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Pile Capacity Analysis Using Hydraulic Static Pile Driver and Pile Driver Analysis Test Method on the Tuntang River Bridge Foundation, Grobogan Regency

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Abstract: Bridges are an important component of highways, which facilitate the passage of geographical features such as rivers, valleys, irrigation channels, railways, and other roads. This ensures uninterrupted traffic flow and fulfillment of road grading requirements within specified limits. Structures Spoon pile foundation is a foundation structure supported by a system of pile groups and tied by pile caps which are used to hold and transmit the load from the upper structure into the soil which has the bearing capacity to withstand it. Piling with HSPD is a foundation piling tool with a jack-in pile system where the pile is pressed into the ground using a hydraulic jack that is given a counter weight so that the pile tool does not lift and helps pile until its design bearing capacity is achieved. The jack-in pile system is very suitable for use in projects with densely populated locations because it does not cause vibration and noise. In relation to this, the author conducted research on the bearing capacity of piles with use mark erection with dial value on the HSPD tool. The value of HSPD is mark pressure with graph on results mark comparison HSPD pressure with depth of layer land. While analysis method with P ile driver analysis Interpretation PDA-Test, where results from mark HSPD chart with depth and value chart from PDA-Test interpretation can be determined capacity Power support Pile stake. Results of the analysis of the compressive pile capacity of the HSPD results with PDA-Test (CAPWAP) with The results of the pile capacity analysis using the PDA Test (CAPWAP) obtained an average value of Qult = 480 tons , while the results of the pile pressure capacity analysis using the HSPD Hydraulic Static Pile Driver press tool obtained an average value of Qult = 250.17 Ton so that maximum load on a single pile with a load of Pmax = 225.78 tons / pile. Capacity analysis results from the interpretation value of the compressive pile capacity from the PDA-Test (CAPWAP) with HSPD Hydraulic Static Pile Driver Power support Pile Q ult = 392 Tons at a depth of 28 m from the top of the pile with a pile settlement value of 14.63 mm, so that pile able to support the maximum load on the pile and the settlement is still safe against Pmax settlement value 2.5 cm.

Keywords: *Compression piles; HSPD; PDA Test; CAPWAP*

1. Introduction

Construction of road and bridge networks as support main tendon the pulse of the economy Nationally, it is hoped that it will be able to connect cross-roads throughout Indonesia and improve the handling of non-cross roads so that they can always function to support the smooth flow of goods and services in order to accelerate economic recovery while maintaining environmental sustainability. In recent government policies, the emphasis has been on creating/improving infrastructure. The Directorate General of Highways has focused on building new roads and preserving roads throughout Indonesia in particular [1].

Bridges are an important component of highways, which facilitate the passage of geographical features such as rivers, valleys, irrigation channels, railways and other roads. This ensures uninterrupted traffic flow and fulfillment of road grading requirements within specified limits [2].

Generally, implementation Pile stake use hammer to insert the pile. Piling, by the method of hammering or drilling, is the main choice in less stable ground conditions. The process of hammering the pile involves the use of a crane or drop hammer which allows the pile to be placed vertically into the ground. The choice of method depends on the strength of the soil, with hammering being more effective for hard soils while drilling is generally more suitable for soft or heterogeneous soils [3]

In areas where there are many Houses resident so that What when use method stake with drop hammer will influence building so that building will damage light until damaged heavy. Besides That, for protected building buildings reserve culture and also buildings heritage also requires installation foundation with level influence on buildings in the area surrounding area for not disturbed.

Piling with HSPD is a foundation piling tool with a jack-in pile system where the pile is pressed into the ground using a hydraulic jack that is given a counter weight so that the piling tool does not lift and helps to pile the pile until its design bearing capacity is achieved. The jack-in pile system is very suitable for use in projects with densely populated locations because it does not cause vibration and noise [4].

Based on these considerations, this study discusses the following problems: determining the bearing capacity of piles obtained from the results of the PDA test with CAPWAP analysis (1), measuring the amount of pressure given by HSPD when driving piles (2), and comparing indicators of bearing capacity such as pile pressure, pile fall, and penetration depth from the results of the HSPD analysis with the results of the PDA test (3). The objectives of this study were to determine the bearing capacity of piles using the PDA test (CAPWAP), quantify the compressive force given by the HSPD tool, and interpret and compare the results of the bearing capacity of piles obtained from the results of the PDA test and HSPD data to evaluate the effectiveness of the Hydraulic Static Pile Driver in achieving the planned bearing capacity while minimizing environmental impacts.

1.1. Literature Review

HSPD Hydraulic Static Pile Driver is a foundation piling tool with a jack-in pile system where the pile is pressed into the ground using a hydraulic jack that is given a counter weight so that the piling tool does not lift and helps to pile the pile until the bearing capacity is achieved. design. Identification of the advantages of jack-in pile driving system include: (i) reducing noise; (ii) less smoke pollution compared to diesel hammer tools; (iii) safer for surrounding buildings because it does not cause vibrations; (iv) avoiding necking (foundation bends) as in the bored pile system; (v) the presence of a pressure gauge that allows for obtaining estimated data on the bearing capacity of the piles. HSPD Hydraulic Static Pile Driver allows faster and more efficient construction than other systems. HSPD is also capable of operating on land with limited space, although on the other hand it requires land surface compaction so that the equipment does not tilt, experienced operators, and attention to conditions location work is very influential to implementation work [7-8].

