COMPARATIVE STUDY OF SINGLE STEEL PILE BEARING CAPACITY BETWEEN GEO5 SOFTWARE AND EMPIRICAL FORMULA METHOD

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***Abstract**: Pile foundation is a part of the Sub-structure that is used to receive and distribute loads from the superstructure to the ground at a certain depth, where it requires suitable bearing capacity. Empirical formula is the one of the methods for calculating pile bearing capacity that based on Standard Penetration Test (SPT) value. This method consumes plenty of time compared with the current method using Geo 5 software. However, the pile bearing capacity results among these methods should be verified beforehand. Therefore, it is necessary to do a comparison of pile bearing capacity laid on various soil types between the empirical formula and the Geo5 program based on SPT data to obtain the value of the correction factor and to find out which method is nearest to the Geo5 software. The Luciano Decourt empirical method results are closer to the Geo5 software for all soil types, both of the end bearing and floating pile conditions with ratio values of 0.90 and 1.09 for dominant clay, 0.97 and 0.96 for dominant silt, and 0.84 and 0.89 for dominant sand. As for the Bazaara Empirical Method, the results are closer to the Geo5 program for the dominant group of sand in floating pile conditions with a ratio value of 0.99. Hence, the Luciano Decourt's empirical formula is more recommended than Bazaara's empirical formula*.

Keywords: *Pile bearing capacity, empirical method, Geo5 program, correction factor, foundation*

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INTRODUCTION

Along with the increasing population growth in Indonesia, the demand for construction services is increasing. Therefore, many construction activities are carried out either by the government or the private sector. This focus can be seen when the government increased the infrastructure budget by 4.9 percent from IDR 399.7 trillion to IDR 419.2 trillion in the 2020 State Revenue and Expenditure Budget Plan (RAPBN) [1]. This means that more construction activities will be carried out in various places in Indonesia.

In construction activities, the subgrade as the foundation of a building on it has a very important role. If the soil has a good bearing capacity, then the construction work will be easier to do and at a lower cost. In fact, not all locations in Indonesia have good subgrade. It is estimated that around 20 million hectares or about 10 percent of the total land area of Indonesia is soft soil. The distribution of soft soil is generally found along the coast, including along the north coast of Java Island, the east coast of Sumatra Island, the south coast of Kalimantan Island, the east coast of Kalimantan Island, the south coast of Sulawesi Island, the west coast of Papua Island and the south coast of Papua Island [2]. To find out the map of the distribution of soft soil in Indonesia can be seen in Figure 1.

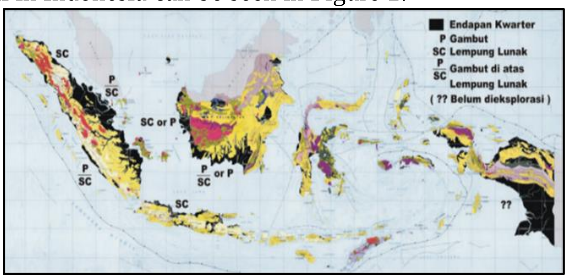

Figure 1 Map of the distribution of soft soil in Indonesia [3]

One way to overcome this is to use a type of deep foundation, such as a pile foundation. The foundation is part of an engineering system that transmits the load supported by the foundation and its own weight to the depth of the soil and rock that lies below it [4]. Pile foundations are used when the foundation soil at normal depths is unable to support the load, and hard soil is located at very deep depths. Likewise, if the building's foundation is on embankment soil that is high enough so that if the building is placed on the embankment, it will be subject to a large enough settlement [5].

The standard penetration test was carried out because of the difficulty of obtaining undisturbed soil samples in granular soils. In this test, soil properties are determined from direct relative density measurements in the field [6]. Determining the bearing capacity of the pile foundation can be done manually, namely by empirical means. This method is carried out based on calculations using soil data from the SPT test results taken from several locations in East Kalimantan and North Kalimantan with a total of 37 locations. However, calculating using this method manually will take longer and be a bit more difficult. Currently, there is a computer program to help calculate the carrying capacity value faster, namely the Geo5 program. However, for the calculation results, we do not know whether the bearing capacity values obtained from the Geo5 program and the empirical method have the same results or not. If different results are obtained for each method, both using empirical calculation methods and computer programs, as an engineer, it is expected to determine which method is the most profitable in addition to saving planning time.

