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Comparison of Pile Bearing Capacity Based on *Standard Penetration Test (SPT), Hydraulic Static Pile Driven (HSPD), and Pile Driving Analyzer (PDA)* Test in The Project of Flyover Antapani – Bandung

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ABSTRACT

The pile foundation is one of a kind of deep foundation that serves to funnel structural loads to hard soil layers that have a high carrying. The purpose of this study was to calculate the bearing capacity of piles.

Based on SPT data obtained and calculated by Mayerhoff method at point BH-01 Qult = 259,992 tons, at point BH-02 Qult = 258,234 tons, and at point BH-03 Qult = 279.586 tons, with HSPD data obtained based on reading dial pressure manometer tool is approximately from 178,365 tons - 186,120 tons, whereas with PDA obtained based on RMX value on PDA test is about 124 tons - 225 tons.

The results of the calculation of bearing capacity there are differences in values, both from the use of calculation methods and the location of points reviewed. From the results of the calculation can be concluded that the big highets bearing capacity the pile is values of SPT. In values of HSPD and PDA is relative same because the method using similar method (hydraulic and wave method).

Keywords : Bearing Capacity, SPT, HSPD, and PDA

1. PRELIMINARY

The pile foundation is one of a kind of deep foundation that serves to funnel structural loads to hard soil layers that have a high carrying. The pile foundation has two ways to support the load of *end bearing pile* and *friction pile*. The end bearing pile is a pile whose support capacity is more determined by the pile end resistance. Generally, the bearing end piles differ in soft soil zones that are in the hard soil. The piles are stuck until they reach the hard soil. While the pile of friction is a pile whose support capacity is more determined by the friction resistance (Hardiyatmo, H.C, 2011).

Factors that affect the difference coefficient value is the soil properties are not homogeneous so as to produce many ways in the calculation of bearing capacity. PDA test and SPT test have been done at Flyover Antapani - Bandung, the value of bearing capacity gives different result. PDA test is one of pile test with dynamic method in field. In this paper the comparison using the bearing capacity value of the test results with various methods from SPT, HSPD, and PDA and will be compare.

1.2. PURPOSE AND OBJECTIVES

2. **Purpose is:**

a. For details on foundation that will be used in flyover Antapani – Bandung.

b. To determine the strength of the load contained in Antapani flyover - the duo had entered the safe criteria or not.

3. **Objectives is:**

a. Analyzing to difference the values of SPT, HSPD, and PDA test in Foundation.

b. Calculate the bearing capacity of pile foundation.

c. The validation and correlation the data.

1.2. LIMITATION PROBLEMS

In the thesis will explain the problems, and this is the limitation of problem as follows:

a. Only calculated the bearing capacity based SPT, Hydraulic Static Pile Driven, and PDA test of Foundation.

b. Not calculated the plan budget (RAB)

c. Comparison of pile bearing based HSPD, SPT, and PDA.

1.3. *FLOWCHART*

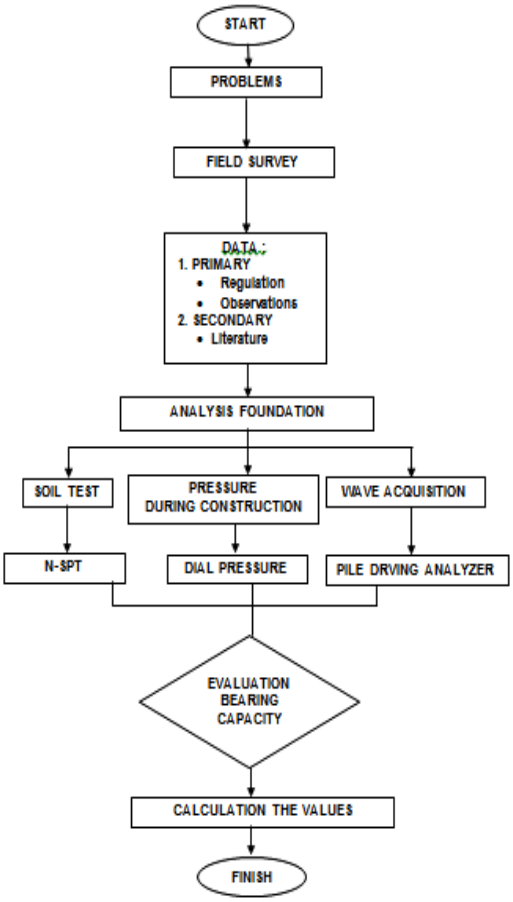

Figure 1.1 *Flowchart*

2. THEORITICAL BASIS

2.1 THE DEFINITION OF SOIL

Soil on natural conditions, consisting of a mixture of mineral granules with or without organic matter content. The granules can be easily separated from one another with a whisk water. This material comes from the weathering of rocks, physically and chemically.

