Study of pile bearing capacity based on calendering and pile driving analyzer at the faspel development project of Ketek Sikara-kara Mandailing Natal district (North Sumatera, Indonesia)

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Abstract. The deep foundation at the Ketek Sikara-kara wharf is the function of foundation that distribute the load from the upper structure of the building to the soil on the bottom of building to the hard soil layer, without effecting shear failure and settlement, has a bearing capacity allowed. The function of Pile Driving Analyzer (PDA) at Parlimbungan Ketek Sikara-kara wharf to determine the bearing capacity of pile and also control to calendering test result, then this researched were tested the pile driving analyzer at 8 sections of pile from 84 sections of calendering pile (10% of the number of sections setting up). Obtained calendering results of lowering is equal to 0.60, 071, 045, 060, 053, 041, 065, 060 fulfilled the specification allowed ≤ 1 inch (2.54 cm). The largest value of pile calendering bearing capacity is 128.52 Ton and the smallest bearing capacity is 73.29 Ton more larger than the allowable pile bearing capacity is 60.9 Ton. Pile driving analyzer results of the largest bearing capacity is equal to TP - B12 Ru 177 Ton more larger than the bearing capacity of pile is allowed on planning is 60.9 Ton and the smallest is equal to TP - B22 Ru 111 Ton more larger than the bearing capacity of pile is allowed on planning is 60.9 Ton.

1. Introduction

The wharf of Parlimbungan Ketek is one of the development project of Sikara-kara wharf which taken place shallow up to -2 m LWS due to the location of Sikara-kara wharf is a sediment catchment area that has properties throughout the year experienced sedimentation due to the movement of currents and wave perpendicular to the coast, effecting shallow at the Sikara-kara wharf, the wharf were only docked by ships ≤ 30 GT. In addition, the 2004 tsunami in the Mandailing Natal district caused problems to damage some parts of the Sikara-kara wharf trestle floor. The attendance of a wharf in the Mandailing Natal district is very needed as a production outlet for the area. Potential area Mandailing Natal district one of them has ± 100,000 ha of oil palm plantation is expected to be transported through Sikara-kara wharf.

Before the upper construction was built, there are several tests which were undertaken on the pile foundation, One of testing are loading testing or pre loading, but because of the difficulty of doing pre-loading test in the sea, therefore it were undertaken the test pile driving analyzer. There were two pile test in the field that was calendering test, which was undertaken at each section of pile that were as much as 84 sections in location and pile driving test analyser was undertaken at 8 sections in location.

In this research, all dynamic formulas are empirical formulas, meaning they contain empirical constants whose value depends on the assumptions and conditions at which developed from the results of the monitoring of calculations and investigations performed over a period of time.

Hilley (Modified) on the factors and co-factors that are identified as ambiguous (type and type of hammer / hammer used, method of applying empirical appeal scale to efectiveness reduction factor. Hilley formula actually refers only to the standard of calendering, regarding the effectiveness of Hilley's modified formulas (in developing the relationship between co-earthquake reduction factors, press laterally while the pile, and press while cap pile) (Das, B.M, 2002).

2. Literatur Review

2.1 Calendering

The action of setting up a pile was stopped when it reached hard soil. The indication of setting up pile has reached the hard soil, when the hammer has already set-up on the position. It usually in each tool has already set-up the size of hammer. if it has already set up the hammer in such a position then it was undertaken the reading of calendering immediately. This reading of pile was undertaken on the setting up. If the high reading of hammer value was less than 2.54 cm, then the setting up of pile can already be stopped That means the pile has reached the sections of hard soil that cause of the reading calendering is value small or less 2.54 cm. If the value setting up of pile continued more 2.54 cm then it could be failure. Calendering reading was under take on the last 10 blowing (U.S. Department of Transportation Federal Highway Administration, 2016).

Calendering is a graphic record that available on a tool pile that the function are knowing so far the setting up of pile that has already been undertaken whether has fulfilled the specification of the allowable bearing capacity which was used in working of setting up pile (concrete and steel pipe) to determine the bearing capacity of the soil empirically through the calculations was taken into account by the blowing tool which is a diesel hammer or hydraulic hammer..

Calendering calculations obtain output which is the bearing capacity in Ton. Calendering was undertaken almost approaching the required top pile, final setting for the last 10 blowing ≤ 2.54 cm. One count to know the bearing capacity of calendaring is used Hilley formula (Fellenius,2018) in this research. It is listed below.

Modified Hilley formula for :

Single acting hammer

$$Q_u = \frac{\alpha \, W \, H_{ef} \, \eta}{S + 0.5 \, (C_C + C_p + C_q)} \qquad \text{----------1)}$$

$$Q_r = \frac{Q_u}{3} \qquad \text{----------2)}$$

Double acting hammer

$$Q_u = \frac{\alpha \, E_h \, \eta}{S + 0.5 \, ((C_C + C_p + C_q)} \qquad \text{----------3)}$$

$$Q_r = \frac{Q_u}{3} \qquad \text{----------4)}$$

where :

Q_u = ultimate load capacity of pile at time of driving predicted by driving formula

Q_r = allowable load
A = hammer efficiency
W = weight of ram
H_{ef} = effective ram stroke
η = blow Efficiency
S = permanent set of pile per blow
P = weight of pile
E = coefisien of restution of cushion
C_c= compression of pile head
C_P= compression of pile
C_q = compression of ground

2.2 Pile Driving Analyser (PDA)

Pile Driving Analyser (PDA) was a digital testing to control or determine the bearing capacity of piles has been achieved and also function re-control the results of the Calendaring testing which the function is to stop the pile of each section. Pile driving analyzer test is also a test for dynamically measuring the pile capacity of the deep foundation, it is good for pile or drill pile, pile integrity, and energy from hammer which refers to ASTM D-4945 (*Standard Test Method for High-Strain Dynamic Testing of Deep Foundations*) (Fellenius, 2018).