In a previous study, Mina, E. [7] conducted a study by comparing the calculation of the pile bearing capacity between the empirical method and the Geo5 program. However, the drawback in this research is that the input data used is only one test data and the soil sample used is a mixture of clay and sand layers. For the calculation of the pile bearing capacity, the value obtained from the Geo5 program is 2.78 times higher than the calculation of the empirical method [7].

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Therefore, to complement some of the shortcomings of previous research, this study will conduct a study to compare the results of the calculation of the pile bearing capacity with the empirical method and the Geo5 program based on SPT data with more data and various types of soil groups. Furthermore, based on the results of these calculations, a comparison ratio value can be obtained which can be made into a correction factor value and can be used to determine the bearing capacity of the pile based on the dominant soil type base on SPT data.

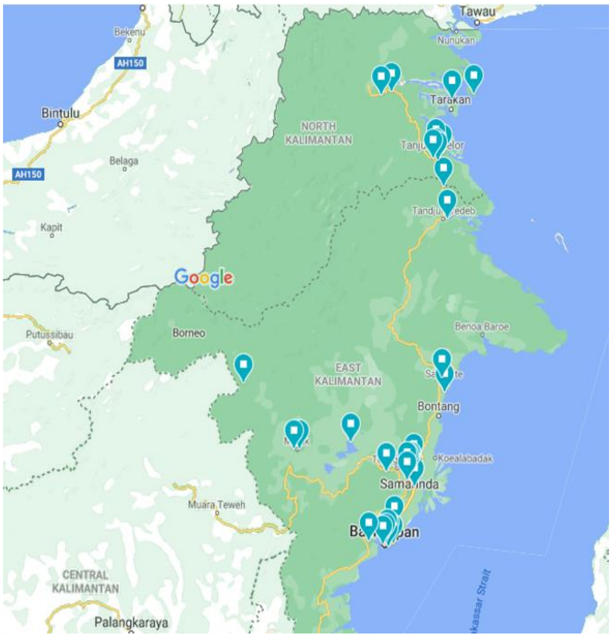

Figure 2 Map location of soil test point

RESEARCH SIGNIFICANCE

This paper examines how the results of a comparison of the calculation of the bearing capacity of pile foundations between the empirical method and the Geo5 program for end bearing and floating pile conditions are used to obtain a correction factor and to find out which method is closest to the Geo5 program for various soil conditions. Here also find out what factors influence the difference in the results of calculating the bearing capacity of steel piles between the empirical and Geo5 methods based on the original formula of each method.

The data used is soil sample data from the SPT test results from 37 different locations in East Kalimantan and North Kalimantan, which are then grouped based on the dominant soil type. It is divided into three groups, namely the dominant group of clay, silt and sand. The data for the sampling location of the soil used in this research can be seen in Figure 2 which obtained from plotting the area on google maps.

METHODOLOGY

In this study, the first step is to group the data samples according to the dominant soil type. Furthermore, the calculation of the bearing capacity of steel piles using 2 empirical methods on the conditions of end bearing piles and floating piles is carried out. The first is the Luciano Decourt method, 1978 and the second uses the Bazaara method, 1967 [8]. Then the calculations were carried out using a computer-aided program, namely the Geo5 application with a calculation formula based on the Decourt & Quaresma method [9]. The calculation only calculates the axial/vertical bearing capacity, does not calculate the horizontal carrying capacity and does not calculate the earthquake load. The piles used are cylindrical steel piles with a diameter of 60 cm. From the calculation results, a comparison ratio between methods is made, namely Luciano/Bazaara, Luciano/Geo5, and Bazaara/Geo5 based on the results of the average value of the comparison. If the average value of the comparison has a coefficient of variation value below 25%, then this value can be used as a correction factor, and if not, a calculation will be made to get an estimate of the appropriate interval value range base on [10].