PDA-Test and CAPWAP Pile Driving Analyzer (PDA) and CAPWAP data are obtained directly from field test results [6]. The output results from CAPWAP include:
- Axial bearing capacity of pile (Ru - ton).
- At maximum pile settlement (Dx – mm)
- Permanent decrease (DFN – mm)

Pile Capacity Results of Pile Driving Analyzer (PDA) and CAPWAP Field Tests , Pile Driving Analyzer (PDA) and CAPWAP Data were obtained direct from Field test results [6]. The output results from CAPWAP include:

- Axial bearing capacity of pile (Ru - ton).
- At maximum pile settlement (Dx – mm)
- Permanent decrease (DFN – mm)

1.2. Interpretation of Pile Driving Analyzer (PDA) and CAPWAP Test Results

- Chin FK Method (1971)

From Chin FK's theory, using a graph shown at Fig. 1.

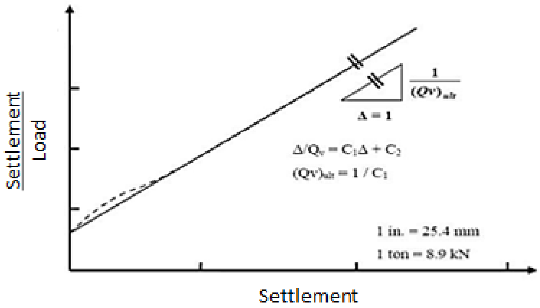

Fig. 1. Chin Method Graph

Load and Settlement on the graph in terms of S/Q relationship, where, S/Q = C1.S + C2. The failure load (Qf) or final load (Qult) is described as:

$$Q_{ult} = \frac{1}{C_1}$$

Where:

S : settlement
Q : additional load
C1 : slope of a straight line

- Davisson method (1972)

The formula written in the Davisson method:

$$\mathrm{X} = 0.15 + \left(\frac{\mathrm{D}}{120}\right)$$

$$\mathrm{Sf} = \Delta + 0.15 + \left(\frac{\mathrm{D}}{120}\right)$$

In Fig. 2 we get the elastic deformation equation line of the Pile which is obtained from the elastic pressure movement line [6]. with the elastic equation of the Pile:

$$\Delta = \frac{\mathrm{Q} \times \mathrm{L}}{\mathrm{AE}}$$

Where:

Sf : Reduction in failure condition
D : Pile diameter
Q : applied load
L : Pile length
E : modulus of elasticity of the Pile
A : area of the Pile

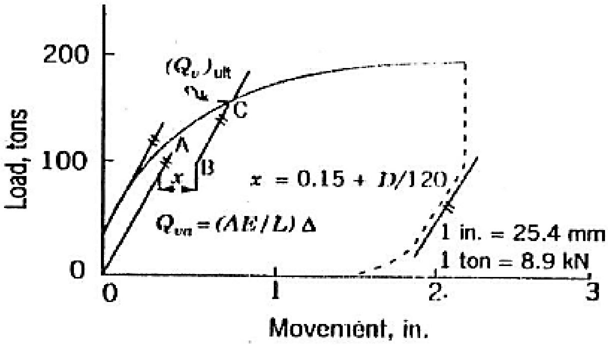

Fig. 2. Davisson Method Graph

- Method Mazurkiewicz . (1972)

According to Prakash, S; and Sharma, H. (1990) capacity Power support ultimate the biggest one got with interesting some point from curve decline to burden with push to the graph line burden until intersect. From the intersection This then draw a line that forms 45 ° angle to the intersection line burden next, then connect the intersection of the lines until cut the load line. Point intersection burden the is burden ultimate the biggest [6]. Graphics the picture can be seen in Fig. 3.

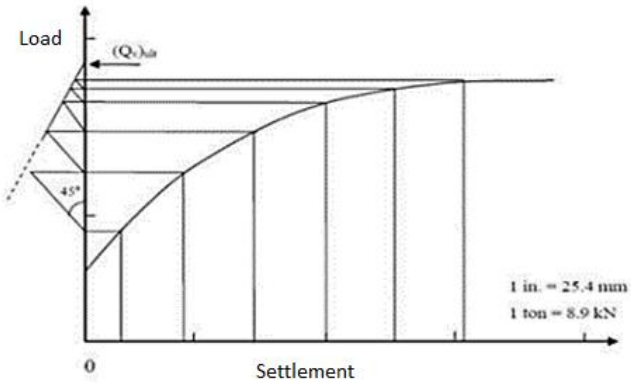

Fig. 3. Mazurkiewics Method Chart

1.2. HSPD (Hydraulic Static Pile Driver) Capacity Erection field

Hydraulic Jack Manometer Reading Method The bearing capacity of piles on the Hydraulic Jack tool can be calculated using the formula:

$Q = P \times A$

Where:

Q : Bearing capacity during piling (tons)

P : Manometer reading (kg/cm^2)

A : Total effective area of the piston cross-section (cm^2)

2. Research Method

Based on the research flow, it can be explained sequentially as.

a. Problem identification
   Formulation of the problem to be studied to solve the problems that have been explained in the background. How is the relationship between the results of static analysis and direct data analysis in the field.
b. Data and analysis
   Conducting data analysis from direct observation on the implementation and process of review and evaluation of the performance and efficiency of this tool in driving piles.
c. HSPD analysis
   Review and evaluation of the performance and efficiency of this tool in driving piles HSPD (Hydraulic Static Pile Driver)

d. PDA analysis
Review and evaluation of the results of the PDA (Pile Driving Analyzer) on the dynamic testing method to measure the bearing capacity of piles, pile integrity, and energy from hammer impacts.
e. Interpretation of analysis results
Review in data analysis to interpret the results of the analysis in order to provide meaning and relevance to the data that has been analyzed. This involves understanding the findings, relating them to the research objectives, and drawing meaningful conclusions.
f. Analysis of results and discussion
Analysis of results and discussion to determine the findings in the Analysis of research interpretation objectively, and interpret the findings relevantly
g. Conclusions and suggestions
This stage contains the final stage where suggestions and conclusions are given based on the research that has been conducted.