Analysis of data pile driving analyzer is undertaken by Case Method procedure (Fellenius, 2018), i.e; the data recorded by the PDA are displayed in real time (blow by blow) in the form of wave traces. Routinely, they are also treated analytically and values of stress, energy, etc., are displayed to the operator. The data analysis of pile driving analyzer is undertaken by Case Method procedure, which includes measurement of velocity data and force during re-strike and dynamic variable calculation in real time to get description about bearing capacity of single pile foundation.

Pile driving analyser test, dynamic load test has several advantages, one of it can do multiple pile-test to save time, require relatively small space, evaluate bearing capacity and structural integrity of pile, Evaluate pile settlement. Disadvantages of the pile driving analyzer include: cannot calculate lateral forces, the results can deviate away from test data and interpretation when is undertaken by an inexperienced person.

3. Research Methodology

Development of rehabilitation of Parlimbungan Ketek wharf is suitable for port master plan in port development so that the right port is formed according to its function and rule it refers to Republic Indonesian Law Number. 17 Year 2008 on shipping identifies the need for the provision of port infrastructure as a place of intra and inter moda transportation.

The geographical position of Parlimbungan Ketek wharf is 0 ° 21'47. 18 "LU and 99 ° 7'16.13" B.T. The location of Parlimbungan Ketek wharf is located on the west coast of North Sumatera Province and is a strait area directly opposite to Tamang island.

Time schedule for the implementation of the research working was planned within 120 calendar days or 4 months after the warrant starts to commence issues, on time schedule.

The activity objectives of this research was determine whether the capacity of the pile bearing capacity is compatible with the required technical specifications, obtained from the test results of the test pile driving analyzer. Calendering testing is undertaken to determine if the pile bring down at the last 10 blowing ≤ 2.54 cm and the setting up pile can be stopped and move to the piling sections next.

Figure 1. Location Project Map

Pile which was used in field testing, there is in shown table 1.

Table 1. Project Information & Pile Properties

Table 1.1 Project Information

Data 1	
Pile Name	TP-A 20
DESC	Steel 50- Diesel 6.5 T
File	TP-A 30 PDA
Blow Number	22
Serial Number	4690 LE
Data 2	
File Name	
DESC	Steel 50 – Diesel 6.5 T
File	TP – B 12 PDA
Blow Number	17
Serial Number	4690 LE
Data 3	
File Name	TP A3-3
DESC	Steel 50- Diesel 6.5 T
File	TP A3-3 PDA
Blow Number	5
Serial Number	4523 LE

Table 1.2 Pile Properties

Data 1	
LE	43.7 m
AR	217. 27 cm^2
EM	2109 T/cm^2
SP	7.88 T/ m^3
WS	5123.0 m/s
WC	5.11 m/s
EA/C	89.5 Tn- s/m
2L/C	17.10 ms
JC	0.50
LP	34.9 meter
Data 2	
LE	47.8 meter
AR	213.75 T/m^2
EM	2109 cm^2
SP	7.88 T/m^3
WS	5123.0 m/s
WC	5112.3 m/s
EA/C	88.0 Tn- s/m
2L/C	18.70 ms
JC	0.50
LP	39.5 m
Data 3	
LE	47.5 m

AR	213.75 cm^2
EM	2109 T/cm^2
SP	7.88 T/m^3
WS	5123.0 m/s
WC	5107.5 m/s
EA/C	88.0 Tn-s/m
2L/C	18.50 ms
JC	0.50
LP	39.0 m

4. Result and Discuss

4.1 Result

A. Data 1 : Calendering data of setting up per day

Results which is obtained from the calendaring test for each pile, is obtained bring down of 10 (ten) last blowing as shown in table 2.

