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COMPARATIVE ANALYSIS OF SPUN PILE CARRYING CAPACITY IN KAMAL-TELUK NAGA-RAJEG (KATARAJA) TANGERANG TOLL ROAD CONSTRUCTION PROJECT

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ABSTRACT

The foundation is the bottom structure in a building, therefore the foundation is a very important part of the structure in building construction. Foundation construction needs to be carried out bearing capacity analysis to avoid structural failure/damage. The Kamal-Teluk Naga-Rajeg Toll Road (KATARAJA) construction project uses a spun pile type foundation. Analysis of pile bearing capacity can be carried out by using static testing, dynamic testing, and empirical testing. In this study to calculate the analysis of the bearing capacity of the piles used dynamic tests, namely the Standard Penetration Test (SPT), Pile Driving Analysis (PDA) and Calendering. Spun pile bearing capacity from SPT data was calculated using the Luciano Decourt and Tomlinson methods. In the PDA test, an analysis of the interpretation of the PDA results is carried out. The carrying capacity of the spun pile from the Calendering data was calculated using the Hiley method, and the Engineering News Record (ENR). In testing the SPT test was carried out at 2 points, namely the PB-48 point and the PB-49 point. The PDA test was carried out on PSL 8-38 piles and PSL points 8-39. Calendaring calculations in this study were carried out at PSL 8-38 piles and PSL points 8-39. The results of the comparison between the carrying capacity of the spun pile using SPT data using the Luciano Decourt method and PDA Interpretation obtained the closest results, namely PB-48 pile of 61%, the Tomlinson method, namely PB-49 pile of 62%. The comparison between the carrying capacity of the spun pile using Calendering data and the closest PDA interpretation is the Hiley method for PSL8-39 piles of 31%, the ENR method, namely PSL 8-38 piles of 36%. The results of the comparison between the carrying capacity of the spun pile using the average SPT data and Calendering data obtained the closest result, namely using the Hiley method on pile PB-48 of 42%, and the ENR method on pile PB-48 of 48%.

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1. INTRODUCTION

The rapid development of the times in the construction industry, especially in the main cities of Indonesia, is currently intensive. Tangerang is one of the big cities in Indonesia so that infrastructure development is oftencarried out such as roads and bridges. The implementation of this construction project is expected to bring progress in economic development in the Tangerang area.

The construction of the Kamal-Teluk Naga-Rajeg (Kataraja) Tangerang Toll Road is one of the construction projects aimed at developing the northern part of Tangerang district. This toll road section starts from Cikupa, Rajeg and Mauk which will be connected to the Sedyatmo Toll Road or Soekarno Hatta Airport area. The project is also expected to increase the distribution of goods and services between regions to support the economic growth of the community, attract more workers, and revitalize coastal areas in Tangerang district.

The Kamal-Teluk Naga-Rajeg (Kataraja) Toll Road Construction Project uses pile foundations. The pile foundation serves to move or transfer loads from the construction above it (superstructure) to the hard soil layer which is very deep) Hutami, 2013).

Piling carrying capacity data is obtained by conducting soil investigations in the field such as *Standard Penetration Test* (SPT). Thisuses data from *Pile Driving Analysis* (PDA) testing. Thecalculation of pile carrying capacity can be done using the pile dynamic formula from Kalendering data. Soilresearch in

the field is very useful to determine soil characteristics in supporting foundation loads by not being affected by damage to soil samples due to drilling operations and sample handling (Savira, 2020).

The problems obtained in the research plan above become a reference in formulating problems, namely: comparison of the carrying capacity of spun pile based on the results of the *Standard Penetration Test* (SPT), Interpretation of *Pile Driving Analysis* (PDA), and data calendaring. Based on the formulation of the problem, the objectives in this study are: (1) Analyze how much the difference value is from the results of calculating the carrying capacity of the spun pile using data *Standard Penetration Test* (SPT), Pile *Driving Analysis* (PDA) interpretation, and calendaring data; (2) Know the types of methods used to analyze the carrying capacity of spun pile. The benefits obtained from this scientific article are as follows: (1) Understand the magnitude of thecomparative value of the carrying capacity of spun pile using various methods different analyzes; (2) It is expected to increase knowledge about various types of spun pile carrying capacity calculation methods. Limitations on the problems in the study: (1) Data used for spun pile carrying capacity analysis using SPT, PDA, and calendaring data on the Kamal-Teluk Naga-Rajeg Toll Road Construction Project (Kataraja) Tangerang; (2) Analysis of the calculation of the carrying capacity of the spun pile using SPT data using the method of Luciano Decourt, and Tomlinson; (3) Analysis of the calculation of the carrying capacity of the spun pile with PDA data using the wave theory method; (4) Analysis of the calculation of the carrying capacity of the spun pile with calendaring data using the Hiley method, and Engineering News Records (ENR).