ANALYSIS AND DISCUSSIONS

A. RESULTS OF CALCULATION OF PILE BEARING CAPACITY BASED ON SPT DATA (DOMINANTLY CLAY)

Calculation of pile bearing capacity based on laboratory data uses 2 methods, namely the manual calculation method based on the Luciano Decourt method and the Bazaara method, then the calculation method using a computer program, namely Geo5 (Decourt & Quaresma method). The results of the Q_{ult} calculation from the manual calculation method and the application for the clay dominant group sample can be seen in Table 1.

B. COMPARISON OF PILE BEARING CAPACITY LUCIANO VS GEO5 METHOD

To find out the comparison of Q_{ult} Luciano vs Geo5 in the sample of the dominant clay group, see Figure 3.

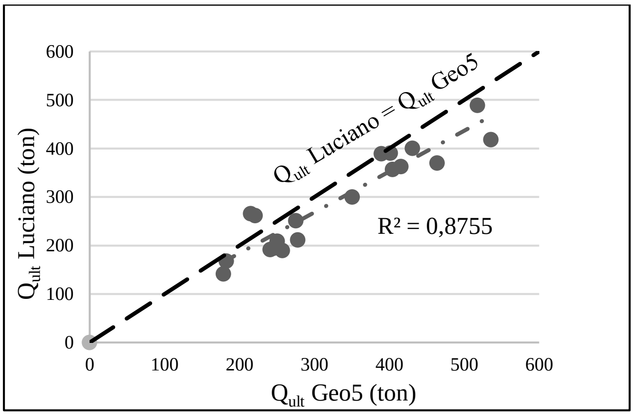

Figure 3 The results of the comparison of Q_{ult} Luciano vs. Q_{ult} Geo5 based on SPT data for the dominant soil group of clay (end bearing pile)

Based on Figure 3, it can be seen that the overall Q_{ult} Luciano value tends to have a lower value (underestimated) than the Q_{ult} Geo5. This can be proven where overall Q_{ult} points are spread below the Fitting Curve line and only a few are above the line. When viewed from the coefficient of determination (R square) which is 0.8755, it is included in the very strong category. This indicates that the relationship between the variables X and Y is very close and influence each other.

The difference in the Q_{ult} value between the Luciano and Geo5 methods occurs because of the difference in

Table 1 Results of calculation of pile bearing capacity based on SPT

No.	Location	Depth (m)	Q_{ult} (ton)		
			Manual (Empirical)		Application (Geo5)
			SPT	SPT	SPT
			Luciano Decourt	Bazaara	Decourt Quaresma
1	L01-BH01	17.50	251.33	481.75	275.27
2	L02-BH02	17.50	363.10	307.69	415.39
3	L02-BH03	15.50	300.09	248.30	350.56
4	L02-BH04	16.00	400.53	332.09	430.91
5	L02-BH05	15.00	357.23	326.47	404.29
6	L03-BH01	9.00	265.43	460.86	214.81
7	L05-BH03	15.00	390.87	677.27	401.30
8	L12-BH01	12.50	141.54	356.50	178.71
9	L13-BH01	13.50	189.96	483.71	257.13
10	L14-BH01	17.00	389.23	373.90	389.60
11	L15-BH01	6.00	418.60	870.22	535.71
12	L21-BH01	18.00	488.89	576.12	517.90
13	L27-BH01	11.50	208.65	496.56	250.61
14	L27-BH02	12.00	369.81	418.74	463.95
15	L28-BH01	13.50	194.26	405.63	245.50
16	L32-BH01	13.50	191.88	471.77	240.84
17	L02-BH01	15.00	261.87	414.95	220.80
18	L05-BH01	7.00	168.10	575.26	182.50
19	L34-BH01	21.00	211.76	460.16	277.73