Table 2. Calendering data of setting up per day

NO	HARI	TANGGAL	TITIK	KEDALAMAN		Potongan tiang	Jarak seabed ke potongan tiang	Panjang pipa yang masuk (seabed kebawah)	JUMLAH PUKULAN	Penurunan 9 Pukulan Terakhir (cm)			Rata - rata penurunan 10 Pukulan Terakhir	KET
				(MTR)	Aruan					1	2	3	(cm)	
1	SELASA	23 AGS 2016	A22	48.529	+2.1	0.471	7.40	41.129	400				8.10	SEGMEN 2
2	SENIN	22 AGS 2016	B22	48.537	+2.1	0.463	7.40	41.137	388				9.70	
3	SENIN	22 AGS 2016	C22	48.592	+2.1	0.408	7.40	41.192	464				7.70	
4	MINGGU	21 AGS 2016	A21	48.485	+2.1	0.515	7.40	41.085	496				7.10	
5	SABTU	10-Sep-16	B'21	49.553	+2.1	0.447	7.40	42.153	427				8.30	
6	SABTU	10-Sep-16	B'21	49.720	+2.1	0.280	7.40	42.320	477				9.60	
7	MINGGU	11-Sep-16	C21	48.050	+2.1	0.950	7.40	45.650	406				9.30	
8	MINGGU	21 AGS 2016	A20	47.028	+2.1	0.435	7.40	41.185	433				6.00	
9	MINGGU	11-Sep-16	B'20	49.451	+2.1	0.549	7.40	42.051	478				7.00	
10	JUMAT	9-Sep-16	B'20	49.514	+2.1	0.486	7.40	42.114	514				4.90	
11	SENIN	12-Sep-16	C20	48.758	+2.1	0.242	7.40	41.358	482				8.90	
12	JUMAT	9-Sep-16	A19	48.500	+2.1	0.500	7.40	41.100	445				8.20	
13	SELASA	13-Sep-16	B'18	49.512	+2.1	0.488	7.40	42.112	448				2.50	
14	RABU	14-Sep-16	B'19	49.407	+2.1	0.592	7.40	42.008	509				6.20	
15	SENIN	12-Sep-16	C19	48.400	+2.1	0.600	7.40	41.000	394				5.00	
16	KAMIS	15-Sep-16	A18	48.491	+2.1	0.509	7.40	41.091	435				4.40	
17	KAMIS	15-Sep-16	B'18	49.501	+2.1	0.499	7.40	42.101	469				5.80	
18	KAMIS	15-Sep-16	B'18	49.570	+2.1	0.430	7.40	42.170	545				9.65	
19	KAMIS	15-Sep-16	C18	48.146	+2.1	0.854	7.40	40.746	400				4.85	
20	JUMAT	16-Sep-16	A17	48.713	+2.1	0.287	7.40	41.313	441				8.95	
21	SABTU	17-Sep-16	B'17	49.804	+2.1	0.196	7.40	42.404	363				7.05	
22	MINGGU	18-Sep-16	B'17	49.682	+2.1	0.318	7.40	42.282	423				6.30	
23	MINGGU	18-Sep-16	C17	48.558	+2.1	0.442	7.40	41.158	492				5.30	
24	SENIN	19-Sep-16	A16	48.357	+2.1	0.642	7.40	40.958	325				5.60	
25	KAMIS	22-Sep-16	B'16	49.590	+2.1	0.410	7.40	42.190	458				6.55	
26	KAMIS	22-Sep-16	B'16	49.801	+2.1	0.199	7.40	42.401	539				7.75	
27	KAMIS	22-Sep-16	C16	48.543	+2.1	0.547	7.40	41.053	408				5.50	
28	JUMAT	23-Sep-16	A15	48.779	+2.1	0.221	7.40	41.379	472				5.90	
29	JUMAT	23-Sep-16	B'15	49.747	+2.1	0.253	7.40	42.347	454				9.00	
30	SABTU	24-Sep-16	B'15	49.258	+2.1	0.742	7.40	41.858	397				5.90	
31	JUMAT	25-Sep-16	C15	48.547	+2.1	0.453	7.50	41.047	384				4.20	
32	SABTU	24-Sep-16	A14	48.555	+2.1	0.445	7.40	41.155	453				7.20	
33	MINGGU	25-Sep-16	B'14	49.769	+2.1	0.231	7.50	42.269	476				9.40	
34	SENIN	26-Sep-16	B'14	49.533	+2.1	0.467	7.50	42.033	469				3.70	
35	SABTU	24-Sep-16	C14	48.532	+2.1	0.468	7.50	41.032	407				6.50	
36	KAMIS	29-Sep-16	A13	48.778	+2.1	0.222	7.40	41.378	405				8.90	
37	RABU	28-Sep-16	B'13	49.481	+2.1	0.519	7.50	41.981	426				7.20	
38	SABTU	1 OKT 2016	B'13	49.642	+2.1	0.358	7.50	42.142	394				8.00	
39	SABTU	1 OKT 2016	C13	48.687	+2.1	0.388	7.50	41.112	388				2.40	
40	SABTU	1 OKT 2016	A12	48.109	+2.1	0.320	7.40	41.280	266				5.90	