3. Result and Discussion

3.1. Data Collection

1. Research Location study can be seen in the following Fig. 4.

Fig. 4. Image of Research Location

Fig. 4. is the location where this research was conducted. The location is in Grobogan Regency, Gubuk District, Central Java with coordinates 465545.48 m E; 9214266.91 m S, and also the HSPD tool when driving the pile foundation on the Glapan Bridge.

2. Image data design
Image data erection foundation pillars on abutments and pillars can be seen in Fig. 5, that explain the design of the abutment foundation and the pillar foundation on the Glapan Bridge. Where the two bridge foundations were made research. HSPD data collection and PDA test data on the pile foundations of the two foundations

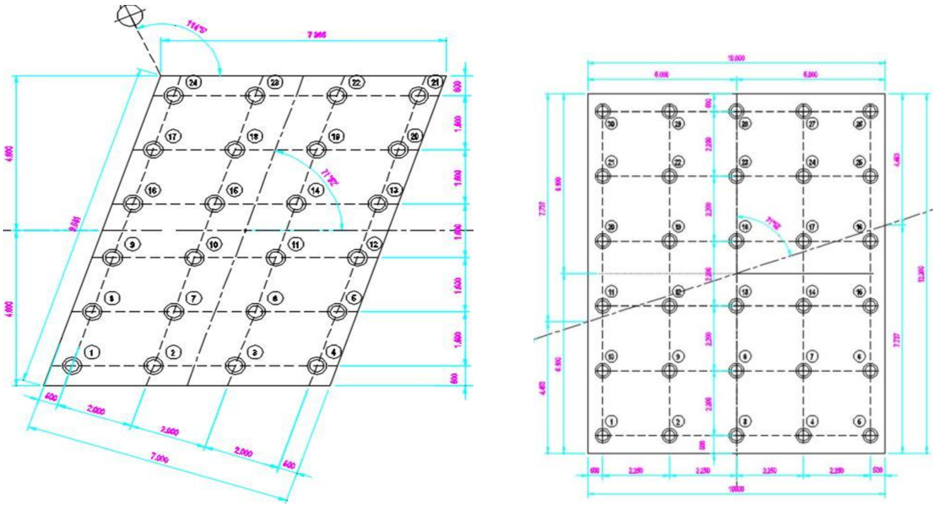

Fig. 5. Point image erection on abutments and pillars

3. Bridge Load Analysis Data on pillars and abutments.
   Table 1 below is a recapitulation of the results of the overall bridge load analysis supported by pile foundations. The load is an analysis based on the bridge loading standard SNI no. 1726 of 2016, with 12 loading combinations.

Table 1. Laod maximun on pillars and abutment

Load Combination	P (ton)	M_x (ton.m)	M_y (ton.m)	P/n (ton)	$M_x*X/\Sigma X^2$	$M_y*Y/\Sigma Y^2$	P_{max} X	P_{min}
SOLID - 1	764.4	225.7	0.0	78.0	3.89	0.00	81.9	81.9
SOLID - 2	731.8	185.3	0.0	74.7	3.19	0.00	77.9	77.9
SOLID - 3	619.0	65.4	230.3	63.2	1.13	2.99	67.3	61.3
SOLID - 4	617.8	43.8	0.0	63.0	0.76	0.00	63.8	63.8
SOLID - 5	618.2	50.0	115.7	63.1	0.86	1.50	65.4	62.4
EXTREME I	699.2	4968.8	5294.6	71.4	85.67	68.76	225.8	88.3
EXTREME II	658.5	94.3	0.0	67.2	1.63	0.00	68.8	68.8
LAYAN I	567.1	149.5	99.2	57.9	2.58	1.29	61.7	59.2
LAYAN II	591.3	175.2	0.0	60.3	3.02	0.00	63.4	63.4
LAYAN III	550.6	124.6	0.0	56.2	2.15	0.00	58.3	58.3
LAYAN IV	486.1	54.6	115.2	49.6	0.94	1.50	52.0	49.0
FATIQ	61.1	75.8	0.0	6.2	1.31	0.00	7.5	7.5
				P_{max}		Max =	225.78	88.26

4. Observation Result Data HSPD Piling

Table 2. and Table 3. is a recapitulation of the recording results on the Manometer Reader Pole Number of the Machine Carrying Capacity 420 (Ton) Machine Carrying Capacity 420 (Ton) Pressure 2 Cylinders 4 Cylinders Mpa Tons Depth (m) Tons Depth (m).

Table 2. Result Data HSPD Piling from location project P.12 on abutment

No	Presure	2 Cylinder		4 Cylinder		No	Presure	2 Cylinder		4 Cylinder	
	(Mpa)	(Ton)	(m)	(Ton)	(m)		(Mpa)	(Ton)	(m)	(Ton)	(m)
1	1	15.6	-	25.8	-	14	14	128.7	26.5	275.7	26.5
2	2	24.3	3.0	45.0	3.0	15	15	137.4	27.3	295.0	27.3
3	3	33.0	6.8	64.3	6.8	16	16	146.2	28.0	314.4	28.0
4	4	41.7	9.8	83.5	9.8	17	17	154.8		333.5	
5	5	50.4	11.8	102.7	11.8	18	18	163.5		352.7	