formula parameter retrieval in the two methods. Among them for the value of the end bearing capacity (Q_p), taking the value of the coefficient of soil characteristics (K_{dq}) is different between the Luciano and Geo5 methods. The K_{dq} value in the Luciano method is more varied depending on the type of soil compared to the K_{dq} Geo5. Then the N_{SPT} value used in the Luciano method to find the end bearing capacity (Q_p) is the average N_{SPT} value of about 4B above to 4B below the base of the foundation pile, while the Geo5 method used is the N_{SPT} value at the end of the pile foundation. This causes the Q_p value for the Luciano method to be smaller when compared to the Geo5 method.

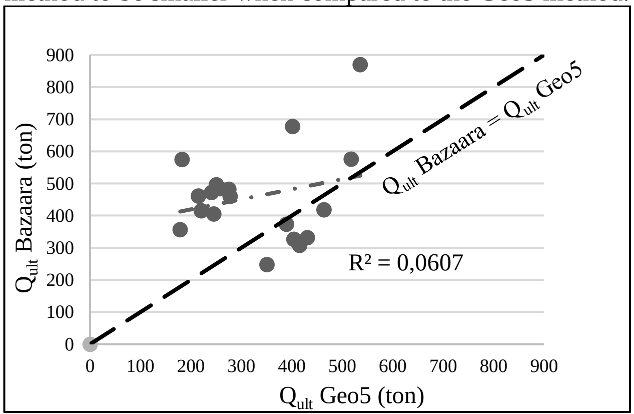

Figure 4 The results of the comparison of Q_{ult} Bazaara vs. Q_{ult} Geo5 based on SPT data for the dominant soil group of clay (end bearing pile)

For the calculation of the blanket bearing capacity (Q_s) the difference occurs in taking the N_{SPT} value used in the calculation. In Luciano's method, the N_{SPT} value used is the average value of N_{SPT} along the embedded foundation pile. As for the Geo5 method, the N_{SPT} value used is the average value of N_{SPT} at the tip and 1 layer above the foundation base. This will result in the Q_s value for the Luciano method will be smaller when compared to the Geo5 method.

C. COMPARISON OF PILE BEARING CAPACITY BAZAARA VS GEO5 METHOD

To find out the comparison of Q_{ult} Bazaara vs Geo5 in the sample of the dominant clay group, see Figure 4. Based on Figure 4, it can be seen that the Q_{ult} Bazaara value tends to have a higher value (overestimated) than the Q_{ult} Geo5, this can be proven where there are many Q_{ult} points scattered above the Fitting Curve line and a few are below the line. Then when viewed from the value of the coefficient of determination (R square) which is 0.0607, it is included in the very small category which indicates that the relationship between variables X and Y is very low or not very close.

The difference in Q_{ult} values between the Bazaara and Geo5 methods occurs because of the different formulas in the two methods. Among them for the value of the end bearing capacity (Q_p), the Bazaara method uses the value of $\bar{N}$ which is the average value of N_{SPT} 4D below the pile tip to 8D above the pile tip. While the Geo5 method, the N_{SPT} value used is the value at the end or base of the foundation. For the Geo5 method, using the alpha coefficient (coefficient of the pile base) which depends on the type of foundation used, while for the Bazzara method it does not use these parameters. The Bazaara method uses a multiplier coefficient which has a fixed value and does not depend on the type of soil, which is 40. Meanwhile, the Geo5 method uses a K_{dq} coefficient whose value varies between (12-40) depending on the type of soil. This results in the Q_p value for the Geo5 method tends to be smaller when compared to the Bazaara method, especially when the layer at the end of the pile is sandy soil.

