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COMPARISON OF BORED PILE AXIAL BEARING CAPACITY BASED ON VESIC'S METHOD (1970), STANDARD PENETRATION TEST (SPT), AND LOADING TEST IN THE PROJECT OF ELEVATED TOLL ROAD JAKARTA – CIKAMPEK STA.9+500 – STA.47+000

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ABSTRACT

As a foundation under the structure can be generally divided into two types, namely the foundation deep and shallow foundation. Selection of the type of foundation depends on the type of structure including the construction load on whether light or heavy loads and also depending on the soil type. For the construction of a light load and soil conditions quite well, usually worn shallow foundation, but the construction of a heavy load is usually the type of deep foundation is the right choice.

In general, the more complex the deep foundation of a shallow foundation. To this writer tried to concentrate on planning the foundation of this thesis in which bored pile (Bored Pile Foundations). Bored Pile foundation is a foundation built by drilling the ground first, then filled with steel reinforcement and cast. Bored pile used when soil solid base which has a carrying capacity of it lies very deep, which is approximately 15 m as well as the state of the soil around the many stands a large building and rise to the feared could lead to cracks in the existing building effect vibrations caused by staking activity when administered pile foundation. Carrying capacity of bored pile end bearing capacity is obtained than that obtained from pressure and friction pile tip bearing capacity obtained from carrying friction or adhesion force between the bored pile and the surrounding soil.

Keyword : Bored Pile, Axial Bearing Capacity, SPT, Loading Test

1. PRELIMINARY

In line with government programs to improve the level of development, as we have seen in countries that are developing. In Jakarta as the capital city of Indonesia, the clean themselves in the development of various sectors.

Development around the city includes the construction of bridges and highway transportation, housing, offices, hotels, entertainment venues, shopping centers, and other means. This development is not only the starting point in the development undertaken by the government, but also private parties participate participating realizing national development.

Before carrying out a construction first times development implemented and done is the foundation work (Structure below). The foundation is a very important job in a civil engineering work because this is the foundation that bears and withstand a load acting on it is the burden of top construction. This foundation to channel voltages occurs in structural loads on the hard ground into a layer that can bear the burden of the construction.

Bored pile-soil interaction circuitry for generating carrying capacity capable of taking and giving security to the top of the structure. To produce an accurate carrying capacity would require an accurate soil investigation as well. There are two methods used in the determination of the bearing capacity of the bored pile is by using static and dynamic methods.

Soil investigation using a static method is penetration test (SPT). Investigations Standard Penetration Test (SPT) to obtain a picture layer of soil based on soil type and color through visual observation, soil properties, and soil characteristics.

Planning foundation bored pile covering a series of activities undertaken by the various stages that include technical feasibility studies. All was done in order to ensure the outcome of the construction is strong, safe and economical.

Based on preliminary, the issues to be discussed in this thesis, are:

a. How to determine the axial bearing capacity of foundation bored pile using laboratory test data, the data standard penetration test (SPT) and data loading test?
b. How would you compare the results of the carrying capacity of the single bored pile with the method of SPT and Loading Test?

The purpose of this research in Elevated Toll Road Jakarta - Cikampek are:

a. Calculating foundation carrying capacity of a single bored pile of test data in labs, standard penetration test (SPT), and loading test.
b. Comparing the results of the carrying capacity of the single bored pile with SPT method, and Loading Test.

2. METHOD

Axial Bearing capacity of the foundation pile / Bore Pile can be calculate based on data from field test results and based on the parameter data in the laboratory soil test results by following general formula derived from the sum of detainees and prisoners Frictional end.

a. Vesic's Method (1970)

Consultant planner testing of soil samples taken in the field, and then tested in the laboratory and get the parameters used as a reference for planning calculations carrying capacity of bored pile.