2. METHOD

Standard Penetration Test (SPT)

Analysis of the calculation of pile carrying capacity using SPT data on cohesive soil can be used several calculation methods, namely as follows:

- *Luciano Decourt*

The formula for calculating the ultimate carrying capacity of the mast with *the Luciano Decourt* Method is as follows:

Qu = (Qp + Qs) (1)

Where:

Qu = Limit carrying capacity (kg)
Qp = End point carrying capacity (kg)
Qs = Carrying capacity of blanket (kg)

The formula for calculating the carrying capacity of the pole end of the Luciano *Decourt* Method is as follows:

$Qp\frac{\alpha \; x \; \overline{Np} \; x \; K \; x \; Ab}{SF}$ = (2)

Where:

Qp = End point carrying capacity (tonnes)
α = Base Coefficient (Table 1)
$\overline{Np}$= The average price of tax returns around 4D above
up to 4D below the base of the pole
K = Coefficient of soil characteristics on foundation (kPa)
12 t/m^2 = 117.7 kPa, for clay
20 t/m^2 = 196 kPa, clayey silt
25 t/m^2 = 245 kPa, for sandy silt
40 t/m2 = 392 kPa, for sand
Ab = Cross-sectional area (cm^2)
SF = Safety Factor = 2.5

(Source: Wahyudi, 2013)

Table 1. Base Coefficient α Decourt (1996)

Soil/pile	Driven Pile	Bored Pile
Clay	1,0	0,85
Intermediate Soil	1,0	0,60
Sand	1,0	0,50

(Source: Inner Foundation Carrying Capacity, Wahyudi, 2013)

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The formula for calculating the carrying capacity of the pole blanket with the *Luciano Decourt Method* is as follows:

$$\frac{\beta \; x \left(\frac{\overline{Ns}}{3}+1\right) x \; As}{SF} \text{Qs} = (3)$$

Where:

Qs = Carrying capacity of blanket (ton)
β = Shaft Coefficient (Table 2)
$\overline{Ns}$ = Average price of sunset pole tax return
As = Area of blanket (m^2)
SF = Safety factor = 2.5

Table 2. *Shaft Coefficient β Decourt* (1996)

Soil/pile	Driven Pile	Bored Pile
Clay	1,0	0,80
Intermediate Soil	1,0	0,65
Sand	1,0	0,50

(Source: Inner Foundation Carrying Capacity, Wahyudi, 2013)

- Tomlinson

  Tomlinson method (1977), pole friction resistance can be obtained by:

  Qs = As. fs (4)
  fs=cd=α cu (5)
  Where:
  cd = adhesion between pole and soil in surrounding (kN/m^2)
  α = adhesion factor (Figure 1)
  cu = underdrained cohesion (kN/m2)(Figure 1)

  Qp = Ab x Cu x Nc (6)
  Where:
  Nc = carrying capacity factor taken 9 (provision)
  Qu = (Qp + Qs) (7)
  Where:
  Qu = Limit carrying capacity (kN)
  Qp = End point carrying capacity (kN)
  Qs = Carrying capacity of blanket (kN)
  (Source: Hardiyatmo, 2015)

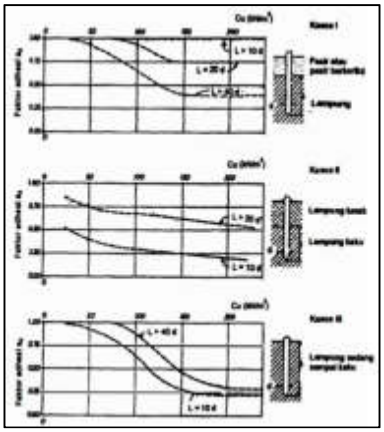

Figure 1 Relationship between Adhesion Factors and Cohesion for Piles in Clay Soil.
(Source: Tomlinson, 1977; Hardiyatmo, 2015)