41	SABTU	1 OKT 2016	B12	48.980	+2.1	0.470	7.50	41.080	403				4.50	
42	SABTU	1 OKT 2016	C12	48.510	+2.1	0.490	7.40	41.110	482				6.00	
43	SENIN	3 OKT 2016	A11	48.552	+2.1	0.448	7.50	41.052	382				8.20	
44	SENIN	3 OKT 2016	B11	48.583	+2.1	0.417	7.50	41.083	328				8.30	
45	SENIN	3 OKT 2016	C11	48.674	+2.1	0.326	7.50	41.174	358				7.40	
46	SENIN	3 OKT 2016	A10	48.474	+2.1	0.526	7.50	40.974	333				7.40	
47	SENIN	3 OKT 2016	B'10	49.666	+2.1	0.334	7.50	42.166	354				6.60	
48	SELASA	4 OKT 2016	B'10	49.586	+2.1	0.414	7.50	42.086	362				9.60	
49	SENIN	3 OKT 2016	C10	48.476	+2.1	0.524	7.50	40.976	309				7.60	
50	SELASA	4 OKT 2016	A9	48.53	+2.1	0.470	7.50	41.030	365				3.00	
51	SELASA	4 OKT 2016	B'9	49.46	+2.1	0.540	7.50	41.960	468				4.00	
52	KAMIS	6 OKT 2016	B'9	49.458	+2.1	0.542	7.50	41.958	418				7.30	
53	SELASA	4 OKT 2016	C9	48.514	+2.1	0.486	7.50	41.014	389				9.45	
54	SABTU	8 OKT 2016	A8	48.529	+2.1	0.471	7.50	41.029	410				7.70	
55	KAMIS	6 OKT 2016	B'8	49.52	+2.1	0.480	7.50	42.020	385				5.80	
56	SABTU	8 OKT 2016	B'8	49.522	+2.1	0.478	7.50	42.022	410				9.00	
57	KAMIS	6 OKT 2016	C8	48.554	+2.1	0.446	7.50	41.054	364				6.00	
58	SABTU	8 OKT 2016	A7	48.697	+2.1	0.303	7.50	41.197	480				9.70	
59	SABTU	8 OKT 2016	B'7	49.672	+2.1	0.328	7.50	42.172	344				7.20	
60	SABTU	8 OKT 2016	B'7	49.480	+2.1	0.520	7.50	41.980	431				5.00	
61	SABTU	8 OKT 2016	C7	48.669	+2.1	0.331	7.50	41.169	372				6.90	
62	JUMAT	28 OKT 2016	A6	48.504	+2.1	0.496	7.50	41.004	360				4.00	
63	JUMAT	28 OKT 2016	B'6	49.549	+2.1	0.451	7.50	42.049	423				4.90	
64	SABTU	29 OKT 2016	B'6	49.352	+2.1	0.648	7.50	41.852	405				5.20	
65	JUMAT	28 OKT 2016	C6	48.496	+2.1	0.504	7.50	40.996	381				5.60	
66	SABTU	29 OKT 2016	A5	48.955	+2.1	0.445	7.50	41.055	358				9.50	
67	SABTU	29 OKT 2016	B'5	49.680	+2.1	0.320	7.50	42.180	448				8.00	
68	SABTU	29 OKT 2016	B'5	49.497	+2.1	0.503	7.50	41.997	410				7.70	
69	SABTU	29 OKT 2016	C5	48.605	+2.1	0.395	7.50	41.105	424				7.50	
70	MINGGU	30 OKT 2016	A4	48.503	+2.1	0.497	7.50	41.003	418				9.30	
71	MINGGU	30 OKT 2016	B'4	49.408	+2.1	0.592	7.50	41.908	419				3.80	
72	MINGGU	30 OKT 2016	B'4	49.478	+2.1	0.522	7.50	41.978	441				7.00	
73	MINGGU	30 OKT 2016	C4	48.575	+2.1	0.425	7.50	41.075	435				6.50	
74	SENIN	31 OKT 2016	A3	48.653	+2.1	0.347	7.50	41.153	450				5.30	
75	SENIN	31 OKT 2016	B'3	49.638	+2.1	0.362	7.50	42.138	436				6.80	
76	RABU	2-Nov-16	B'3	49.683	+2.1	0.317	7.50	42.183	417				8.30	
77	SENIN	31 OKT 2016	C3	48.573	+2.1	0.427	7.50	41.073	398				7.30	
78	RABU	2-Nov-16	A2	48.846	+2.1	0.154	7.50	41.346	383				4.60	
79	RABU	2-Nov-16	B'2	49.641	+2.1	0.359	7.50	42.141	408				4.10	
80	RABU	2-Nov-16	B'2	49.541	+2.1	0.459	7.50	42.041	480				4.10	
81	SELASA	1-Nov-16	C2	48.64	+2.1	0.360	7.50	41.140	419				4.00	
82	SELASA	8-Nov-16	A1	48.762	+2.1	0.238	7.50	41.262	400				5.60	
83	SELASA	8-Nov-16	B1	48.488	+2.1	0.502	7.50	40.988	444				4.80	
84	SABTU	4-Nov-16	C1	48.621	+2.1	0.379	7.50	41.121	429				5.10	SEGMEN 1