2.2 DEFINITION OF SOIL INVESTIGATION

Soil investigation is an attempt to obtain information for the planning of underground civil building foundation. Soil investigation must reach a depth where the soil provides supportability or contribute to a decline due to the structure to be built. Soil investigation include, among others, land drilling, soil sampling, field testing, laboratory testing and observation of groundwater. The depth of investigation depends on the type Structures, Soil type, initial forecast the type of foundation will be used.

2.3 DEFINITION OF FOUNDATION

The foundation is a part of the construction of buildings that serves to place the building and continue the distributed load of the upper structure to the ground base strong enough foundation held without the occurrence of differential settlement on the system structure. To select the type of foundation is adequate, to consider whether it is suitable foundation for a variety of circumstances on the soil and whether the foundation was allowed to be solved economically in accordance with the work schedule.

The following points need to be considered in choosing the type of foundation:

1. The state of foundation soil
2. The limits due to construction on it (upper structure)
3. Circumstances surrounding area locations
4. Sturdy, rigid and strong.

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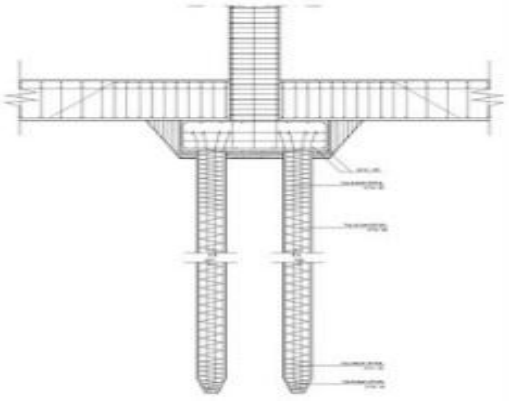
2.4 PILE FOUNDATION

The pile foundation is construction parts made of wood, concrete, or steel, which is used to pass (transmit) burdens surface to levels lower surface in soil mass *(Bowles, J. E., 1991)*. The use of pile foundation as a foundation of the building when the ground under the base of the building does not have the carrying capacity (bearing capacity) that is sufficient to carry the weight of the building and the load acting on it *(Sardjono, H. S., 1988)* or when the soil has sufficient bearing capacity to carry the entire weight of the building and the work load is at a very deep layer of surface soil depth of> 8 m *(Bowles, J. E., 1991).*



2.5 BEARING CAPACITY BASED ON SPT

The SPT method is a method of using a rod rod (which has a pointing tip) into the ground using a hammer blow and for measuring the number of penetration penetration points. This method has been standardized as ASTMD 1586 since 1958 with periodic revisions to this day. And calculated the data using the Mayerhoff Method.

a. The bearing capacity of pile foundation ends bearing on cohesive and non-cohesive soils with SPT data:

$$Q_p = 40 * N\text{-}SPT * L_i/D * A_p$$

b. Resistence Strength of skin friction pile on non cohesive soil:

$$Q_s = 2 * N\text{-}SPT * p * L_i$$

When:

D : Diametres pile (ton)

L_i : Length layer of soil (m)

A_p : Cross section area of Pile (m^2)

p : Around Pile (m)

c. Bearing Capacity pile foundation on cohesive soil C_u

$$Qp = 9 * C_u * Ap \text{ (in kN / m2)}$$

When:

Ap : Area of cross section pile

C_u : Undrained cohesion

: N-SPT*2/3*10

d. Shear resistence of skin friction on cohesive soil C_u

$$Qs = \alpha * C_u * P * L$$

When:

A : Adhesion factor

C_u : Undrained cohesion

: N-SPT*2/3*10

P : Around of Pile

L: Length of Pile

ϕ	Nc	Nq	Nγ	Nq/Nc	tan ϕ
0	5,14	1,00	0,00	0,20	0,00
1	5,38	1,09	0,07	0,20	0,02
2	5,63	1,20	0,15	0,21	0,03
3	5,90	1,31	0,24	0,22	0,05
4	6,19	1,43	0,34	0,23	0,07
5	6,49	1,57	0,45	0,24	0,09
6	6,81	1,72	0,57	0,25	0,11
7	7,16	1,88	0,71	0,26	0,12
8	7,53	2,06	0,86	0,27	0,14
9	7,92	2,25	1,03	0,28	0,16
10	8,35	2,47	1,22	0,30	0,18
11	8,80	2,71	1,44	0,31	0,19
12	9,28	2,97	1,69	0,32	0,21
13	9,81	3,26	1,97	0,33	0,23
14	10,37	3,59	2,29	0,35	0,25
15	10,98	3,94	2,65	0,36	0,27
16	11,63	4,34	3,06	0,37	0,29
17	12,34	4,77	3,53	0,39	0,31
18	13,10	5,26	4,07	0,40	0,32
19	13,93	5,80	4,68	0,42	0,34
20	14,63	6,40	5,39	0,43	0,36
21	15,82	7,07	6,20	0,45	0,38
22	16,88	7,82	7,13	0,46	0,40
23	18,05	8,66	8,20	0,48	0,42
24	19,32	9,60	9,44	0,50	0,45
25	20,72	10,66	10,88	0,51	0,47
26	22,25	11,85	12,54	0,53	0,49
27	23,94	13,20	14,47	0,55	0,51
28	25,80	14,72	16,72	0,57	0,53
29	27,86	16,44	19,34	0,59	0,55
30	30,14	18,40	22,40	0,61	0,58
31	32,67	20,63	25,99	0,63	0,60
32	35,49	23,18	30,22	0,65	0,62
33	38,64	26,09	35,19	0,68	0,65
34	42,16	29,44	41,06	0,70	0,67
35	46,12	33,30	48,03	0,72	0,70
36	50,59	37,75	56,31	0,75	0,73
37	55,63	42,92	66,19	0,77	0,75
38	61,35	48,93	78,03	0,80	0,78
39	67,87	55,96	92,25	0,82	0,81
40	75,31	64,20	109,41	0,85	0,84
41	83,86	73,90	130,22	0,88	0,87
42	93,71	85,38	155,55	0,91	0,90
43	105,11	99,02	186,54	0,94	0,93
44	118,37	115,31	224,64	0,97	0,97
45	133,88	134,88	271,76	1,01	1,00
46	152,10	158,51	330,35	1,04	1,04
47	173,64	187,21	403,67	1,08	1,07
48	199,26	222,31	496,01	1,12	1,11
49	229,93	265,51	613,16	1,15	1,15
50	266,89	319,07	762,89	1,20	1,19

Figure 2.1 *Mayerhoff Table*

2.6 BEARING CAPACITY BASED ON HSPD

Hidraulyc Jacking System is the tool a method of fixing the piles using hydraulic mechanism, the system consists of a hydraulic ram which is placed parallel to the pile to be put up, where to hit the pylon placed a mechanism in the form of plate suppressant that is on top of the mast also placed a holder mechanism (grip) pile, then the pile is pressed into the soil, without sound, without a blow, and without vibration. Placement of hydraulic pressure systems that compound and clamped on two sides of the pile caused stake point position obtained sufficient precision and accuracy. For loading, placed concrete blocks or iron plates on both sides of the assignment pads tools adapted to the required load pile.

Figure 2.2 *Hydraulic Jack in System*

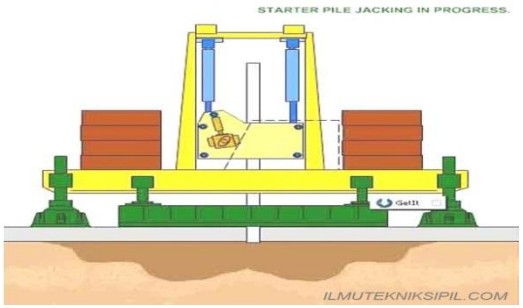


Figure 2.3 *During Construction (the dial pressure)*

Calculation of bearing capacity capacity of pile foundation on emphasis based on manometer readings available at stake. The bearing capacity of the pile foundation can be calculated by the formula:

P_{ult} = Manometer during construction (Mpa) * values the (assumption from convertion the Mpa values)

Bearing capacity based on hydraulic jack in system manometer reading with capacity of 200 tons:

Q = Dial Pressure Machine (Mpa) * 7.755 (Ton)

When:

1 Mpa for this machine: 7.755 ton (assumption from the PT. Mitra Pondasi Tama)

2.7 BEARING CAPACITY BASED ON PDA

PDA is a system consisting of a computer electronic device and equipped with accelerometer sensor and strain transducer (picture). The PDA is based on data analysis of the wave vibration recordings that occur at the time of the mast in the pound with a sledgehammer. Strain and wave acceleration due to the impact of the tool is measured using a strain transducer and accelerometer. The result of strain and acceleration measurement is needed to estimate the carrying capacity of the pole by using the theory of one-dimensional

wave. The testing procedure is carried out in accordance with ASTM D 4945-96. The tested pile is already stuck, the test is done with a restrike or redrive. Restrike stopped after having obtained good recording quality with relatively high hit energy. Further analysis can use CAPWAP.