No	Presure	2 Cylinder		4 Cylinder		No	Presure	2 Cylinder		4 Cylinder	
	(Mpa)	(Ton)	(m)	(Ton)	(m)		(Mpa)	(Ton)	(m)	(Ton)	(m)
6	6	59.1	13.8	122.0	13.8	19	19	172.4		371.9	
7	7	67.8	15.0	141.1	15.0	20	20	181.3		391.2	
8	8	76.5	17.5	160.4	17.5	21	21	190.2		410.4	
9	9	85.4	18.8	180.0	18.8	22	22	199.1		429.6	
10	10	93.9	20.0	198.9	20.0	23	23	208.1		448.9	
11	11	102.6	22.5	218.1	22.5	24	24	217.0		468.2	
12	12	111.5	23.8	237.7	23.8	25	25	226.0		487.5	
13	13	120.0	25.0	256.6	25.0	26					

Table 3. Result Data HSPD Piling from location project P.1 on pillars

No	Presure	2 Cylinder		4 Cylinder		No	Presure	2 Cylinder		4 Cylinder	
	(Mpa)	(Ton)	(m)	(Ton)	(m)		(Mpa)	(Ton)	(m)	(Ton)	(m)
1	1.0	15.6		25.8	-	14.0	14.0	128.7		275.7	
2	2.0	24.3		45.0	4.0	15.0	15.0	137.4		295.0	
3	3.0	33.0		64.3	9.0	16.0	16.0	146.2		314.4	
4	4.0	41.7		83.5	13.0	17.0	17.0	154.8		333.5	
5	5.0	50.4		102.7	15.8	18.0	18.0	163.5		352.7	
6	6.0	59.1		122.0	18.1	19.0	19.0	172.4		371.9	
7	7.0	67.8		141.1	20.0	20.0	20.0	181.3		391.2	
8	8.0	76.5		160.4	22.5	21.0	21.0	190.2		410.4	
9	9.0	85.4		180.0	23.8	22.0	22.0	199.1		429.6	
10	10.0	93.9		198.9	25.0	23.0	23.0	208.1		448.9	
11	11.0	102.6		218.1	26.5	24.0	24.0	217.0		468.2	
12	12.0	111.5		237.7	27.3	25.0	25.0	226.0		487.5	
13	13.0	120.0		256.6	28.0	26.0					

5. Test Result Data Pile Driving Analyzer (PDA) and CAPWAP field
   PDA-Test and Capwap analysis results for Abutment A1-12 is presented and table tabulation capwap in Table 4 and Fig. 6., and While for Pillar P1-12 is presented and table tabulation capwap in Table 5 and Fig. 7.

Table 4. Result Data PDA Test Piling from location project on abutments A1-12

Soil Segment No.	Depth Below Gages (m)	Depth Below Grade (m)	Activated Resistance R (T)	Sum Down of R (T)	Sum UP of R (T)	Unit Resistance (Depth) (T/m)	Unit Resistance (Area) (T/m²)
1	1.74	1.64	0	0.00	392	0.00	0.00
2	3.39	3.29	4	4	392	2.42	1.54
3	5.03	4.93	10	14	388	6.1	3.88
4	6.68	6.58	17	31	378	10.3	6.56
5	8.32	8.22	16	47	361	9.76	6.21
6	9.97	9.87	21	68	345	12.73	8.1
7	11.61	11.51	21	89	324	12.8	8.15
8	13.26	13.16	24	113	303	14.55	9.26
9	14.9	14.8	24	137	279	14.63	9.32
10	16.54	16.44	22	159	255	13.41	8.54
11	18.19	18.09	22	181	233	13.33	8.49
12	19.83	19.73	21	202	211	12.8	8.15
13	21.48	21.38	20	222	190	12.12	7.72
14	23.12	23.02	20	242	170	12.2	7.76
15	24.77	24.67	19	261	150	11.52	7.33
16	26.41	26.31	15	276	131	9.15	5.82
17	28.06	27.96	14	290	116	8.48	5.4
18	29.7	29.6	12	302	102	7.32	4.66
Toe	29.7	29.6	90	392	90	0.00	458.48

Data on Table 4. is a record of the results of PDA tests on abutments. This data is used for analysis with 3 methods. Chin FK Method, Davisson's method (1972), and Mazurkiewicz Method (1972).

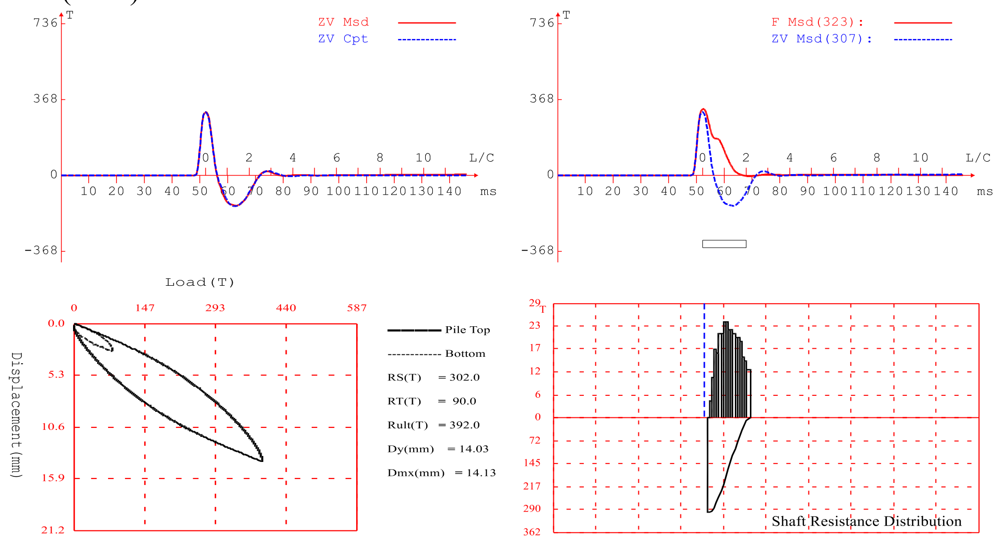

Fig. 6. Point image Piling of Abutmens

Fig. 6.a are recordings of the results of PDA tests on abutments A1-12. Where this data is data to be used for analysis with 3 methods. Chin FK Method, Davisson's method (1972), and Mazurkiewicz Method (1972).