Table 1. Formula of Vesic's Method (1970)

	Nilai Qb (kN)	Nilai Qs (kN)	No. Equations
Vesic (1967)	Tanah Cohesive: $Q_p = Ap\, Cu\, Nc^*$	$Q_s = f \times Li \times p$ When, Cohesive Soil: $f = a * \times Cu$	2.1
	Tanah Non-Cohesive: $Q_p = Ap\, q'(Nq^* - 1)$	$Q_s = f \times Li \times p$ When, Non-Cohesive Soil: $f = Ko \times \sigma v' \times \tan \delta$	2.2

Where:

Qp = Detainees end unit area (tons)
Ap = cross-sectional area bore pile (m2)
Cu = undrained Cohesion (ton / m2)
Nc * = factor bearing capacity of the land, to bore pile value Nc * = 9 (Whitaked and Cooke, 1966)
q' = pressure vertical effective (ton / m2)
Nq * = factor bearing capacity

Vesic (1967) proposed a correlation between the angle of friction and Nq * as shown in the following figure:
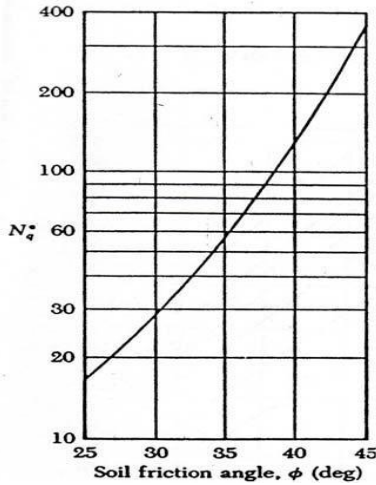

Image 1. Factor Nq* (Vesic's, 1970)

b. Reese & Wright (1967)

The consultant investigated of soil and calculate the carrying capacity of the foundation pile of SPT data with the following formula:

Table 2. Formula of Reese & Wright's Method (1967)

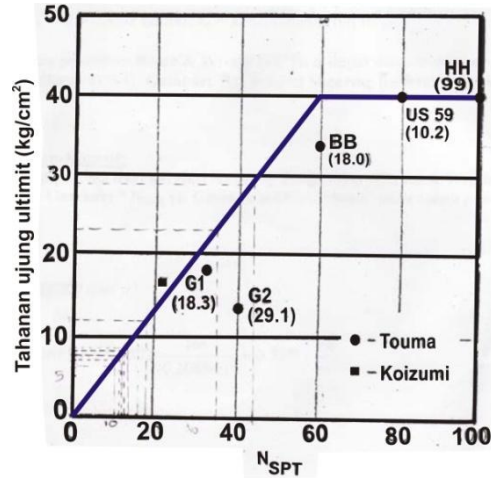|	Nilai Qb (kN)	Nilai Qs (kN)	No. Equations
Reese & Wright (1967)	Tanah Cohesive: $Q_p = Ap \times q$ When, qp = 9 . Cu, that Cu = N-SPT/2 x 2/3 x 10		2.3
	Tanah Non-Cohesive: $Q_p = Ap \times q$ When, qp = using Graph Reese and Wright (1977), that include correlation between value qp and N-SPT	Qs = f . Li . p When, Cohesive soil F = α x Cu	2.4

Image 2. Bearing capacity of the boundary bore pile on the ground (Reese & Wright, 1977)

Where:

Ap = cross-sectional area bore pile (m2)
qp = Detainees end unit area (ton / m2)
Qp = Bearing capacity of the pile (tons)
Qs = Power Frictional bearing (tons)
F = Prisoners unit skin friction (ton / m2)
Li = length of the soil layer (m)
P = Roving pole (m)
α = adhesion factor, based on research Reese & Wright value of
    α = 0.55
    cu = cohesion soil (ton / m2)

C. Loading Test Data

The purpose of the experiment loading vertical (compressive loading test) to the pile foundation was to determine the relationship between the load and a decrease in the foundation due to load plan, to test the pile held capable of supporting the load plan and prove that the implementation is not a failure occurs, and to determine the ultimate carrying capacity of the real (real ultimate bearing capacity) as the control of the results of calculations based on static and dynamic formula (Hardiyatmo, 2010).