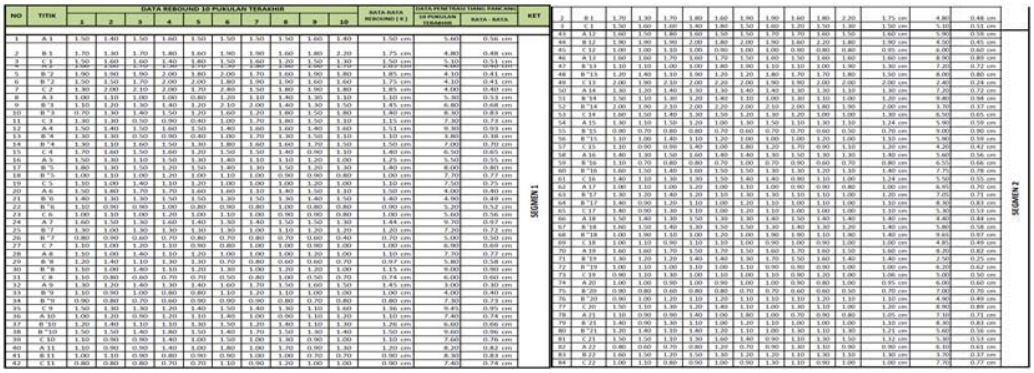
A. Data 2 : Calendering bearing capacity record (Hilley Formula)
Capacity of bearing capacity based on Hilley formula using calendaring data as shown in table 3.