Table 5. Result Data PDA Test Piling from location project on Pillars P.1-12

Soil Segment No.	Depth Below Gages (m)	Depth Below Grade (m)	Activated Resistance R (T)	Sum Down of R (T)	Sum UP of R (T)	Unit Resistance (Depth) (T/m)	Unit Resistance (Area) (T/m²)
1	1.86	1.66	0.0	0.0	311.0	0.00	0.00
2	3.51	3.31	0.0	0.0	311.0	0.00	0.00
3	5.17	4.97	0.0	0.0	311.0	0.00	0.00
4	6.82	6.62	10.0	10.0	311.0	6.06	3.86
5	8.48	8.28	15.0	25.0	301.0	9.04	5.75
6	10.14	9.94	15.0	40.0	286.0	9.04	5.75
7	11.79	11.59	21.0	61.0	271.0	12.73	8.10
8	13.45	13.25	23.0	84.0	250.0	13.86	8.82
9	15.11	14.91	23.0	107.0	227.0	13.86	8.82
10	16.76	16.56	22.0	129.0	204.0	13.33	8.49
11	18.42	18.22	22.0	151.0	182.0	13.25	8.44
12	20.08	19.88	21.0	172.0	160.0	12.65	8.05
13	21.73	21.53	20.0	192.0	139.0	12.12	7.72
14	23.39	23.19	20.0	212.0	119.0	12.05	7.67
15	25.04	24.84	20.0	232.0	99.0	12.12	7.72
16	26.70	26.50	19.0	251.0	79.0	11.45	7.29
Toe	26.70	26.50	60.0	311.0	60.0	-	305.65

Table 5 are recordings of the results of PDA tests on pillars P.1-12. Where this data is data to be used for analysis with 3 methods. Chin FK Method, Davisson's method (1972), and Mazurkiewicz Method (1972).

Fig. 7. are recordings of the results of PDA tests on Pillars P1-12. Where this data is data to be used for analysis with 3 methods. Chin FK Method, Davisson's method (1972), and Mazurkiewicz Method (1972).

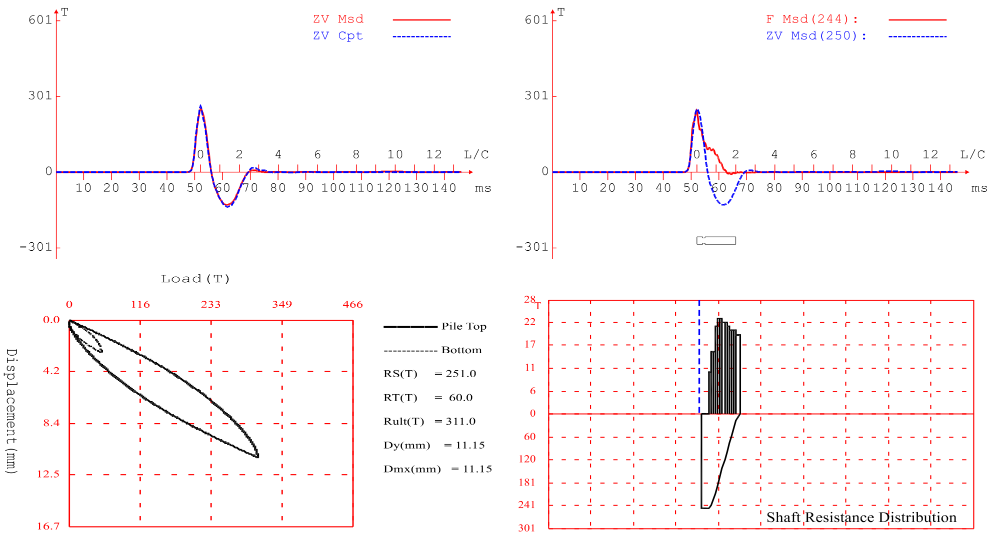

Fig. 7. Point image Piling of Pillars P.1-12

3.2. Interpretation of Analysis of PDA Test Results CAPWAP

From the results of the PDA test analysis with assistance of CAPWAP (Case Pile Wave Analysis Program) software with Chin's method can be interpreted in Fig. 8, Fig. 9, and Fig. 10.

1. Chin FK Method (1971)

   Fig. 8 presents the analysis results of PDA Test data interpretation and CAPWAP using the Chin FK Method. The interpreted ultimate bearing capacity is 588.25 tons.