For the calculation of the blanket bearing capacity (Q_s), the Bazaara method uses the parameter Cl_i, namely the value of N/2 for clay soils and N/5 for sandy soils where N is the N_{SPT} value at the end of the pile. As for the Geo5 method, using a value (N/3+1) which does not depend on the type of soil with N being the average value of N_{SPT} at

Table 2 Q_{ult} difference ratio results between manual calculations and auxiliary programs

No.	Location	Depth (m)	Q_{ult} (ton) Manual (Empirical) SPT Luciano Decourt	SPT Bazaara	Program (Geo5) SPT Decourt Quaresma	Comparison ratio Luciano/ Geo5	Bazaara/ Geo5	Luciano/ Bazaara
1	L01-BH01	17.50	251.33	481.75	275.27	0.91	1.75	0.52
2	L02-BH02	17.50	363.10	307.69	415.39	0.87	0.74	1.18
3	L02-BH03	15.50	300.09	248.30	350.56	0.86	0.71	1.21
4	L02-BH04	16.00	400.53	332.09	430.91	0.93	0.77	1.21
5	L02-BH05	15.00	357.23	326.47	404.29	0.88	0.81	1.09
6	L03-BH01	9.00	265.43	460.86	214.81	1.24	2.15	0.58
7	L05-BH03	15.00	390.87	677.27	401.30	0.97	1.69	0.58
8	L12-BH01	12.50	141.54	356.50	178.71	0.79	1.99	0.40
9	L13-BH01	13.50	189.96	483.71	257.13	0.74	1.88	0.39
10	L14-BH01	17.00	389.23	373.90	389.60	1.00	0.96	1.04
11	L15-BH01	6.00	418.60	870.22	535.71	0.78	1.62	0.48
12	L21-BH01	18.00	488.89	576.12	517.90	0.94	1.11	0.85
13	L27-BH01	11.50	208.65	496.56	250.61	0.83	1.98	0.42
14	L27-BH02	12.00	369.81	418.74	463.95	0.80	0.90	0.88
15	L28-BH01	13.50	194.26	405.63	245.50	0.79	1.65	0.48
16	L32-BH01	13.50	191.88	471.77	240.84	0.80	1.96	0.41
17	L02-BH01	15.00	261.87	414.95	220.80	1.19	1.88	0.63
18	L05-BH01	7.00	168.10	575.26	182.50	0.92	3.15	0.29
19	L34-BH01	21.00	211.76	460.16	277.73	0.76	1.66	0.46

the tip and 1 layer above the foundation base. Then the Geo5 method uses the beta parameter (coefficient of pile friction) which depends on the type of foundation used, while the Bazaara method does not use these parameters. This will cause the Q_s value for the Bazaara method to be higher than the Geo5 method for clay dominant soils.

D. COMPARISON OF PILE BEARING CAPACITY LUCIANO VS BAZAARA METHOD

To find out the comparison of Q_{ult} Luciano vs Bazaara in the sample of the dominant clay group, see Figure 5.

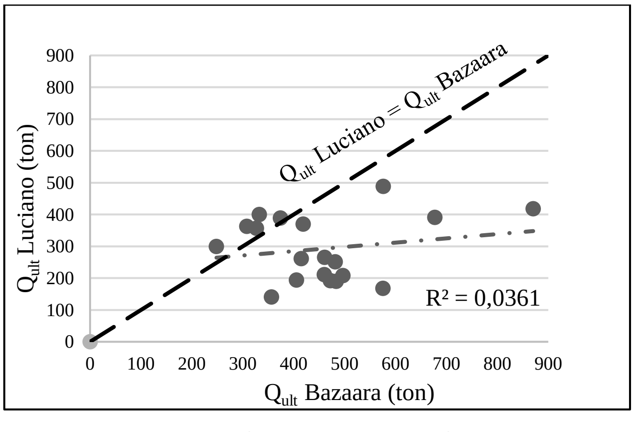

Figure 5 The results of the comparison of Q_{ult} Luciano vs. Q_{ult} Bazaara based on SPT data for the dominant soil group of clay (end bearing pile)

Based on Figure 5, it can be seen that the Q_{ult} Luciano value tends to have a lower value (underestimated) than the Q_{ult} Bazaara, this can be proven where there are many Q_{ult} points scattered below the Fitting Curve line and very few are above the line. When viewed from the coefficient of determination (R square) which is 0.0361, it is included in the very small category which tends to have similarities to the R square value between the Bazaara and Geo5 methods. This indicates that the relationship between variables X and Y is very low or not very close.