1. Chin's Method (1970)

Based on the assumption that only the shear deformation occurs and that the load-reduction curve is shaped hyperbole, the graph Δ / Qva - Δ is a straight-line sloping location.

The amount of ultimate bearing capacity is the inverse slope of the line that divided Δ Δ / Qva.

➢ Figure Δ / Qva against Δ, where Δ is the reduction of Δ / Qva is the applied load.
➢ Ultimate load (Qx) ult = 1 / C. The image below illustrates these terms.
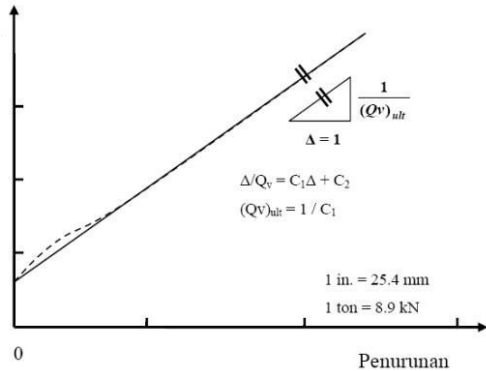➢ The relationship given in this picture that the load curve approaching a hyperbolic decline.

Image 3. Curve Method Interpretation Chin (1970)

2. **Mazurkiewich's Method (1972)**

Mazurkiewich ultimate load determination procedure is as follows:

➢ The load curve plotted against a decline.
➢ Draw a line from some point reduction have to cut a curve, then a vertical line drawn up to cut the load axis.
➢ From the intersection of each load, created a line of 45 ° to the line of intersection next and so on.
➢ Connect the dots thus formed to produce a straight line.
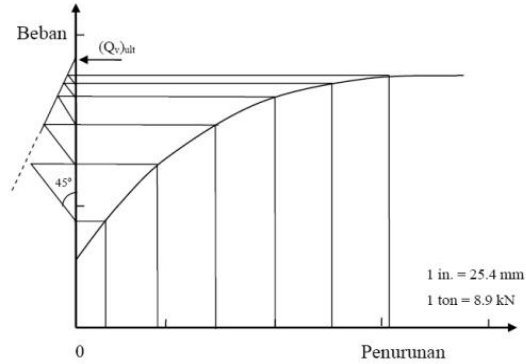➢ The intersection of the straight line with the axis of the load is a load Ultimate.

Image 4. Curve Method Interpretation Mazurkiewich's Method (1972)

3. RESULT

The calculation of bearing capacity of bored pile data was taken at BH-04A, BH-03B, BH-02A, BH-01B, P-1A, P-2B, P-3A, P-4B.

a. **Vesic's Method (1970)**

Table 3. Calculation Data from Vesic's Method (1970)

No.	Depth (m)	Soil Type	Diameter Pile (m)	Ap (m²)	N-SPT	Cu	Nc*	α	f	Li	p	Qp	Qs Local	Qs Sum	Qu kN	Qall kN	Qall Ton
1	0,00	CLAY	1,2	1,1304	18,00	9	1,2	21,6	4,50	3,768	183,1248	116,64	116,64	299,7648	99,9216	9,99216
2	0,50	CLAY	1,2	1,1304	18,00	9	1,2	21,6	4,50	3,768	183,1248	116,64	233,28	416,4048	138,8016	13,88016
3	1,00	CLAY	1,2	1,1304	18,00	9	1,2	21,6	4,50	3,768	183,1248	116,64	349,92	533,0448	177,6816	17,76816
4	1,50	CLAY	1,2	1,1304	18,00	9	1,2	21,6	4,50	3,768	183,1248	116,64	466,56	649,6848	216,5616	21,65616
5	2,00	CLAY	1,2	1,1304	18,00	9	1,2	21,6	4,50	3,768	183,1248	116,64	583,2	766,3248	255,4416	25,54416