Table 3. Calendering bearing capacity record (Hilley Formula)

No. titik	W (ton)	P (ton)	H (m)	S (cm)	K (cm)	n	R (ton)	EF	SF	R. Pakai (ton)	KET
A 1	604.18	8.36	1.60	0.56	1.50	0.50	278.68	0.90	3.00	**83.60**	SEGMEN 1
B 1	604.18	8.36	1.60	0.48	1.75	0.50	257.43	0.90	3.00	**77.23**	
A 2	604.18	8.36	1.60	0.46	1.65	0.50	272.07	0.90	3.00	**81.62**	
B'2	604.26	8.36	1.60	0.41	1.85	0.50	254.05	0.90	3.00	**76.22**	
B"2	604.26	8.36	1.60	0.41	1.75	0.50	265.81	0.90	3.00	**79.74**	
C 2	604.18	8.36	1.60	0.40	1.85	0.50	255.15	0.90	3.00	**76.54**	
A 3	604.18	8.36	1.60	0.53	1.10	0.50	352.19	0.90	3.00	**105.66**	
B"3	604.26	8.36	1.60	0.68	1.45	0.50	269.56	0.90	3.00	**80.87**	
B"3	604.26	8.36	1.60	0.83	1.40	0.50	257.47	0.90	3.00	**77.24**	
C 3	604.18	8.36	1.60	0.73	1.15	0.50	305.36	0.90	3.00	**91.61**	
A 4	604.18	8.36	1.60	0.93	1.51	0.50	235.28	0.90	3.00	**70.58**	
B'4	604.26	8.36	1.60	0.38	1.10	0.50	387.94	0.90	3.00	**116.38**	
B"4	604.26	8.36	1.60	0.70	1.50	0.50	260.98	0.90	3.00	**78.29**	
C 4	604.18	8.36	1.60	0.65	1.40	0.50	280.04	0.90	3.00	**84.01**	
A 5	604.18	8.36	1.60	0.55	1.25	0.50	318.93	0.90	3.00	**95.68**	
B"5	604.26	8.36	1.60	0.80	1.40	0.50	260.98	0.90	3.00	**78.29**	
B"5	604.26	8.36	1.60	0.77	1.00	0.50	324.38	0.90	3.00	**97.31**	
C 5	604.18	8.36	1.60	0.75	1.10	0.50	310.31	0.90	3.00	**93.09**	
A 6	604.18	8.36	1.60	0.40	1.50	0.50	302.15	0.90	3.00	**90.64**	
B'6	604.26	8.36	1.60	0.49	1.40	0.50	303.79	0.90	3.00	**91.14**	
B"6	604.26	8.36	1.60	0.52	0.90	0.50	404.34	0.90	3.00	**121.30**	
C 6	604.18	8.36	1.60	0.56	1.00	0.50	368.00	0.90	3.00	**110.40**	
A 7	604.18	8.36	1.60	0.97	1.44	0.50	238.21	0.90	3.00	**71.46**	
B'7	604.26	8.36	1.60	0.72	1.20	0.50	299.04	0.90	3.00	**89.71**	
B"7	604.26	8.36	1.60	0.50	0.70	0.50	478.47	0.90	3.00	**143.54**	
C 7	604.18	8.36	1.60	0.69	1.00	0.50	339.69	0.90	3.00	**101.91**	
A 8	604.18	8.36	1.60	0.77	1.10	0.50	306.99	0.90	3.00	**92.10**	
B'8	604.26	8.36	1.60	0.58	0.97	0.50	370.42	0.90	3.00	**111.13**	
B"8	604.26	8.36	1.60	0.90	1.15	0.50	280.08	0.90	3.00	**84.02**	
C 8	604.18	8.36	1.60	0.60	0.74	0.50	428.42	0.90	3.00	**128.52**	
A 9	604.18	8.36	1.60	0.80	1.45	0.50	328.04	0.90	3.00	**98.41**	
B'9	604.26	8.36	1.60	0.40	1.00	0.50	410.11	0.90	3.00	**123.03**	
B"9	604.26	8.36	1.60	0.73	0.80	0.50	375.27	0.90	3.00	**112.58**	
C 9	604.18	8.36	1.60	0.95	1.36	0.50	249.06	0.90	3.00	**74.72**	
A 10	604.18	8.36	1.60	0.74	1.10	0.50	312.00	0.90	3.00	**93.60**	
B'10	604.26	8.36	1.60	0.66	1.26	0.50	299.04	0.90	3.00	**89.71**	
B"10	604.26	8.36	1.60	0.96	1.50	0.50	233.40	0.90	3.00	**70.02**	
C 10	604.18	8.36	1.60	0.76	1.10	0.50	308.64	0.90	3.00	**92.59**	
A 11	604.18	8.36	1.60	0.82	1.20	0.50	284.20	0.90	3.00	**85.26**	
B 11	604.18	8.36	1.60	0.83	0.90	0.50	331.84	0.90	3.00	**99.55**	
C 11	604.18	8.36	1.60	0.74	0.90	0.50	350.05	0.90	3.00	**105.01**	
A 1	604.18	8.36	1.60	0.56	1.50	0.50	278.68	0.90	3.00	**83.60**	SEGMEN 2
B 1	604.18	8.36	1.60	0.48	1.75	0.50	257.43	0.90	3.00	**77.23**	
A 12	604.18	8.36	1.60	0.59	1.60	0.50	262.14	0.90	3.00	**78.64**	
B 12	604.18	8.36	1.60	0.45	1.90	0.50	244.29	0.90	3.00	**73.29**	
C 12	604.18	8.36	1.60	0.60	0.95	0.50	370.37	0.90	3.00	**111.11**	
A 13	604.18	8.36	1.60	0.89	1.60	0.50	230.55	0.90	3.00	**69.17**	
B'13	604.26	8.36	1.60	0.72	1.30	0.50	284.24	0.90	3.00	**85.27**	
B"13	604.26	8.36	1.60	0.80	1.50	0.50	249.63	0.90	3.00	**74.89**	
C 13	604.18	8.36	1.60	0.24	2.00	0.50	256.28	0.90	3.00	**76.89**	
A 14	604.18	8.36	1.60	0.72	1.30	0.50	284.20	0.90	3.00	**85.26**	
B'14	604.26	8.36	1.60	0.94	1.20	0.50	268.80	0.90	3.00	**80.49**	
B"14	604.26	8.36	1.60	0.87	2.00	0.50	242.26	0.90	3.00	**72.68**	
C 14	604.26	8.36	1.60	0.65	1.30	0.50	294.44	0.90	3.00	**88.33**	
A 15	604.26	8.36	1.60	0.59	1.24	0.50	313.75	0.90	3.00	**94.12**	
B'15	604.26	8.36	1.60	0.90	0.70	0.50	358.85	0.90	3.00	**107.65**	
B"15	604.26	8.36	1.60	0.59	1.10	0.50	339.74	0.90	3.00	**101.92**	
C 15	604.26	8.36	1.60	0.42	1.20	0.50	354.42	0.90	3.00	**106.33**	
A 16	604.26	8.36	1.60	0.56	1.40	0.50	292.94	0.90	3.00	**87.88**	
B'16	604.26	8.36	1.60	0.66	0.80	0.50	394.61	0.90	3.00	**118.38**	
B"16	604.26	8.36	1.60	0.78	1.40	0.50	263.98	0.90	3.00	**79.19**	
C 16	604.26	8.36	1.60	0.55	1.24	0.50	320.76	0.90	3.00	**96.23**	
A 17	604.26	8.36	1.60	0.70	1.00	0.50	358.74	0.90	3.00	**101.62**	
B'17	604.26	8.36	1.60	0.71	1.20	0.50	301.40	0.90	3.00	**90.42**	
B"17	604.26	8.36	1.60	0.83	1.10	0.50	297.49	0.90	3.00	**89.25**	
C 17	604.26	8.36	1.60	0.53	1.10	0.50	352.24	0.90	3.00	**105.67**	
A 18	604.26	8.36	1.60	0.44	1.40	0.50	312.04	0.90	3.00	**93.61**	
B'18	604.26	8.36	1.60	0.58	1.40	0.50	289.98	0.90	3.00	**86.99**	
B"18	604.26	8.36	1.60	0.97	1.40	0.50	242.77	0.90	3.00	**72.83**	
C 18	604.26	8.36	1.60	0.49	1.00	0.50	386.64	0.90	3.00	**115.99**	
A 19	604.26	8.36	1.60	0.82	1.60	0.50	237.26	0.90	3.00	**71.18**	
B'19	604.26	8.36	1.60	0.25	1.40	0.50	347.97	0.90	3.00	**104.39**	
B"19	604.26	8.36	1.60	0.62	1.00	0.50	354.42	0.90	3.00	**106.33**	
C 19	604.26	8.36	1.60	0.50	1.06	0.50	368.05	0.90	3.00	**110.42**	
A 20	604.26	8.36	1.60	0.60	0.95	0.50	370.42	0.90	3.00	**111.13**	
B'20	604.26	8.36	1.60	0.70	0.70	0.50	410.11	0.90	3.00	**123.03**	
B"20	604.26	8.36	1.60	0.49	1.10	0.50	361.11	0.90	3.00	**108.33**	
C 20	604.26	8.36	1.60	0.89	1.20	0.50	274.72	0.90	3.00	**82.42**	
A 21	604.26	8.36	1.60	0.71	0.90	0.50	401.20	0.90	3.00	**120.36**	
B'21	604.26	8.36	1.60	0.83	1.10	0.50	297.49	0.90	3.00	**89.25**	
B"21	604.26	8.36	1.60	0.56	1.21	0.50	324.38	0.90	3.00	**97.31**	
C 21	604.26	8.36	1.60	0.53	1.32	0.50	310.36	0.90	3.00	**93.11**	
A 22	604.26	8.36	1.60	0.61	0.90	0.50	380.24	0.90	3.00	**114.07**	
B 22	604.26	8.36	1.60	0.37	1.30	0.50	343.81	0.90	3.00	**103.14**	
C 22	604.26	8.36	1.60	0.77	1.00	0.50	324.38	0.90	3.00	**97.31**	

