	Pile diameter (m)	net supporting capacity (Q_u) (kN)
1	Static	λ α U.S. Army Corps Tomlinson	9 9 9 9	0,35 0,35 0,35 0,35	549,201 426,292 459,545 474,191
2	N-SPT	Mayerhof Schmertmann	9 9	0,35 0,35	738,645 451,327
3	PDA *Test*	Dinamik	9	0,35	755, 116

(Source: author's analysis)

From the results of the comparative analysis of the carrying capacity of the pile at bore hole-6 static way and the results of the N-SPT test, the two methods are compared with the results of the PDA (Pile Driving Analyzer) Test as described in table 8. below .

Tabel 8. Comparison of Bearing Piles Carrying Capacity at Bore Hole-6

No	Way of analysis	Method	Pile length (m)	Pile diameter (m)	net supporting capacity (Q_u) (kN)
1	Static	λ α U.S. Army Corps Tomlinson Average	7 7 7 7 7	0,35 0,35 0,35 0,35 0,35	455,368 318,566 349,921 401,615 381,368
2	N-SPT	Mayerhof Schmertmann	7 7	0,35 0,35	645,124 409,129
3	PDA *Test*	Dinamik	7	0,35	657, 049

(Source: author's analysis)

From the results of the comparative analysis of the carrying capacity of the pile at bore hole-8 static way and the results of the N-SPT test, the two methods are compared with the results of the PDA (Pile Driving Analyzer) Test as described in table 9. below

Tabel 9. Comparison of Bearing Piles Carrying Capacity at Bore Hole-8

No	Cara Analisis	Metode	Panjang Tiang (m)	Diameter tiang (m)	Kapasitas dukung (Q_u) (kN)
1	Statik	λ α U.S. Army Corps	6 6 6	0,35 0,35 0,35	421,363 319,77 350,648

		Tomlinson	6	0,35	382,912
2	N-SPT	Mayerhof Schmertmann	6 6	0,35 0,35	545,813 320,8
3	PDA *Test*	Dinamik	6	0,35	608, 015

(Source: author's analysis)

CONCLUSION

Based on the results of the research and discussion described in the previous chapter, the following conclusions are obtained:

1. The results of the analysis of the carrying capacity of the pile based on the static method with the λ (Vijayvergiya & Focht, 1974) method of 549,201 kN; the α (McClelland, 1974) method of 426,292 kN; The U.S Army Corps Method is 459,545 kN and the Tomlinson Method (1977) is 474,191 kN. While the results of N-SPT were bearing piles bearing capacity with the Mayerhof method (1956) of 738,645 kN and the Schmertmann Method (1967) of 451,327 kN. Based on these results, the N-SPT test based on the Mayerhof Method (1956) of 738,645 kN was the closest to the PDA test results of 755,116 kN.
2. Comparison of the results of the analysis of the carrying capacity of piles based on static methods, N-SPT and PDA test is 19: 24: 30. This shows that the carrying capacity of static piles and PDA tests has a difference of 37% while between N-SPT and PDA tests has a difference of 20%.

REFERENCES

[1] Bemhardt, David. 2017. *AASHTO LFRD Bridge Design Specification.* America : AASHTO

[2] Fahriani, Ferra ; Yusti, Andi. Analisis Daya Dukung Pondasi Pancang Diverifikasi dengan Hasil Uji Pile Driving Analyzer Test dan Capwap (studi kasus Proyek Pembangunan Gedung Kantor Bank Sumsel Babel di Pangkalpinang. *Jurnal Fropil,* 2014, 2.1 : 19-31

[3] Hardiyatmo, Hary Christady . (2018). *Analisis dan Perancangan Fondasi II.* Yogyakarta : Gadjah Mada University Press.

[4] Silitonga, Ary Pardomuan ; Iskandar, Rudi. Perbandingan Daya Dukung Pondasi Tiang Pancang Metode Analitis dan Loading Test terhadap Metode Elemen Hingga Menggunakan Model Mohr-Coulomb dan Soft Soil pada Bore-Hole I (Studi kasus Pembangunan Rusunawa Jatinegara Barat Jakarta Timur). *Jurnal USU,* 2017, 1.7 : 15-29

[5] Sulha ; Sarita, Umran ; fitriah ; Sukri, Muhammad. Analisis Kapasitas Dukung Tiang Pancang Tunggal Berdasarkan Data N-SPT, CPT dan Kalendering. *Jurnal Stabilita,* 2019, 7.2 : 39-46

[6] Tanjung, Darlina ; Nusa, Ahmad Bima. Pengaruh Daya Dukung Pondasi Tiang Pancang pada Proyek Pembangunan GIS (Gas Insulated Switch Gear) Di Kecamatan Payung Sekaki Pekanbaru. *Buletin Utama Teknik,* 2018, 14.1 : 41-47