The difference in the Q_{ult} value between the Luciano and Bazaara methods occurs because of the different formulas in the two methods. Among them for the value of the end bearing capacity (Q_p), for the Geo5 method using the K_{dq} coefficient whose value varies depending on the type of soil. While the Bazaara method uses a multiplier coefficient which is fixed and does not depend on the type of soil, which is 40. This causes the Q_p value in the Luciano method to be smaller than that of Bazaara, especially when the pile tip layer is sandy soil. Then the N_{SPT} value used in the Luciano method to find the end bearing capacity (Q_p) is the average N_{SPT} value of about 4B above to 4B below the base of the foundation pile, while the Bazaara method uses the $\overline{N}$ value which is the average price of N_{SPT} 4D below pole end until 8D above the pole end. For the Luciano method, using the alpha coefficient (coefficient of pile base) which depends on the type of foundation used, while the Bazaara method does not use these parameters.

For the calculation of the blanket bearing capacity (Q_s), the Luciano method uses the value (N_s/3+1) which does not depend on the type of soil where Ns is the average value of N_{SPT} along the embedded pile. While the Bazaara method uses the parameter Cl_i, namely the value of N/2 for clay soils and N/5 for sandy soils where N is the N_{SPT} value at the end of the pile. Whereas. Then the Luciano method uses the beta parameter (coefficient of pile friction) which depends on the type of foundation used, while the Bazaara method does not use these parameters. This will result in the Q_s value for the Luciano method tends to be smaller when compared to the Bazaara method.

Based on the comparison between manual calculations and auxiliary programs, the difference between manual calculations and auxiliary programs can be obtained as shown in Table 2. Then from these results obtained the average value of the difference, the value of the standard deviation and coefficient of variation between manual calculations, and auxiliary programs as shown in Table 3.

Table 3 The results of the average ratio of Q_{ult} differences between manual calculations and auxiliary programs based on SPT data for the dominant clay soil group (end bearing pile)

No.	Ratio	N	SD	COV (%)
1	Luciano/Geo5	0.90	0.131	14.6
2	Bazaara/Geo5	1.55	0.618	40.0
3	Luciano/Bazaara	0.69	0.309	44.8

Based on Table 3, it can be seen that the calculation using the Bazaara method produces greater carrying capacity than when using auxiliary programs and other manual methods, where the Bazaara method is approximately 1.55 times greater than Geo5. The Luciano method has a value of 0.90 times compared to Geo5, this indicates that the bearing capacity of Geo5 based on SPT data is greater than the Luciano method. Meanwhile, the comparison of manual calculations between the Luciano and Bazaara methods is 0.69. This shows that the carrying capacity produced by the Bazaara method is greater than the Luciano method.

When viewed from the standard deviation value, which is a measure of how spread out the numbers are in a data set, the comparison between the Luciano and Geo5 methods has the smallest value of 0.131. This shows that the closer the value of a data point is to its average value, the smaller the deviation level.

Then when viewed from the coefficient of variation value, it is a statistical value that shows the relationship between one data set and another. From the three comparison ratios, it can be seen that the Luciano/Geo5 method has a coefficient of variation value below 25%, which means that the average value of the comparison can be directly used as a correction factor.

Meanwhile, the Bazaara/Geo5 and Luciano/ Bazaara methods have coefficient of variation values above 25% so the average value of the comparison cannot be directly used as a correction factor. Furthermore, to find out the limit of the average value interval to be used, it can be seen through the following calculations.