B. Data 3. Data rebound calendering the last 10 (ten) blowing
There is a ten (10) rebound of calendaring data in accordance with the number of last 10 (ten) blowing and the rebound value is on the average as shown in Table 4.

Table 4. Data rebound calendaring the last 10 blowing



C. Data 4: Recapitulation calendaring of setting up data

The magnitude of the last 10 (ten) blowing, on the average into Calendering (final set) as shown table 5.

Table 5. Recapitulation calendering of setting up data

No	No. Titik Tiang Pancang	Kedalaman TP (Laporan Pemancangan)			Jumlah (m)	Grand Total dan Re-rata (m)	Kalendring/ Penurunan (cm)	Penurunan yang diijinkan
		Cut Level ke Muka air (m)	Muka Air ke Seabed (m)	Seabed ke Tanah Keras (m)				
(1)	(2)	(3)	(4)	(5)	(6 = 3+4+5)	(7)	(8)	
1	A.1	2.10	5.40	41.262	48.762	145.88	0.56	
2	B.1	2.10	5.40	40.998	48.498	48.63	0.48	
3	C.1	2.10	5.40	41.121	48.621		0.51	
4	A.2	2.10	5.40	41.346	48.846		0.46	
5	B'2	2.10	5.40	42.141	49.641	196.67	0.41	
6	B"2	2.10	5.40	42.041	49.541	49.17	0.41	
7	C.2	2.10	5.40	41.140	48.640		0.40	
8	A.3	2.10	5.40	41.153	48.653		0.53	
9	B'3	2.10	5.40	42.138	49.638	196.55	0.68	
10	B"3	2.10	5.40	42.183	49.683	49.14	0.83	
11	C.3	2.10	5.40	41.073	48.573		0.73	
12	A.4	2.10	5.40	41.003	48.503		0.93	≤ 1,0 inchi atau
13	B'4	2.10	5.40	41.908	49.408	195.96	0.38	≤ 2,54 inchi
14	B"4	2.10	5.40	41.978	49.478	48.99	0.70	
15	C.4	2.10	5.40	41.075	48.575		0.65	
16	A.5	2.10	5.40	41.055	48.555		0.55	
17	B'5	2.10	5.40	42.180	49.680	196.34	0.80	
18	B"5	2.10	5.40	41.997	49.497	49.08	0.77	
19	C.5	2.10	5.40	41.105	48.605		0.75	
20	A.6	2.10	5.40	41.004	48.504		0.40	
21	B'6	2.10	5.40	42.049	49.549	195.90	0.49	
22	B"6	2.10	5.40	41.852	49.352	48.98	0.52	
23	C.6	2.10	5.40	40.996	48.496		0.56	
24	A.7	2.10	5.40	41.197	48.697		0.97	
25	B'7	2.10	5.40	42.172	49.672	196.52	0.72	
26	B"7	2.10	5.40	41.980	49.480	49.13	0.50	
27	C.7	2.10	5.40	41.169	48.669		0.69	
28	A.8	2.10	5.40	41.029	48.529		0.77	
29	B'8	2.10	5.40	42.022	49.522	196.13	0.58	
30	B"8	2.10	5.40	42.020	49.520	49.03	0.90	
31	C8	2.10	5.40	41.054	48.554		0.60	
32	A.9	2.10	5.40	41.030	48.530		0.30	
33	B'9	2.10	5.40	41.960	49.460	195.96	0.40	
34	B"9	2.10	5.40	41.958	49.458	48.99	0.73	
35	C.9	2.10	5.40	41.014	48.514		0.95	
36	A.10	2.10	5.40	40.974	48.474		0.74	
37	B'10	2.10	5.40	42.166	49.666	196.20	0.66	
38	B"10	2.10	5.40	42.086	49.586	49.05	0.96	
39	C.10	2.10	5.40	40.976	48.476		0.76	
40	A.11	2.10	5.40	41.052	48.552	145.81	0.82	
41	B.11	2.10	5.40	41.083	48.583	48.60	0.83	
42	C.11	2.10	5.40	41.174	48.674		0.74	