***Pile Driving Analysis* (PDA)**

Predicting thedensity of the carrying capacity of the pole using wave theory, generally carried out two calculation steps, namely the first step of PDA data collection, in the form of acceleration and strain

data which is then carried out per power calculation support the pole through *damping coefficient (Jc*) data which is then inputted by the program user. This damping coefficient is generally chosen based on the type of soil in the field (Hardiyatmo, 2020). Then the next number is carried out ananalysis of data obtained from the field using the CAPWAP (*Case Pile Wave Analysis Program*) program. From the results of this CAPWAP programming, data on the distribution of friction resistance and lower end resistance of the pole were obtained, as well as an estimate of the improved carrying capacity *(improve capacity prediction*).

$$\text{Qtotal}\frac{1}{2}\left[(F-ZV)_{\left(to+\frac{2L}{c}\right)}+(F-ZV)_{(to)}\right] = (8)$$

(Source: Salgado, 2008)

Calendaring

The pile formulas used in the calculation of pile carrying capacity are as follows:

- Hiley

$$\frac{2W_r\ x\ H}{S+H}\ x\ \frac{W_r+n^2+W_p}{W_r+W_p}\text{Qu} = (9)$$

Where:

Wr = hammer weight (tons)
Wp = overall mast weight (tons)
H = height of fall beater (cm)
S = penetration per stroke (cm)
K = rebound (cm)
n = restitution coefficient (Table 3)
SF = 4

Table 3 Coefficient of Restitution n (ASCE, 1941)

Materials	n
Broomed Wood	0
Wooden pole (end not damaged)	0,25
Solid wooden sleepers on steel poles	0,32
Solid wooden sleepers on steel poles	0,40
Steel on steel anvil on steel or concrete poles	0,50
Cast iron bat on concrete pole without cap	0,40

(*Source: Hardiyatmo, 2015*)

- *Engineering News Record* (ENR)

$$\frac{e_h W_r h\ (W_r+n^2\ W_p)}{(s+0{,}25)(W_r+W_p)}\ \text{Qu} = (10)$$

Where:
Wr= hammer weight (tons)
Wp= overall mast weight (tons)
S= penetration per stroke (cm)
n = restitution coefficient (Table 3)
eh = efficiency value (Table 4)
SF = 6

Table 4. Efficiency Value (eh)

Type	Eh
Drop hammer	0,75 - 1
Single acting hammer	0,75 - 0,85
Double acting hammer	0,85
Diesel hammer	0,85 - 1

(Source: Hardiyatmo, 2015)

Research Objectives.

The purpose of this study is to determine the comparison of the carrying capacity of spun pile based on several test data, namely SPT, PDA, and ringing kalen data using various calculation methods.

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Data Collection Techniques

The data in this study was obtained from submitting a data request to agencies related to the Kamal-Teluk Naga-Rajeg (Kataraja) Tangerang Toll Road Construction Project. The data needed for the purposes of preparing this research include: SPT Data, PDA Data, and Calendaring Data.

Data Processing Techniques

- The calculation of the carrying capacity of spun pile with SPT data is carried out by several methods, namely the method of Luciano Decourt, and Tomlinson. The calculation of the ultimate carrying capacity of the spun pile is done by calculating the Qp value and the Qs value then divided by the Safety Factor (SF) value.
- The calculation of the carrying capacity of the *spun pile* with PDA data is carried out by interpreting the PDA test results using *wave theory*.
- The calculation of the carrying capacity of spun pile with calendaring data is carried out by several methods, namely the Hiley method, and ENR.
  Calculation of the carrying capacity of the ultimate spun pile
  then divided by the Safety Factor (SF) value.
- Determine the percentage difference in the comparison of the carrying capacity value of *the spun pile* from several calculation methods using SPT, PDA, and calendaring data.

More details, depicted in the flowchart below.