D.1 INTERVAL ESTIMATION CALCULATION FOR BAZAARA/GEO5 METHOD MEAN

For small samples (n<30)

Known: $\bar{X}$ = 1.55; σ = 0.618; $z_{0.005}$ = 2.878 (level of confidence 99%)

99% confidence interval for the Bazaara/Geo5 average ratio:

$$\bar{X} - t_{\alpha/2}.\frac{s}{\sqrt{n}} < \mu < \bar{X} + t_{\alpha/2}.\frac{s}{\sqrt{n}} \qquad (1)$$

1.55 - 2.878(0.618/√19) < μ < 1.55 + 2.878(0.618/√19)

1.14 < μ < 1.95

So, it can be trusted 99% that the average value of the Bazaara/Geo5 ratio is between 1.14 to 1.95.

D.2 INTERVAL ESTIMATION CALCULATION FOR LUCIANO/BAZAARA METHOD MEAN

For small samples (n<30)

Known: $\bar{X}$ = 0.69; σ = 0.309; $z_{0.005}$ = 2.878 (level of confidence 99%)

99% confidence interval for the Luciano/Bazaara average ratio:

$$\bar{X} - t_{\alpha/2}.\frac{s}{\sqrt{n}} < \mu < \bar{X} + t_{\alpha/2}.\frac{s}{\sqrt{n}} \qquad (2)$$

0.69 - 2.878(0.309/√19) < μ < 0.69 + 2.878(0.309/√19)

0.49 < μ < 0.89

So, it can be trusted 99% that the average value of the Luciano/Bazaara ratio is between 0.49 to 0.89.

In the same way as the calculation of the pile bearing capacity in the end bearing pile condition, the results of the average value difference, standard deviation value and coefficient of variation between manual calculations and auxiliary programs in floating pile conditions can be seen in Table 4.

Table 4. The results of the average ratio of Q_{ult} differences between manual calculations and auxiliary programs based on SPT data for the dominant clay soil group (floating pile)

No.	Ratio	N	SD	COV (%)
1	Luciano/Geo5	1.09	0.249	22.7
2	Bazaara/Geo5	1.27 – 2.22	0.643	36.9
3	Luciano/Bazaara	0.51 – 0.91	0.275	38.7

E. COMPARISON OF BEARING CAPACITY BASED ON SPT DATA (DOMINANTLY SILT)

In the same way as the calculation of the pile bearing capacity for the clay dominant soil group, then from these results obtained the average value of the difference ratio, the standard deviation value and the coefficient of variation between manual calculations and auxiliary programs on the silt dominant soil group for end bearing piles as in Table 5 and floating pile as in Table 6.

Table 5 The results of the average ratio of Q_{ult} differences between manual calculations and auxiliary programs based on SPT data for the dominant silt soil group (end bearing pile)

No.	Ratio	N	SD	COV (%)
1	Luciano/Geo5	0.97	0.073	7
2	Bazaara/Geo5	1.51	0.321	21
3	Luciano/Bazaara	0.67	0.128	19

Table 6 The results of the average ratio of Q_{ult} differences between manual calculations and auxiliary programs based on SPT data for the dominant silt soil group (floating pile)

No.	Ratio	N	SD	COV (%)
1	Luciano/Geo5	0.96	0.119	12
2	Bazaara/Geo5	1.25	0.308	25
3	Luciano/Bazaara	0.80	0.152	19

Table 7 The results of the average ratio of Q_{ult} differences between manual calculations and auxiliary programs based on SPT data for the dominant sand soil group (end bearing pile)

No.	Ratio	N	SD	COV (%)
1	Luciano/Geo5	0.84	0.083	10.0
2	Bazaara/Geo5	0.83	0.149	17.9
3	Luciano/Bazaara	1.02	0.131	12.8

Table 9 Factors that affect the difference in the calculation of the pile bearing capacity based on SPT data

