Sheet-Pile Foundation for Flood Control of Musi river Basin

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Sheet-Pile Foundation for Flood Control of Musi river Basin

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Abstract— **Pile foundation serves to carry load. Each foundation must be capable of supporting load up to a predeterminet safety limits, including supporting the maximum possible loads. The purpose of this study was to quantify and compare the axial bearing capacity of piles using the SPT data with Mayerhof and Briaud Et Al methods, and also using the numerical methods with the helps of Plaxis 2D 8.2 Version Program. The difference of bearing capacity may caused by the difference of soil, testing methods which depends on the accuracy of operator and the difference of the parameters used in each calculation.**

Keywords—*axial bearing capacity, pile foundation, numerical methods, flaxis programme*

I. INTRODUCTION

Geographically, the Musi River is located at 02° 58 '12 "- 04° 59' 24" LS and 103° 34 '12 "- 105° 0' 36" BT with an area of 7,760,222.86 Ha and an average width of 504 M. Musi River is divided into 22 sub watershed that belongs to 4 (four) provinces in Sumatera Island namely South Sumatra, Bengkulu, Jambi and Lampung. (Source: BPS 2011, and FDAS South Sumatra). With this wide coverage area, the Musi River area is a potential area with rapid development. On the banks of this river there are commercial, residential, and public spaces. This leads to the need for adequate riverside construction to support regular activities on the river banks [3].

The soil condition located on the banks of the Musi River is a land consisting of sand and mud that are at risk of movement of the soil and causing sliding. Efforts to prevent sliding can be done with several methods that can be used one of them is using sheet pile as a retaining ground. Sheet pile is a continuous wall construction made by connecting interlocking pieces/sections aimed at resisting horizontal pressures from soil and water. The type of sheet pile to be covered is a sheet pile with pile reinforcement. To avoid damage and collapse, single and group pile foundations must have a strong carrying capacity to carry the construction load on it. In order for the pile that interacts with the soil has an accurate carrying it is necessary to conduct an accurate ground investigation as well. So the authors do the analysis based on soil conditions to obtain accurate pile bearing power through analytical and numerical methods with Plaxis 2D Software Version 8.2.
it is necessary to conduct an accurate ground investigation as well. So the authors do the analysis based on soil conditions to obtain accurate pile bearing power through analytical and numerical methods with Plaxis 2D Software Version 8.2.
Based on the background above, the problem of this research is how the comparison of the analysis results of the axial bearing power of single piles from the results of analytical methods with SPT and numerical data ?.

Piles are construction parts made of wood, concrete, and or steel, which are used to forward (transmit) surface loads to lower surface levels in the soil mass [5]. The use of pile as a foundation of the structure if the soil under the base of the structure does not have enough bearing capacity to bear the weight of the structure and the loads that work on it.

Or if the soil has sufficient carrying capacity to carry the weight of the structure and all working loads are in a very deep layer from the soil surface depth of more than 8 m [5] .

In the execution of erection is generally erected perpendicular in the ground, but there is also battle pile to be able to with stand horizontal forces that work, This kind of thing often occurs on the dock where there is sideways pressure from ships and boats. The angle of the slope that can be reached by the pole depends on the tools used and also adjusted with the planning [5].

A. Power Capacity Supporting Foundation Pole Analysis Methods

The Standard Penetration Test (SPT) is a kind of dynamic experiment by including a tool called split spoon into the ground. With this experiment will be obtained relative density (relative density), soil shear angle (Φ) based on the value of the number of strokes (N) [6].
Estimated capacity of bearing capacity of pile foundation on sand and silt ground based on SPT field test data, determined by formulation as follows:

Mayerhof, 1976 for non-cohesive soil as:

$$Qp = 40.\ N\text{-}SPT.\ L / D.\ Ap < 400.\ N\text{-}SPT\ Ap \tag{1}$$

$$Qs = 0.2.\ N\text{-}SPT.\ p.\ Li \text{ (for sand land)} \tag{2}$$

$$Qs = 0.5\ .N\text{-}SPT.\ p.\ Li \text{ (for clay)} \tag{3}$$

Where :
Qs = Shear resistance, KN
Li = Length of soil layer, m
P = circumference of pole, m