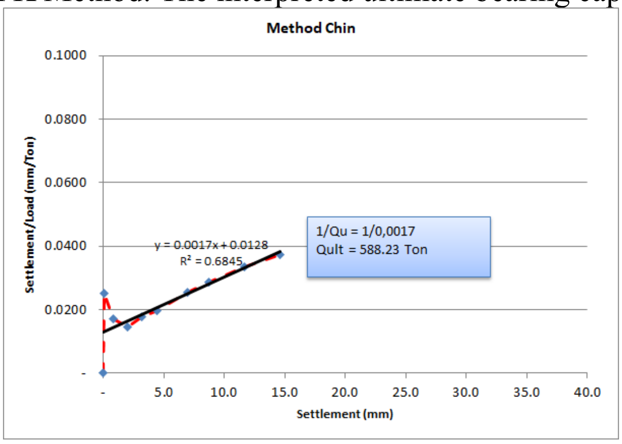

Fig. 8. Interpretation Method Chin FK

2. Davisson 's method (1972)

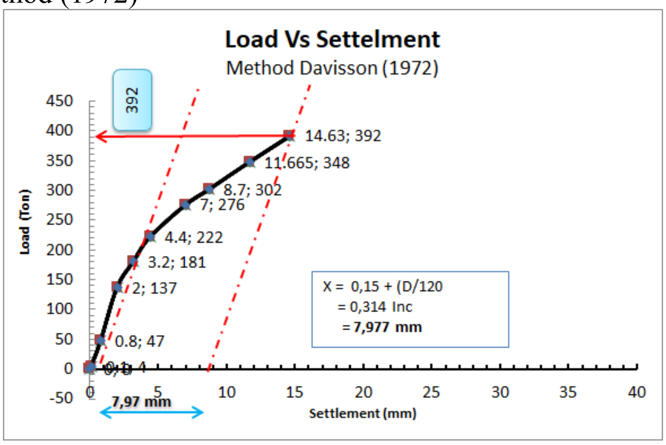

Fig. 9. Interpretation Davisson 's method

Fig. 9. presents the interpretation results of PDA Test and CAPWAP analysis using Davisson's method, indicating an ultimate load capacity of 392 tons.

3. Mazurkiewicz Method (1972)

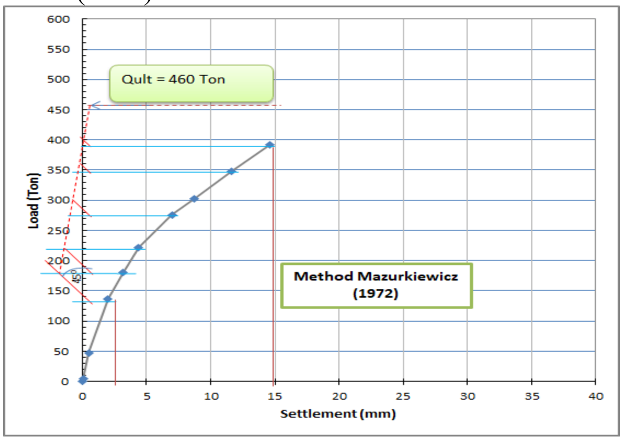

Fig. 10. Interpretation Method Mazurkiewicz

3.3. Recapitulation of PDA Analysis Interpretation Results Using Three Methods

Based on the recapitulation of the results of the interpretation of PDA Test and CAPWAP data on the three methods, the Chin FK Method (1971), Davisson method (1972) and Mazurkiewicz Method. (1972), the average value of the maximum load with a safety factor value of 2.5 can be tabulated in Table 6.

Table 6. Interpretation Result Load PDA Test and CAPWAP

Description of Activities	Metode Chin F.K. (1971)		Metode Davisson (1972)		Metode Mazurkiewicz (1972)	
1 Ton = 9.8 kN	Ton	kN	Ton	kN	Ton	kN
Acxial Load (Qult)	588.00	5233.20	392.00	3488.80	460.00	4094.00
Safety Factor (Fs)			2.50			
Acxial Load (Qall)	235.20	2093.28	156.80	1395.52	184.00	1637.60

Based on the analysis of Table 6. The results of the PDA Test Interpretation calculation from the Chin FK method, Davisson method and Mazurkiewicz method, the average value of the maximum ultimate load is obtained as Qult = 480 tons, Qall = 192 tons.

3.4. Interpretation HSPD (Hydraulic Static Pile Driver) Capacity Erection field

From the results of direct monometer reading observations in the field in monitoring the pressure value on the HSPD, the penetration value with the depth of the pile can be seen in Table 7 for Abutments and Table 8 for pillars which are data for the analysis of the calculation of the maximum pile bearing capacity based on summary data for each monometer point on the Abutment and Pillar piles. While Fig. 11. is the result of the logarithmetic analysis of penetration with the depth of the pile and the results are directly obtained by reading the pile capacity value graph.

Table 7. Calculation Results Power Support Pile Based on Data (Piling Daily Record) on abutment

Pile Number	Presure	2 Cylinder		4 Cylinder	
	Mpa	Ton	Depth (m)	Ton	Depth (m)
1	13	119.96		256.60	28
2	13	119.96		256.60	28
3	13	119.96		256.60	28
4	13	119.96		256.60	28

Pile Number	Presure	2 Cylinder		4 Cylinder	
	Mpa	Ton	Depth (m)	Ton	Depth (m)
5	13	119.96		256.60	28
6	13	119.96		256.60	28
7	13	119.96		256.60	28
8	13	119.96		256.60	28
9	13	119.96		256.60	28
10	13	119.96		256.60	28
11	11	102.59		218.10	28
12	13	119.96		256.60	28
13	11	102.59		218.10	28
14	13	119.96		256.60	28
15	13	119.96		256.60	28
16	12	111.46		237.70	28
17	13	119.96		256.60	28
18	12	111.46		237.70	28
19	12	111.46		237.70	28
20	12	111.46		237.70	28
21	13	119.96		256.60	28
22	13	119.96		256.60	28
23	13	119.96		256.60	28
24	12	111.46		237.70	28

Table 7 Recapitulation of pile bearing capacity readings on abutment piles based on direct readings of the HSPD Machine monometer with a capacity of 420 (Ton) 4 Cylinders and the known pile bearing capacity against the depth of the pile in the soil.