Figure 2.4 *Pile Driving Analyzer*

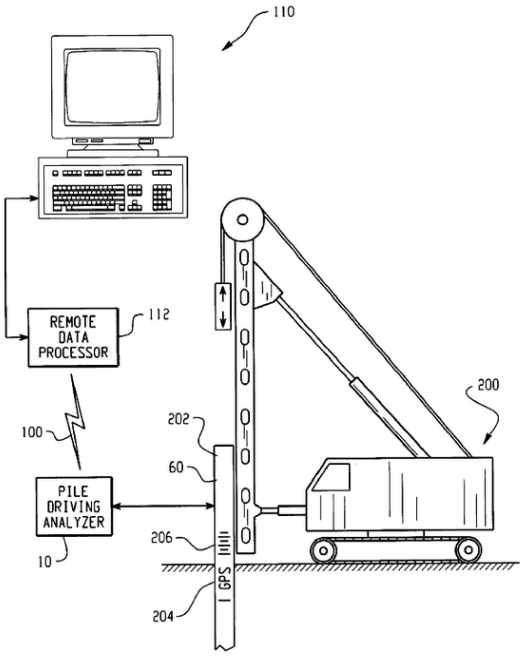


Figure 2.5 *Ilustration the PDA test*

Code	Information
BN	Blow
RMX	**Bearing Capacity (ton)**
FMX	Maximum compressive force (ton)
CTN	Maximum tensile force (ton)
EMX	Energy transferred (tonm)
DMX	Maximum settelment (mm)
DFN	Permanent settelment (mm)
STK	High falls of hammer (m)
BPM	Blow/minutes
BTA	Value of pile integrity
LE	Length of pile under instrument (m)
LP	Length embedded (m)
AR	Area of pile (cm^2)

Figure 2.6 *Table the Parameters of PDA test*

3. METHODOLOGY

3.1 TYPES AND SOURCES OF THE DATA

a. Primary data is the main data obtained directly from the project site and this data can be taken by students without going through an intermediary. So this data is the original data observed in the field.
b. Secondary data is data obtained indirectly from the project site, but there is an intermediary or documents, pictures, archives related to the location.

3.2 COLLECTING DATA METHOD

To achieve the aims and objectives of this study, several stages are considered necessary and outlined as follows:

The first stage is to review and study the literature on text boox and journals related to the pile foundation, the problems on the pile foundation, with the design and implementation of the pile foundation.

The second stage is the review and learning again when conducting activities in the project as well as collecting data that is deemed necessary.

The third stage is the implementation of collecting data from parties related to this project. And the data obtained are as follows:

1. Data bore hole at the point reviewed
2. Data of SPT results
3. Laboratory Data, and Soil Profile
4. PDA data simply

The fourth stage is to conduct data analysis using the above data based on the existing formula

The fifth stage is to conduct an analysis of the count done and make a conclusion

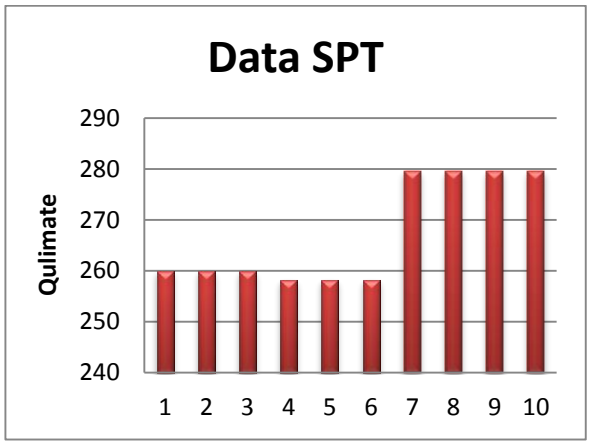
4. RESULT AND DISCUSSION

In this chapter, the author will apply the method of calculation of bearing capacity which has been conveyed in chapter II. The carrying capacity of the pole shall be calculated by using SPT data and comparing calculations with the carrying capacity with the HSPD system and the PDA value.