Mayerhof, 1976 for cohesive soil below:

$$Qp = 9.\ Cu.\ Ap \tag{4}$$

For prisoner shear blanket pole:

Qs =. Cu. p. Li (5)

Cu = N-SPT$^{2/3}$. 10 (6)

Where :

= Coefficient Adhesion between ground and pole

Cu = Cohesion

p = Circumference pole

Li = Length of ground layer

Briand et al (1985):

Qb = Ab. 19.7. r. N-SPTi.0.36 (7)

Qs = As. 0.224. r. N-SPTi.0.29 (8)

Where :

Qb = KN tip resistance

Qs = Shear resistance (friction) KN

N-SPT = Average SPT value

Ab = Area of pole end

As = Area of pole blanket

r = Reference voltage 100 kN/m^2

B. Power Capacity Supporting Numerical Methods

The Plaxis program was developed in 1987 by Deft University Of Technology, Deft, The Netherlands [7]. This program is a program approach of finite element method principle in analysis some complex geotechnical problems. The basic concept of this program divides the infinitesimal small elements of irregular triangles (meshing). At the vertex of the triangle represents an unknown value of deformation. The study used the Plaxis program to determine the carrying capacity of the foundation and the decline that occurred due to the building load above it.

To analyze the carrying capacity and decrease of pile foundation in Plaxis, soil parameter parameters such as; weight of soil type (γ), Young Modulus (E), poison ratio (v), cohesion (c), shear angle (f), and permeability (k). In his research [6] proposed an N-SPT correlation with heavier volume and shear strength values, as in tables

TABLE I. THE WEIGHT VALUE OF SOIL TYPE (Γ) BASED ON SOIL CONSISTENCY

Type	Soil description	Unit Weight range (KN/m3)	
		Dry	Saturated
Cohesionless	Soft sedimentary		
	(Chalk,Shale,Siltstone, Coal)		
Compacted	Hard Sedimentary		
Broken rock	(Conglomerate, Sandstone)		
	Methamorpic		
	Igneus		
Cohesionless	Verry Loose		
	Loose		
Sand and	Medium dense		
Gravels	Dense		
	Verry dense		
	Loose		
Cohesionless	Uniformly graded		
	Well graded		
Sands	Dense		
	Uniformly graded		
	Well graded		
	Soft-Organic		
Cohesive	Soft-non Organic		
	Stiif		
	Hard		

TABLE II. DESCRIPTION OF CLAY CONSISTENCY BASED ON N-SPT DATA

Material	Describtion	SPT –N	Strength
Clay	V. Soft	≤	0-12 kpa
	Soft	2-5	12-15 kpa
	Firm	5-10	25-50 kpa
	Stiiff	10-20	50-100 kpa
	V.Stiff	20-40	100-200 kpa
	Hard	>40	>200 kpa

Meanwhile "Analysis of Pile Foundation's Bearing Capacity of 13-14 Ulu Sheet Pile, Palembang" aims to:

1. Acquired the axial carrying capacity of a single pile foundation based on several methods.
2. Knowing and analyzing the comparison of bearing capacity of pile foundation from analytical and numerical method.

C. Limitation of The Reseach

Limitations of the research are:

1. The type of reinforcement to be analyzed for its axial carrying capacity is a single pile.
2. Data obtained from field investigation results are SPT (Standard Penetration Test)
3. Other soil parameters obtained from the correlation of data and table specification of the commonly used literature.
4. This research uses analytical and numerical methods (Plaxis 2D Version 8.2)
5. The point to be reviewed is the point BH-01, BH-02 and BH-03.

II. MATERIAL AND METHOD

An easy way to comply with the conference paper formatting requirements is to use this document as a template and simply type your text into it.