- **Calculation at the Point 1 (BH-04A)**
  Example in depth 0,5 m:
  ➢ End Bearing Capacity:
  $$Q_p = Ap\ Cu\ Nc^*$$
  $$Qp = 1,131 \times 18 \times 9 = 183,125\ kN$$
  ➢ Friction Bearing Capacity:
  $$Q_s = f \times Li \times p$$
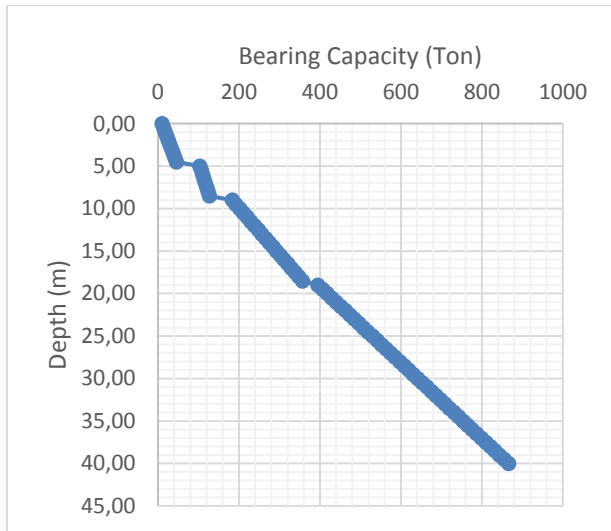 $$Q_s = 21,6 \times 4,5 \times 3,768 = 116,64\ kN$$

Image 5. Graph of Bearing Capacity BH-04A

b. Reese and Wright (1967)

Table 4 Calculation Data from Reese and Wright (1967)

No.	Depth (m)	Soil Type	Diameter Pile (m)	Ap (m²)	N-SPT	Cu	q	α	f	Li	p	Qp	Qs Local	Qs Sum	Qu	Qall kN	Qall Ton
1	0,00	CLAY	1,2	1,1304	0	0,00	0,00	1,2	0	2,00	3,768	0	0	0	0	0	0
2	0,50	CLAY	1,2	1,1304	3	10,00	90,00	1,2	12	2,00	3,768	101,736	90,432	90,432	192,168	64,056	6,4056
3	1,00	CLAY	1,2	1,1304	3	10,00	90,00	1,2	12	2,00	3,768	101,736	90,432	180,864	282,6	94,2	9,42
4	1,50	CLAY	1,2	1,1304	3	10,00	90,00	1,2	12	2,00	3,768	101,736	90,432	271,296	373,032	124,344	12,4344
5	2,00	CLAY	1,2	1,1304	3	10,00	90,00	1,2	12	2,00	3,768	101,736	90,432	361,728	463,464	154,488	15,4488
6	2,50	CLAY	1,2	1,1304	5	16,67	150,00	1,2	20	2,00	3,768	169,56	150,72	512,448	692,008	227,336	22,7336
7	3,00	CLAY	1,2	1,1304	5	16,67	150,00	1,2	20	2,00	3,768	169,56	150,72	663,168	832,728	277,576	27,7576

- **Calculation at the Point 1 (BH-04A)**
  Example in depth 1,0 m:
  ➤ End Bearing Capacity:
  $$Q_p = Ap \times q$$
  $$Qp = 1,131 \times 90 = 101,736 \ kN$$
  ➤ Friction Bearing Capacity:
  $$Q_s = f \times Li \times p$$
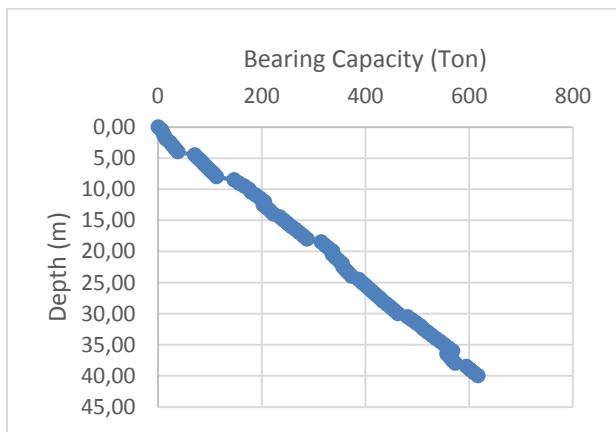 $$Q_s = 12 \times 2 \times 3,768 = 90,432 \ kN$$