Figure 2.7 *Ilustration the point of pile foundation*

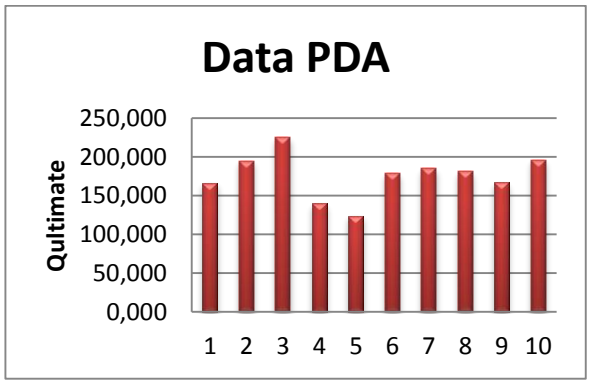
1. The Result Qultimate from SPT in the depth (8.00metres)

No	Working Point	Data SPT
1	Pier 1 number 1	259.992
2	Pier 1 number 5	259.992
3	Pier 1 number 14	259.992
4	Pier 2 number 18	258.234
5	Pier 2 number 39	258.234
6	Pier 2 number 42	258.234
7	Pier 3 number 46	279.586
8	Pier 3 number 49	279.586
9	Pier 3 number 64	279.586
10	Pier 3 number 67	279.586



2. The Result Qultimate from PDA on point which the execution that test

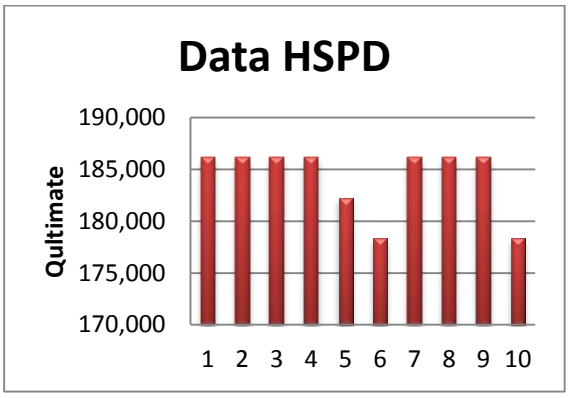
No	Working Point	Data PDA
1	Pier 1 number 1	166.000
2	Pier 1 number 5	195.000
3	Pier 1 number 14	225.000
4	Pier 2 number 18	140.000
5	Pier 2 number 39	124.000
6	Pier 2 number 42	179.000
7	Pier 3 number 46	185.000
8	Pier 3 number 49	181.000
9	Pier 3 number 64	167.000
10	Pier 3 number 67	196.000



3. The Result Qultimate from HSPD on point which the execution that test

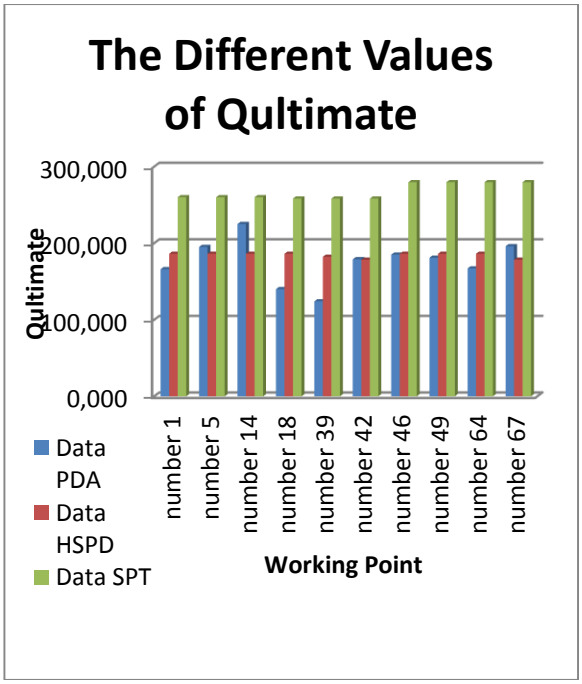
No	Working Point	Data HSPD
1	Pier 1 number 1	186.120
2	Pier 1 number 5	186.120
3	Pier 1 number 14	186.120
4	Pier 2 number 18	186.120
5	Pier 2 number 39	182.243
6	Pier 2 number 42	178.365
7	Pier 3 number 46	186.120