A. Location and Data Collection

The location of this analysis lies in the sheet pile building along the banks of Musi River 13-14 Ulu Seberang Ulu II district of Palembang City. This plaster construction uses pile as the foundation structure, hence the necessity of analysis of bearing pile support. Map Location analysis can be seen in Fig. 1.

Fig 1. Research location

The data used in the writing of this thesis is derived from the collection of reference books related to the title for the literature study process. Furthermore, secondary data collection is data obtained indirectly in the form:

Standard Penetration Test conducted by 3 points of drilling along the banks of Musi River 13-14 Ulu District Seberang Ulu II of Palembang City. This data is used to obtain the soil parameters used in the analysis. These parameters include the N-SPT (correction), the weight of the soil, permeability, cohesion, internal shear angle, and dilatation to be used in the calculation of bearing capacity of piles either by analytical or numerical methods.

B. Data Analysis

In this study, the calculation of pile bearing capacity is analysis and numerical. The calculation of bearing pile support capacity by using Meyerhof and Briand et al method, while calculation of bearing pile power numerically using Plaxis 2D V 8.2 programme.

III. RESULTS AND DISCUSSION

A. N-SPT

The N-SPT data for the calculation of the carrying capacity of the Meyerhof and Briand Et Al piles was obtained from the Land Investigation Report of Musi River Retrograde Development 2016 at three points of drilling which can be seen in the following table

TABLE III. THE VALUE OF N-SPT AT POINT BH-01

Depth (m)	N-SPT	NB-1	NB-2	N-SPT Value
2,00	1	4,5	4,5	4,5
4,00	8	4,5	4,5	4,5
6,00	1	1	1	1
8,00	1	2	4,5	3,25
10,00	3	8,5	2	5,25
12,00	14	12,5	7,5	10
14,00	11	12,5	7	9,75
16,00	14	19	14	16,5
18,00	24	30	17,5	23,75
20,00	36	39,5	25	32,25
22,00	43	46,5	33,5	40
24,00	50	50,5	43	46,75
26,00	51	52	47	49,5
28,00	53	53,5	51,5	52,5
30,00	54	56,5	52,5	54,5
33,00	59	59	56,5	57,75

TABLE IV. THE VALUE OF N-SPT AT POINT BH-02

Depth (m)	N-SPT	NB-1	NB-2	N-SPT Value
2,00	2	3	3	3
4,00	4	3	3	3
6,00	2	2,5	2	2,25
8,00	3	3,5	3,5	3,5
10,00	4	7	3	5
12,00	10	11	6,5	8,75
14,00	12	13	8	10,5
16,00	14	18,5	12	15,25
18,00	23	27,5	17,5	22,5
20,00	32	36,5	23	29,75
22,00	41	43,5	32	37,75
24,00	46	48	39	43,5
26,00	50	52	45,5	48,75
28,00	54	54	50	52
30,00	54	56	52	54
32,00	58	59	56	57,5
34,00	60	60	57	58,5

TABLE V. THE VALUE OF N-SPT AT POINT BH-03

Depth (m)	N-SPT	NB-1	NB-2	N-SPT Value
2,00	1	2,5	2,5	2,5
4,00	4	4	2,5	3,25
6,00	4	3,5	2,5	3
8,00	3	3,5	3,5	3,5
10,00	4	7,5	4	5,75
12,00	11	11,5	7	9,25
14,00	12	13	8	10,5
16,00	14	18,5	12,5	15,5
18,00	23	30,5	17,5	24
20,00	38	40	26	33
22,00	42	46,5	32,5	39,5
24,00	51	51	44,5	47,75
26,00	51	52,5	46,5	49,5
28,00	54	54,5	52,5	53,5
30,00	55	56	53	54,5
33,00	57	58,5	56	57,25
35,00	60	60	57,5	58,75

B. Analysis of Pile's Axial Bearing Capasity with Empirical Methods

The carrying capacity of the pole foundation by the Meyerhof method is obtained from the sum of pole ends (Qp) and shear resistance (Qs). To calculate the carrying capacity of the pole at a depth of 24 meters is as follows:

TABLE VI. THE CALCULATION RESULTS OF PILE'S AXIAL BEARING CAPACITY OF THE SPT DATA AT THE POINT BH-01 WITH MEYERHOF METHODS

Depth (m)	Qp (kN)	Qs (kN)	Q ult (KN)	Q all (ton)
2,00	53,04	88,63	141,66	5,67
4,00	53,04	177,26	230,29	9,21
6,00	11,79	62,86	74,64	2,99
8,00	38,30	272,38	310,68	12,43
10,00	61,88	482,90	544,78	21,79
12,00	117,86	722,86	840,71	33,63
14,00	114,91	826,54	941,45	37,66
16,00	194,46	1133,94	1328,41	53,14
18,00	279,91	1262,96	1542,87	61,71
20,00	380,09	1858,21	2238,30	89,53
22,00	471,43	2175,70	2647,12	105,88
24,00	550,98	2774,01	3324,99	133,00
26,00	583,39	3181,95	3765,35	150,61
28,00	618,75	3634,40	4253,15	170,13
30,00	642,32	4042,34	4684,66	187,39
33,00	680,63	4711,74	5392,37	215,69

TABLE VII. THE CALCULATION RESULTS OF PILE'S AXIAL BEARING CAPACITY OF THE SPT DATA AT THE POINT BH-02 WITH MEYERHOF METHODS

Depth (m)	Qp (kN)	Qs (kN)	Q ult (KN)	Q all (ton)
2,00	35,36	62,86	98,21	3,93
4,00	35,36	125,71	161,07	6,44
6,00	26,52	141,43	167,95	6,72
8,00	41,25	293,33	334,58	13,38
10,00	58,93	0,00	58,93	2,36
12,00	103,13	704,00	807,13	32,29
14,00	123,75	847,00	970,75	38,83
16,00	179,73	1086,38	1266,11	50,64
18,00	265,18	1315,29	1580,46	63,22
20,00	350,63	1683,00	2033,63	81,35
22,00	444,91	2053,31	2498,22	99,93
24,00	512,68	2581,17	3093,84	123,75
26,00	574,55	3133,74	3708,30	148,33
28,00	612,86	3599,79	4212,64	168,51
30,00	636,43	4005,26	4641,69	185,67
32,00	677,68	4549,18	5226,86	209,07
34,00	689,46	4917,57	5607,03	224,28

TABLE VIII. THE CALCULATION RESULTS OF PILE'S AXIAL BEARING CAPACITY OF THE SPT DATA AT THE POINT BH-03 WITH MEYERHOF METHODS

Depth (m)	Qp (kN)	Qs (kN)	Q ult (KN)	Q all (ton)
2,00	29,46	52,38	81,85	3,27
4,00	38,30	136,19	174,49	6,98
6,00	35,36	188,57	223,93	8,96
8,00	41,25	293,33	334,58	13,38
10,00	67,77	496,96	564,73	22,59
12,00	109,02	697,71	806,73	32,27
14,00	123,75	847,00	970,75	38,83
16,00	182,68	1078,21	1260,89	50,44
18,00	282,86	1267,20	1550,06	62,00
20,00	388,93	1631,77	2020,70	80,83
22,00	465,54	2148,50	2614,03	104,56
24,00	562,77	2833,35	3396,12	135,84
26,00	583,39	3181,95	3765,35	150,61
28,00	630,54	3703,63	4334,16	173,37
30,00	642,32	4042,34	4684,66	187,39
33,00	674,73	4670,95	5345,68	213,83
35,00	692,41	5083,83	5776,24	231,05

The bearing capacity of the pile foundation with Briand Et Al method is also obtained from the sum of pole ends (Qp) and shear resistance (Qs). To calculate the carrying capacity of the pole at a depth of 24 meters is as follows

TABLE IX. THE CALCULATION RESULTS OF PILE'S AXIAL BEARING CAPASITY OF THE SPT DATA AT THE POINT BH-01 WITH BRIAND ET AL METHODS