Table 8. Calculation Results Power Support Pile Based on Data (Piling Daily Record) on Pillars

Pile Number	Presure (MPa)	2 Cylinder		4 Cylinder	
		Ton	Depth (m)	Ton	Depth (m)
1	13	119.96		256.60	28
2	13	119.96		256.60	28
3	13	119.96		256.60	28
4	13	119.96		256.60	28
5	13	119.96		256.60	28
6	13	119.96		256.60	28
7	13	119.96		256.60	28
8	13	119.96		256.60	28
9	13	119.96		256.60	28
10	13	119.96		256.60	28
11	11	102.59		218.10	28
12	13	119.96		256.60	28
13	11	102.59		218.10	28
14	13	119.96		256.60	28
15	13	119.96		256.60	28
16	12	111.46		237.70	28
17	13	119.96		256.60	28
18	12	111.46		237.70	28
19	12	111.46		237.70	28
20	12	111.46		237.70	28

Pile Number	Presure (MPa)	2 Cylinder		4 Cylinder	
		Ton	Depth (m)	Ton	Depth (m)
21	13	119.96		256.60	28
22	13	119.96		256.60	28
23	13	119.96		256.60	28
24	12	111.46		237.70	28
25	13	119.96		256.60	28
26	13	119.96		256.60	28
27	13	119.96		256.60	28
28	13	119.96		256.60	28
29	13	119.96		256.60	28
30	13	119.96		256.60	28

Table 8. Recapitulation of pile bearing capacity readings on Pillars piles based on direct readings of the HSPD Machine monometer with a capacity of 420 (Ton) 4 Cylinders and the known pile bearing capacity against the depth of the pile in the soil.

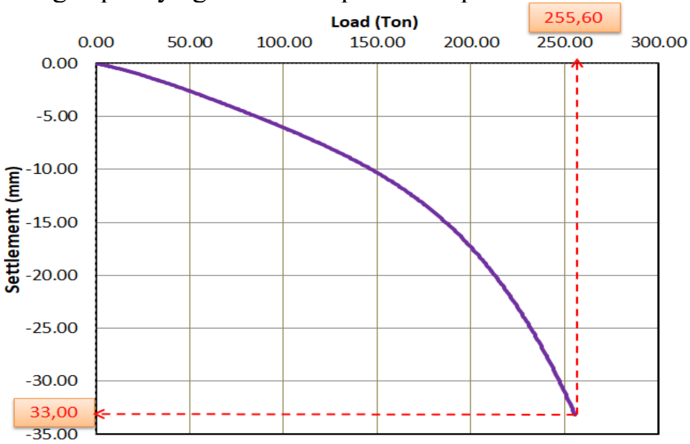

Fig. 11. Reading Power Support Pile based on monometer reading

Based on Fig. 11 The reading of the pile bearing capacity based on the HSPD monometer reading and interpreted into a graph so that the pile bearing capacity is obtained at a depth of pile length of 255.60 ton with a depth of 33 m in the ground.

3.5. Recapitulation of HSPD (Hydraulic Static Pile Driver) Interpretation Results.

Based on the recapitulation of the interpretation results of the HSPD (Hydraulic Static Pile Driver) Test for Field Piles with direct monometer reading observations in the field and combining the pressure values on the HSPD from the abutment piles and pillar piles, the maximum load value from the pile penetration can be obtained with an average value of the safety factor value of 1 (direct reading) can be tabulated in Table 9.

Table 9. Table Comparison HSPD (Hydraulic Static Pile Driver) Capacity

Description of Activities	Piling Daily Record HSPD Pilar		Piling Daily Record HSPD Abutment	
	Ton	kN	Ton	kN
Axial Load (Qult)	250.88	2232.86	249.45	2220.14
Safety Factor (Fs)	1		1	
Axial Load (Qall)	250.88	2232.86	249.45	2220.14

Base the analysis Fig. 6. calculation results interpretation Capacity of HSPD (Hydraulic Static Pile Driver) from point Pile stake pillar foundation and foundation abutment is obtained mark capacity Qall = 250.88 Tons on pillars and Qall = 249.45 Tons on abutments with mark average value Qall = 250.17 Tons

3.6. Comparison of Bearing Capacity of PDA Pile from CAPWAP Test Results of Stake with HSPD (Hydraulic Static Pile Driver)

Capacity of average axial bearing capacity of piles from PDA test CAPWAP with HSPD (Hydraulic Static Pile Driver) can be seen in table 10. and Fig. 12. below:

In table 10. The highest ultimate capacity value was obtained from the Chin method of 588 kN, while the lowest value was recorded in the HSPD results at the Abutment, which was 249.45 kN. The CAPWAP method uses a conservative safety factor (Fs = 2.5), so that the resulting allowable bearing capacity (Qall) value is smaller than the actual HSPD pile driving results using Fs = 1.0. Although the allowable bearing capacity of the HSPD at the Pillar and Abutment is higher than the Qall from the CAPWAP results, this needs to be reviewed carefully because it is directly related to the long-term safety aspects of the structure.