8	Pier 3 number 49	186.120
9	Pier 3 number 64	186.120
10	Pier 3 number 67	178.365



4.1 THE DIFFERENT VALUES OF Qult

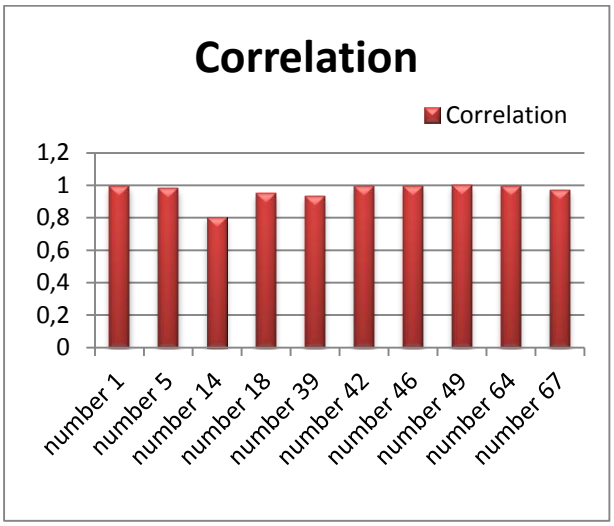
Working Point the Test	Data PDA (Ton)	Data HSPD (Ton)	Data SPT (Ton)
Pier 1 number 1	166.000	186.120	259.992
Pier 1 number 5	195.000	186.120	259.992
Pier 1 number 14	225.000	186.120	259.992
Pier 2 number 18	140.000	186.120	258.234
Pier 2 number 39	124.000	182.243	258.234
Pier 2 number 42	179.000	178.365	258.234
Pier 3 number 46	185.000	186.120	279.586
Pier 3 number 49	181.000	186.120	279.586
Pier 3 number 64	167.000	186.120	279.586
Pier 3 number 67	196.000	178.365	279.586



4.2 ANALYSIS CORRELATION

SPSS is one of the first statistical software created in 1968. When first created this software is operated on mainframe computers, until finally publisher McGraw-Hill publish user manual SPSS.

No	Working Point	Correlation
1	Pier 1 number 1	0.993
2	Pier 1 number 5	0.981
3	Pier 1 number 14	0.804
4	Pier 2 number 18	0.951
5	Pier 2 number 39	0.934
6	Pier 2 number 42	0.996
7	Pier 3 number 46	0.997
8	Pier 3 number 49	0.999
9	Pier 3 number 64	0.997
10	Pier 3 number 67	0.970



4.3 DISCUSSION

Analysis of bearing capacity of pile at Antapani Flyover Project - Bandung is to know the bearing capacity of the pile. The amount of carrying capacity obtained from field data calculated using empirical formula from Mayerhoff and data from dynamic data based on HSPD and PDA data get different values.

With the difference in Qult's value we can compare. the magnitude of the difference can be calculated by statistical analysis between the difference of numbers, namely the correlation and reabiltas validation test. In this thesis the authors analyze it by using SPSS software and data obtained will be read and the result must be close to 1 to know that the data is valid.

5. CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

a. From the results of these calculations can be concluded that the results of SPT data is the relative has the hightest value, while the results of PDA and HSPD has a relatively similar value due to using the method of dynamics (Hydraulic and Wave).
b. The different Qultimate can be caused from the specification soil, soil types which the different distance the closest one even at the location is can be caused differences in soil conditons thus affecting the bearing capacity.
c. A significant level given the symbol p or α symbol is expressed in proportion or percentage, while the price (1-α) 100% is called the trust level. For example, if we set α of 0.05 or 5% is equal to determine the level of confidence or trust level of (1-0.05) = 0.95 or 95%. And the result of the calculation using SPSS software is close to the result where the values ranges is 0.804 – 0.999, where the number is close to 1 with type error 0.05. So the data has valid or fairly small error rate.

5.2 RECOMMENDATION

1. Before doing calculation we should get complete technical data, because the data is very supportive in making the calculation analysis in accordance with the conditions
2. More thorough in carrying out testing both in the use equipment and reading the result contained in some test equipment, so the possibility of inaccuracy of numbers is getting smaller
3. For further research the amount of data being evaluated needs to be added to get better results
4. Other than that the method used should be more so far comparison more and more again to compare
5. Besides the empirical analysis needs to be made in a computer programming to speed up the calculation process and as a tool used for correction when by manual there is a mistake that is not seen.

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