Depth (m)	Qp (kN)	Qs (kN)	Q ult (kN)	Q all (ton)
2,00	665,01	108,89	773,90	30,96
4,00	665,01	217,79	882,80	35,31
6,00	386,96	211,20	598,16	23,93
8,00	591,49	396,35	987,84	39,51
10,00	702,96	569,36	1.272,32	50,89
12,00	886,48	823,61	1.710,10	68,40
14,00	878,44	953,85	1.832,30	73,29
16,00	1.061,61	1.269,79	2.331,40	93,26
18,00	1.210,35	1.587,66	2.798,01	111,92
20,00	1.351,27	1.927,73	3.279,00	131,16

22,00	1.460,20	2.257,16	3.717,36	148,69
24,00	1.544,52	2.576,27	4.120,78	164,83
26,00	1.576,63	2.837,60	4.414,23	176,57
28,00	1.610,38	3.108,47	4.718,85	188,75
30,00	1.632,20	3.366,81	4.999,01	199,96
33,00	1.666,59	3.766,23	5.432,82	217,31

TABLE X. THE CALCULATION RESULTS OF PILE'S AXIAL BEARING CAPASITY OF THE SPT DATA AT THE POINT BH-02 WITH BRIAND ET AL METHODS

Depth (m)	Qp (kN)	Qs (kN)	Q ult (kN)	Q all (ton)
2,00	574,69	96,81	671,51	26,86
4,00	574,69	193,63	768,32	30,73
6,00	518,15	267,19	785,35	31,41
8,00	607,48	404,96	1.012,44	40,50
10,00	690,72	561,36	1.252,08	50,08
12,00	844,88	792,33	1.637,21	65,49
14,00	902,19	974,58	1.876,77	75,07
16,00	1.031,92	1.241,11	2.273,04	90,92
18,00	1.187,02	1.562,96	2.749,98	110,00
20,00	1.312,58	1.883,15	3.195,73	127,83
22,00	1.430,08	2.219,58	3.649,66	145,99
24,00	1.504,97	2.522,99	4.027,96	161,12
26,00	1.567,98	2.825,07	4.393,05	175,72
28,00	1.604,84	3.099,86	4.704,70	188,19
30,00	1.626,79	3.357,83	4.984,62	199,38
32,00	1.663,99	3.647,51	5.311,50	212,46
34,00	1.674,35	3.894,90	5.569,26	222,77

TABLE XI. THE CALCULATION RESULTS OF PILE'S AXIAL BEARING CAPASITY OF THE SPT DATA AT THE POINT BH-03 WITH BRIAND ET AL METHODS

Depth (Li) (m)	Qp (m)	Qs (m)	Q ult (kN)	Q all (ton)
2,00	538,18	91,83	630,01	25,20
4,00	591,49	198,17	789,67	31,59
6,00	574,69	290,44	865,13	34,61
8,00	607,48	404,96	1.012,44	40,50
10,00	726,36	584,58	1.310,94	52,44
12,00	861,95	805,20	1.667,15	66,69
14,00	902,19	974,58	1.876,77	75,07
16,00	1.037,98	1.246,98	2.284,96	91,40
18,00	1.214,92	1.592,49	2.807,41	112,30
20,00	1.362,50	1.940,63	3.303,12	132,12
22,00	1.453,60	2.248,94	3.702,55	148,10
24,00	1.556,33	2.592,13	4.148,46	165,94
26,00	1.576,63	2.837,60	4.414,23	176,57
28,00	1.621,36	3.125,53	4.746,88	189,88
30,00	1.632,20	3.366,81	4.999,01	199,96
33,00	1.661,38	3.756,74	5.418,13	216,73
35,00	1.676,93	4.014,42	5.691,35	227,65

The comparison of calculation results of axial bearing capacity at the point BH-01, BH-02 and BH-03 can be seen in the following graph:

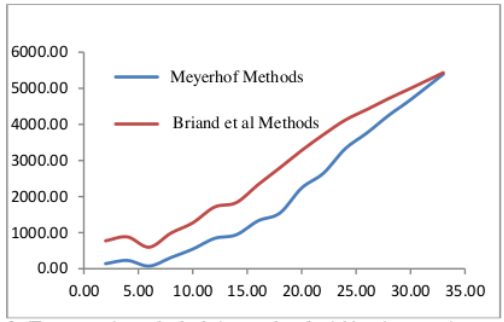

Fig.2. The comparison of calculation results of axial bearing capacity at the point BH-01 Source: Calculation Result, 2017

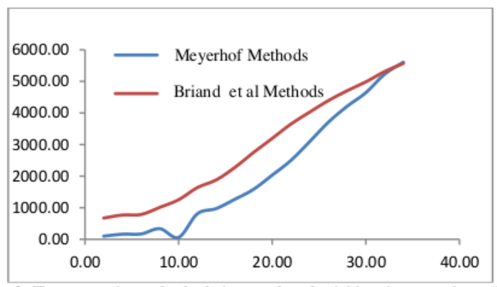

Fig 3. The comparison of calculation results of axial bearing capacity at the point BH-02 Source: Calculation Result, 2017

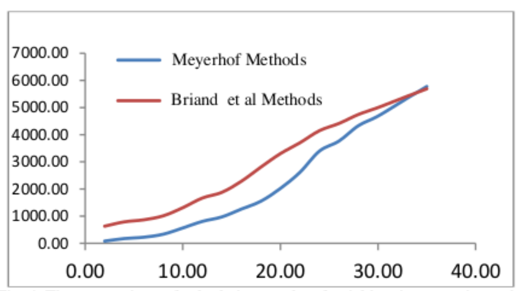

Fig. 4. The comparison of calculation results of axial bearing capacity at the point BH-01 Source: Calculation Result, 2017

C. Analysis Of Pile's Axial Bearing Capasity With Numerical Methods

In the calculation of axial bearing capacity analysis of piles using plaxis program requires data properties of soil and pole as the input of soil and pole parameters. Parameter of soil material in this research is obtained from secondary data in the form of NSPT data which then correlated to get description of soil layer and typical value of soil parameter [6].

TABLE XII. PILE PARAMETERS INPUTS WITH PLAXIS 2D

Sheet pile	W-500 A1000	
Parameter	**Value**	**Unit**
EA	1.20E+07	kN/m
EI	2.50E+05	kNm²/m
N	0,01	
Mp	1.00E+15	kN/m/m
Np	1.00E+15	kN/m

TABLE XIII. THE CALCULATION RESULTS OF PILE'S AXIAL BEARING CAPASITY WITH PLAXIS 2D

Point	Msf	Pu (kN)	Q ult (kN)
BH-01	2,79	1.916,00	5.337,98
BH-02	2,68	1.861,00	4.994,92
BH-03	3,19	1.987,00	6.342,50

TABLE XIV. THE COPARITION OF CALCULATION RESULTS OF PILE'S AXIAL BEARING CAPASITY WITH EMPIRICAL METHODS (SPT) AND NUMERICAL METHODS WITH PLAXIS 2D

Point	Empirical methods		Numerical methods (Plaxis)	Units
	Meyerhof	Briand Et Al		
BH-01	3.324,99	4.120,78	5.337,98	kN
BH-02	3.093,84	4.027,96	4.994,92	kN
BH-03	3.396,12	4.148,46	6.342,50	kN

IV. CONCLUSIONS

From the calculation of the axial bearing capacity of the pile it can be concluded that the difference in carrying capacity can be caused by the different types of soil, the way of implementation test depends on the accuracy of the operator and the difference of parameters used in the calculation.

In this analysis when compared between the calculation by using analytical and numerical methods (Plaxis 2D program), then the difference of calculation result of analytical method with the result of numerical method calculation ranged from 24.01% - 61.45%.

V. SUGGESTION

In analyzing the axial bearing capacity the piles should use more than one method as a comparison so as to obtain more accurate results. In addition, the parameters used in the analytical process should be supplemented from ground data in the field to reduce the use of approaches on the parameters used so as to minimize the percentage gap calculation results numerical method and analysis methods.

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