	Tiang Pancang	Muka air (m)	Seabed (m)	Tanah Keras (m)		(m)	(cm)	diijinkan
(1)	(2)	(3)	(4)	(5)	(6 = 3+4+5)	(7)	(8)	
1	A.1	2.10	5.40	41.262	48.762	145.88	0.56	
43	A.12	2.10	5.30	41.277	48.677	145.72	0.59	
44	B.12	2.10	5.40	41.030	48.530	48.57	0.45	
45	C.12	2.10	5.30	41.110	48.510		0.60	
46	A.13	2.10	5.30	41.378	48.778		0.89	
47	B'13	2.10	5.40	41.981	49.481	196.59	0.72	
48	B"13	2.10	5.40	42.142	49.642	49.15	0.80	
49	C.13	2.10	5.40	41.187	48.687		0.24	
50	A.14	2.10	5.30	41.155	48.555		0.72	
51	B'14	2.10	5.40	42.269	49.769	196.39	0.94	
52	B"14	2.10	5.40	42.033	49.533	49.10	0.37	
53	C.14	2.10	5.40	41.032	48.532		0.65	
54	A.15	2.10	5.30	41.379	48.779		0.59	
55	B'15	2.10	5.30	42.347	49.747	196.33	0.90	
56	B"15	2.10	5.30	41.858	49.258	49.08	0.59	
57	C.15	2.10	5.40	41.047	48.547		0.42	
58	A.16	2.10	5.30	40.957	48.357		0.56	
59	B'16	2.10	5.30	42.190	49.590	196.20	0.66	≤ 1,0 inchi atau
60	B"16	2.10	5.30	42.402	49.802	49.05	0.78	≤ 2,54 inchi
61	C.16	2.10	5.30	41.053	48.453		0.55	
62	A.17	2.10	5.30	41.313	48.713		0.70	
63	B'17	2.10	5.30	42.404	49.804	196.76	0.71	
64	B"17	2.10	5.30	42.282	49.682	49.19	0.83	
65	C.17	2.10	5.30	41.158	48.558		0.53	
66	A.18	2.10	5.30	41.091	48.491		0.44	
67	B'18	2.10	5.30	41.101	48.501	193.71	0.58	
68	B"18	2.10	5.30	41.170	48.570	48.43	0.97	
69	C.18	2.10	5.30	40.746	48.146		0.49	
70	A.19	2.10	5.30	41.100	48.500		0.82	
71	B'19	2.10	5.30	42.112	49.512	195.82	0.25	
72	B"19	2.10	5.30	42.007	49.407	48.95	0.62	
73	C.19	2.10	5.30	41.000	48.400		0.50	
74	A.20	2.10	5.30	41.165	48.565		0.60	
75	B'20	2.10	5.30	41.051	48.451	195.29	0.70	
76	B"20	2.10	5.30	42.114	49.514	48.82	0.49	
77	C.20	2.10	5.30	41.358	48.758		0.89	
78	A.21	2.10	5.30	41.085	48.485		0.71	
79	B'21	2.10	5.30	42.153	49.553	195.81	0.83	
80	B"21	2.10	5.30	42.320	49.720	48.95	0.56	
81	C.21	2.10	5.30	40.650	48.050		0.53	
82	A.22	2.10	5.30	41.129	48.529	145.66	0.61	
83	B.22	2.10	5.30	41.137	48.537	48.55	0.37	
84	C.22	2.10	5.30	41.192	48.592		0.77	

4.2 Discuss

Calculation of bearing capacity of pile using data calendaring and Hilley formula is obtained by bearing capacity of pile as shown in table 6

Table 6. Bearing capacity of calendering

Pile Name	**CALENDERING**											
	W Ton	P Ton	H m	S cm	K cm	n	R Ton	EF	SF	R use Ton	Cut water level + water level to seabed + seabed to hard soil (m)	Calendering /settlement (decrease) (cm)
TP-A20	604.26	8.36	1.60	0.60	0.95	0.50	370.42	0.90	3.00	111.13	48.565	0.60
TP-A21	604.26	8.36	1.80	0.71	0.90	0.50	401.20	0.90	3.00	120.36	48.485	0.71
TP-B12	604.18	8.36	1.60	0.45	1.90	0.50	244.29	0.90	3.00	73.29	48.530	0.45
TP-C12	604.18	8.36	1.60	0.60	0.95	0.50	370.37	0.90	3.00	111.11	48.510	0.60
TPA3-3	604.18	8.36	1.60	0.53	1.10	0.50	352.19	0.90	3.00	105.66	48.653	0.53
TPB2-2	604.26	8.36	1.60	0.41	1.75	0.50	265.81	0.90	3.00	79.74	49.541	0.41
TP- C4	604.18	8.36	1.60	0.65	1.40	0.50	280.04	0.90	3.00	84.01	48.575	0.65
TP-C8-1	604.18	8.36	1.60	0.60	0.74	0.50	428.42	0.90	3.00	128.52	48.554	0.60

Calculation of bearing capacity of pile using data pile driving analyzer and CAPWAP software, is obtained the bearing capacity of pile as shown in table 7

Table 7. Bearing Capacity of Pile Driving Analyzer

Pile Name	PDA	CAPWAP				
	Bearing Capacity (RMX/RSU) Ton	**Bearing Capacity** (RU) Ton	**Friction** (SF) Ton	**End Bearring** (EB) Ton	**Elastic Displacement** (Dy) mm	**Displacement Maximum** (Dx) mm
TP-A20	163	158	157	2	46.39	71.36
TP-A21	125	143	140	3	61.22	97.65
TP-B12	173	177	159	18	16.50	40.37
TP-C12	140	133	125	8.0	37.33	55.19
TP- A3-3	199	174	172	2.0	18.90	28.29
TP- B2-2	111	111	110	1.0	35.22	72.21
TP- C4	177	153	145	8.0	16.31	33.18
TP-C8-1	161	148	148	0.0	11./53	43.49

5. Conclusions

1. The result of the calendering test are 0.60, 071, 045, 060, 053, 041, 065, 060 fulfilled allowable settlement $\leq$ 1 inchi (2.54 cm).
2. The largest pile bearing capacity calendering is equal to 128.52 ton and the smallest bearing capacity is equal 73.29 Ton > The bearing capacity of pile is allowed on planning is 60.9 Ton
3. CAPWAP software calculation results for Pile Driving Analyzer test at 8 pile sections ie highest bearing capacity on TP - B12 Ru 177 ton > The bearing capacity of pile is allowed on planning is 60.9 Ton and lowest bearing capacity TP - B22 Ru 111 ton > The bearing capacity of pile is allowed on planning is 60.9 Ton
4. The CAPWAP software analysis results for the Pile Driving Analyzer test state that the bearing capacity of the pile is safe to ultimate the load of allowable bearing capacity , Ru > The bearing capacity of pile is allowed on planning is 60.9 Ton

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