Image 6. Graph of Bearing Capacity BH-04A

c. Bearing Capacity Using Loading Test

The calculation of bearing capacity of bored pile per layer using Chin Method (1970) and Mazurkiewich (1972) Method and Data Loading Test was taken at BH-04A, BH-03B, BH-02A, BH-01B, P-1A, P-2B, P-3A, P-4B.

Table 5. Dial Reading of Loading Test Data

Group									
1	640	0	0	0	7397			0	0,00
	25%	160	85	-225,5	7171,5	7170	7173	-2,255	2,26
	50%	320	150	-396,5	7000,5	7004	6997	-3,965	3,97
	25%	160	73	-195,5	7201,5	7201	7202	-1,955	1,96
	0%	0	0	0	7397	7397	7397	0	0,00
2	640	0	0	0	7397			0	0,00
	50%	320	147	-388	7009	7007	7011	-3,88	3,88
	75%	480	227	-598,5	6798,5	6794	6803	-5,985	5,99
	100%	640	313	-821,5	6575,5	6566	6585	-8,215	8,22
	75%	480	222	-592	6805	6804	6806	-5,92	5,92
	50%	320	146	-389,5	7007,5	7008	7007	-3,895	3,90
	0%	0	0	0	7397	7397	7397	0	0,00
3	640	0	0	0	7397			0	0,00
	50%	320	147	-385,5	7011,5	7006	7017	-3,855	3,86
	100%	640	309	-820,5	6576,5	6576	6577	-8,205	8,21
	125%	800	384	-1022,5	6374,5	6378	6371	-10,225	10,23
	150%	960	458	-1214,5	6182,5	6183	6182	-12,145	12,15
	125%	800	375	-999,5	6397,5	6400	6395	-9,995	10,00
	100%	640	313	-830,5	6566,5	6567	6566	-8,305	8,31
	50%	320	147	-391,5	7005,5	7006	7005	-3,915	3,92
	0%	0	0	0	7397	7397	7397	0	0,00
4	640	0	0	0	7397			0	
	50%	320	147	-292	7105	7103	7107	-2,92	
	100%	640	305	-807	6590	6587	6593	-8,07	
	150%	960	458	-1212	6185	6181	6189	-12,12	
	175%	1120	536	-1419	5978	5975	5981	-14,19	
	200%	1280	616	-3562,24	3834,8	5754	5763		-35,6224
	150%	960	480	-1272,5	6124,5	6124	6125	-12,725	
	100%	640	320	-849,5	6547,5	6547	6548	-8,495	
	50%	320	160	-424,5	6972,5	6972	6973	-4,245	
	0%	0	0	0	7397	7397	7397	0	
5	640	0	0	0	7397			0	
	50%	320	161	-428	6969	6969	6969	-4,28	
	100%	640	321	-640	6757	6545	6969	-6,4	
	150%	960	482	-1278	6119	6119	6119	-12,78	
	200%	1280	641	-1699	5698	5698	5698	-16,99	
	225%	1440	721	-3743,91	3653,1	5486	5486	5767	-37,4391
	150%	960	481	-1273,5	6123,5	6123	6124	-12,735	
	100%	640	320	-848	6549	6548	6550	-8,48	
	50%	320	160	-443	6954	6971	6937	-4,43	
	0%	0	0	0	7397	7397	7397	0	

1. Chin's Method (1970)

Table 6. Settlement and Load in Loading Test

PRECENTAGE	SEATELMENT	LOAD	SEATELMENT/LOAD
0	0	0	0
25	2,26	79	0,028607595
50	3,97	149,14	0,026618774
75	5,96	224,5	0,026547884
100	8,261	312	0,026477564
125	10,12	379,5	0,026666667
150	12,33	465,33	0,026497135
175	14,19	536	0,026473881
200	35,62	616	0,057824675