Factors	The Calculation Method		
	Luciano Decourt	Bazaara	Geo5
Formula	$Q_p = \alpha.K_{dq}.N_p.A_p$ $Q_s = \beta.\left(\frac{N_s}{3}+1\right).A_{s,i}$	$Q_p = 40\overline{N} \times A_p$ $Q_s = \left(\frac{N_i}{2}\right).A_{s,i}(cohesive)$ $Q_s = \left(\frac{N_i}{5}\right).A_{s,i}(non-cohesive)$	$Q_p = \alpha.K_{dq}.N.A_p$ $Q_s = \beta.\left(\frac{N_i}{3}+1\right).A_{s,i}$
Tip bearing capacity (Q_p)	The value of the coefficient of soil characteristics (K_{dq}) used varies depending on the type of soil	Using a fixed value of the coefficient is 40	The value of the coefficient of soil characteristics (K_{dq}) used varies depending on the type of soil
	The N_{SPT} value used is an average of 4D above – 4D below the base of the pile	The N_{SPT} value used is an average of 8D above – 4D below the base of the pile	The N_{SPT} value used is at the end of the pile
	Using the basic coefficient of the pile (α) whose value is 1 (steel pile)	Do not use pile base coefficient	Using the basic coefficient of the pile (α) whose value is 1 (steel pile)
Side bearing capacity (Q_s)	Using the pile friction coefficient (β) whose value is 1 (steel pile)	Do not use pile friction coefficient	Using the pile friction coefficient (β) whose value is 1 (steel pile)
	The N_{SPT} value used is (N/3+1), where N is the average along the embedded pile	The N_{SPT} value used is N/2 for cohesive soil and N/5 for non-cohesive soil, where N is the N_{SPT} value at the end of the pile	The N_{SPT} value used is (N/3+1), where N is the average value of N_{SPT} at the tip and 1 layer above the foundation base

Table 8 The results of the average ratio of Q_{ult} differences between manual calculations and auxiliary programs based on SPT data for the dominant sand soil group (floating pile)

No.	Ratio	N	SD	COV (%)
1	Luciano/Geo5	0.89	0.095	10.6
2	Bazaara/Geo5	0.84 – 1.14	0.345	35.0
3	Luciano/Bazaara	0.96	0.190	19.7

F. COMPARISON OF BEARING CAPACITY BASED ON SPT DATA (DOMINANTLY SAND)

In the same way as the calculation of the pile bearing capacity for the clay dominant soil group, then from these results obtained the average value of the difference ratio, the standard deviation value and the coefficient of variation between manual calculations and auxiliary programs on the silt dominant soil group for end bearing piles as in Table 7 and floating pile as in Table 8. Based on the explanation above, then a summary of the factors that affect the difference in the calculation of the foundation bearing capacity based on the SPT data can be seen in Table 9.

CONCLUSIONS

From the results and discussion in the previous chapter, it can be concluded that the results of the calculation of the bearing capacity of steel piles using the empirical method compared with the auxiliary program in general based on SPT data show that the Luciano Decourt method in the end bearing pile and floating pile conditions has varying values compared to the Geo5 method, with values respectively 0.90 and 1.09 times. for the clay dominant sample, 0.97 and 0.96 times for the silt dominant sample, and 0.84 and 0.89 times for the sand dominant sample. While the results of the comparison between the Bazaara and Geo5 methods on the conditions of the end bearing pile and floating pile are 1.14-1.95 and 1.27-2.22 times for the clay dominant sample, 1.51 and 1.25 times for the silt dominant sample, and 0.83 and 0.99 times for the sand dominant sample.

For the calculation of the bearing capacity of single steel piles using the empirical method in general, based on SPT data, it shows that the Luciano Decourt method in the end bearing pile and floating pile conditions has a smaller value than the Bazaara method, with values respectively 0.49-0.89 and 0.5-0.9 times for clay dominant soil samples, 0.67 and 0.80 times for silt dominant samples, 1.02 and 0.96 times for sand dominant samples. samples, and 0.97 times for the sand dominant sample. Furthermore, the comparison ratio value can be used as a correction factor according to the method to be used based on the dominant type of soil.

The Luciano decourt empirical method results are closer to the Geo5 auxiliary program for all soil groups, both end bearing pile conditions and floating pile conditions, so it is more recommended.

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