Table 10. Table Capacity Comparison of PDA test CAPWAP with HSPD

Description of Activities	Metode Chin F.K.	Metode Davisson	Metode Mazurkiewicz	Piling Daily Record HSPD Pilar	Piling Daily Record HSPD Abutment
Acxial Load (Qult)	588.00	392.00	460.00	250.88	249.45
Safety Factor (Fs)	2.50	2.50	2.50	1.00	1.00
Acxial Load (Qall)	235.20	156.80	184.00	250.88	249.45

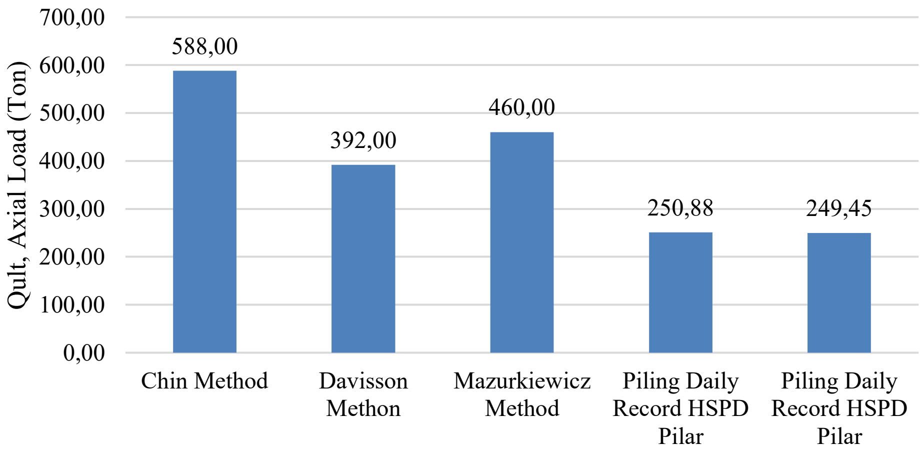

Fig. 12. Graph Table Capacity Comparison of PDA test CAPWAP with HSPD

Based on Fig. 12. The value of the results of the bearing capacity analysis in table 5. is presented in graphical form to facilitate the reading of the bearing capacity of the pile in the PDA CAPWAP test and the bearing capacity of the HSPD (Hydraulic Static Pile Driver) with a coefficient value of Fs = 2.5 for the results of the PDA test analysis obtained the largest single pile bearing capacity value of the Chin FK Method Qult = 588.00 Ton and the smallest value of the Davisson method with a value of Qult = 392.00 Ton. While for the average value of the permitted pile bearing capacity Qult = 480.00 Ton. While for the bearing capacity of the HSPD (Hydraulic Static Pile Driver) without taking into account the coefficient or with the coefficient Fs = 1.0. obtained the largest single pile bearing capacity Qall Qult = 250.17 Ton on the pillar and Qult = 249.54.17 Ton on the pillar.

From the results of the analysis of the capacity comparison results pile bearing capacity, settlement and depth Pile stake from analysis data PDA Test (CAPWAP) with HSPD (Hydraulic Static Pile Driver) Capacity in serve in picture Fig. 13.

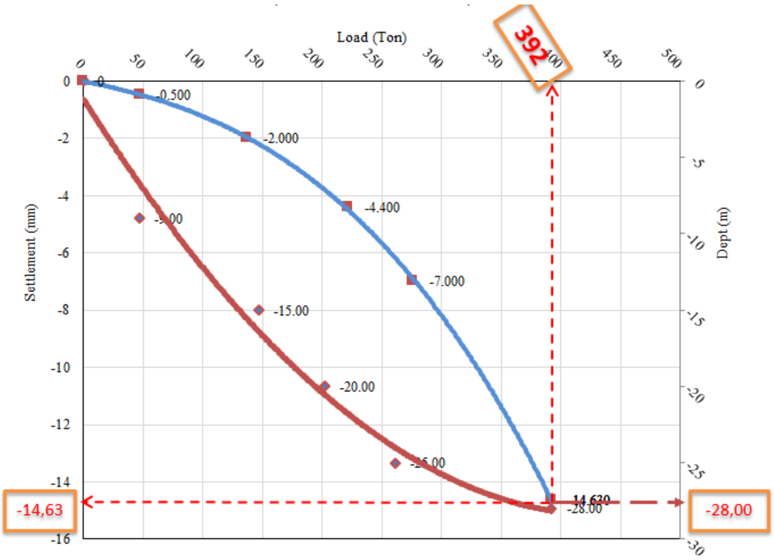

Fig. 13. Graph of Interpretation value pile bearing capacity, settlement and depth Pile

Interpretation value based on graph Fig 13. from the PDA analysis of the CAPWAP test and the capacity of HSPD (Hydraulic Static Pile Driver) obtained Pile bearing capacity Q ult = 392 Tons at a depth of 28.00 m from the top of the mast stake with mark decline Pile of 14.63 mm.

4. Conclusion and Suggestions

Berdasarkan hasil analisa kapasitas tekan tiang pancang menggunakan PDA-Test (CAPWAP) dan alat HSPD Hydraulic Static Pile Driver (HSPD), diperoleh bahwa kapasitas daya dukung tiang pancang (Qult) dengan metode PDA-Test mencapai rata-rata 480 ton dan mampu menahan beban maksimum sebesar 225,78 ton per tiang. Sementara itu, hasil analisa dengan alat HSPD menunjukkan kapasitas rata-rata Qult sebesar 250,17 ton dengan kemampuan menahan beban maksimum yang sama. Dari interpretasi data, diperoleh bahwa pada kedalaman 28 meter, daya dukung tiang mencapai 392 ton dengan penurunan 14,63 mm, yang masih berada dalam batas aman penurunan maksimum sebesar 2,5 cm. Oleh karena itu, dapat disimpulkan bahwa tiang pancang pada kedalaman tersebut mampu menahan beban maksimal dengan penurunan yang masih dalam batas aman. Sebagai saran, dalam penerapan metode pemancangan press menggunakan alat HSPD, perlu diperhatikan kondisi lokasi proyek, terutama jika berada di daerah bantaran sungai. Hal ini penting untuk memastikan daya dukung tanah permukaan memadai, mengingat alat HSPD memiliki berat sebesar 420 ton dan dapat memengaruhi kestabilan serta hasil pemancangan di lokasi tersebut.

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