After we know the settlement and the load from dial reading, we must plot the result into a graph, and make trendline equation from that using Microsoft excel, as shown in figure below:
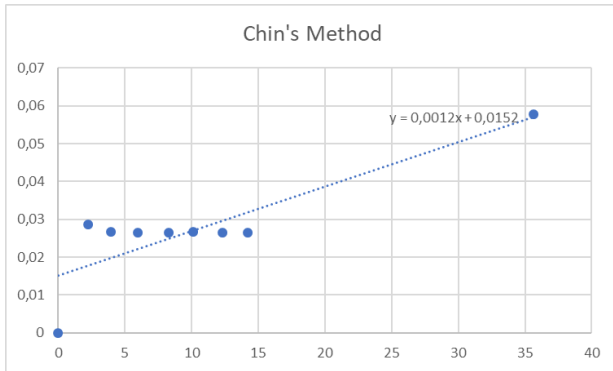

Image 7. Graph of Interpretation Loading Test

After we know the equation, we can calculate from that and known the interpretation bearing capacity from loading test data.

$$Q\ ult = \frac{1}{m}$$

That the **m** is the value in front of the **X.** So, we can calculate the interpretation loading test bearing capacity is

$$Q\ ult = \frac{1}{0,0012} = 833,33\ ton$$

2. Mazurkiewich's Method (1972)

Like Chin's Method, this method using software Microsoft excel and focus on graphic method without calculate the interpretation. We should plot the loading data test and make interpretation from drawing a line in the graph like shown in figure below.
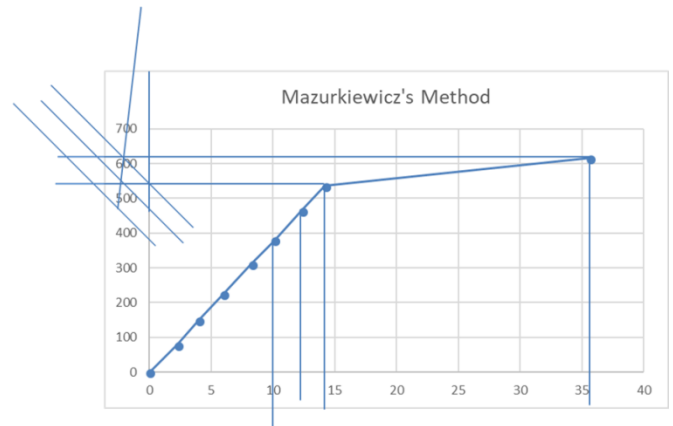

Image 8. Graph of Mazurkiewich Method

So, we can see the end of the graph line is in over 700 ton, and if that's figure can be shown, the value of interpretation is in the range of **800 ton** till **900 ton**.

4. DISSCUSION

From the result bearing capacity from each method, we can recap the result like shown in table below:

Table 7. Comparison of Bored Pile Bearing Capacity

Method	BH-04A	BH-03A	BH-02B	BH-01B	P-1A	P-2B	P-3A	P-4B
VESIC'S	764 ton	790 ton	417 ton	964 ton	609 ton	230 ton	609 ton	195 ton
SPT DATA	551 ton	561 ton	586 ton	511 ton	725 ton	615 ton	673 ton	615 ton
LOADING TEST DATA	830 Ton							

5. CONCLUSION

b. From the calculation result can be concluded that the value of real bearing capacity from loading test is the largest value, while the result from Vesic's Method and SPT Data Method have relatively the same in some borehole.

c. The different ultimate bearing capacity can be caused from the specification soil, soil type which different distance the

closest one even at the location is can be caused differences in soil condition thus affecting the bearing capacity.

d. From the SPT data can be concluded that if the B-SPT value is small than the density of soil is small and the soil is soft. Even when the value f N-SPT is big, so the density value is big too and the soil is hard soil. (Sosrodarsono dan Nakazawa, 1983)

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