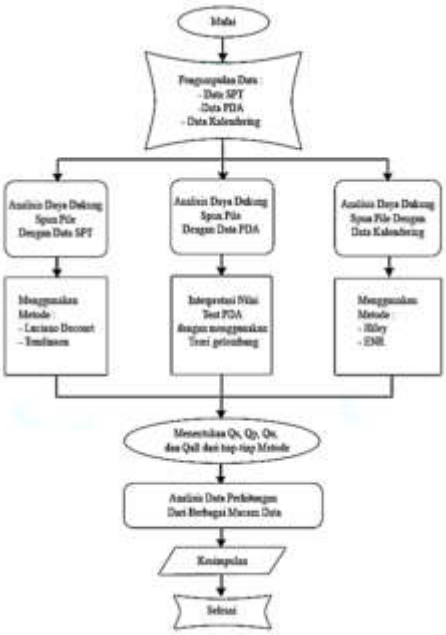

Figure 3 Research *Flowchart*

3. RESULTS AND DISCUSSION

Spun Pile Carrying Capacity Analysis with Luciano Decourt Method SPT Data

- Used Spun pile with a diameter of 60 cm
- N-SPT value = 15 (clay soil)
- Depth 12.25 m point PB-48
- **N'** = N = 15 (no cohesive due to cohesive soil)
- $Np = \frac{14+15+29}{3} = 19{,}333$
- $Ns = \frac{8+15+15+18+14+15}{6} = 14{,}17$
- $K = 20\ t/m^2$
- $Ap = \frac{1}{4}\ x\ \pi\ x\ d^2 = 0{,}25\ x\ \pi\ x\ 0{,}6^2 = 0{,}2827\ m^2$
- $As = \pi\ x\ 0{,}65\ x\ 12{,}25 = 23{,}091\ m^2$

$Qult = [\alpha\ x\ (Np.K)\ x\ Ap] + \left[\beta\ x\ \left(\frac{Ns}{3} + 1\right) x\ As\right]$

$= 225.86\ t$

$Qijin = \frac{225,86}{2,5} = 90.343\ t$

Table 5 Calculation of the Carrying Capacity of *Spun Pile Method Luciano Decourt* Point P B-48 and Point PB-49

depth (m)	BOREHOLE PB-48			BOREHOLE PB-49		
	N'-SPT	Qult (t)	Qijin (t)	N'-SPT	Qult (t)	Qijin (t)
8,25	2	128,19	51,28	0	119,80	47,92
10,25	13	194,64	77,86	2	141,60	56,64
12,25	15	225,86	90,34	14	220,41	88,16
14,25	12	229,19	91,68	23	296,06	118,43
16,25	17	282,42	112,97	7	215,35	86,14
18,25	16	297,91	119,16	24	356,60	142,64
20,25	23	375,86	150,34	17	328,08	131,23
22,25	20	376,68	150,67	16	342,31	136,93
24,25	10	309,19	123,68	20	401,40	160,56
26,25	19	416,26	166,50	15	376,86	150,75
28,25	22	471,78	188,71	20	450,82	180,33
30,25	12	386,69	154,68	12	386,69	154,68

Spun Pile Carrying Capacity Analysis with Thomlinson Method SPT Data

- Used Spun pile with a diameter of 60 cm
- N-SPT value = 15 (clay soil)
- Depth 12.25 m point PB-48
- N' = N = 15 (no cohesive due to cohesive soil)
- Nc = Taken 9
- Cu = 6N = 78 kPa (Kulhawry and Mayne, 1990)
- α = 0.690)Tomlnson chart)
- *Qult* = (Ap x Cu x *Nc) +)As x α x Cu)*

= (0.2827 x 78 x 9) + (22.90 x 0.690 x 78)

= 1441.23 kN = 145.93 t

- $Qijin = \frac{145,93}{2,5} = 58.78\ t$

Table 6 Calculation of Bearing Capacity of Spun Pile Tomlinson Method Point P B-38 and Point PB-39

depth (m)	BOREHOLE PB-48			BOREHOLE PB-49		
	N'-SPT	Qult (t)	Qijin (t)	N'-SPT	Qult (t)	Qijin (t)
8,25	2	105,585	42,234	0	99,887	40,665
10,25	13	126,275	50,51	2	118,65	59,55
12,25	15	145,929	58,78	14	137,98	70,23
14,25	12	167,65	67,06	23	168,23	75,77
16,25	17	188,34	75,34	7	182,44	86,11
18,25	16	209,03	83,61	24	214,97	95,54
20,25	23	229,72	91,89	17	240,12	106,96
22,25	20	250,41	100,17	16	261,46	114,05
24,25	10	271,13	108,44	20	286,91	129,77
26,25	19	291,792	116,72	15	300,65	142,21
28,25	22	312.48	124,99	20	323,21	155,83
30,25	12	333,17	133,27	12	356,71	167,92

Based on calculations that have been carried out with several point methods P B-38 and P B-39, it can be seen the relationship between ultimate carrying capacity and depth shown in Figure **4** and **Figure 5**.

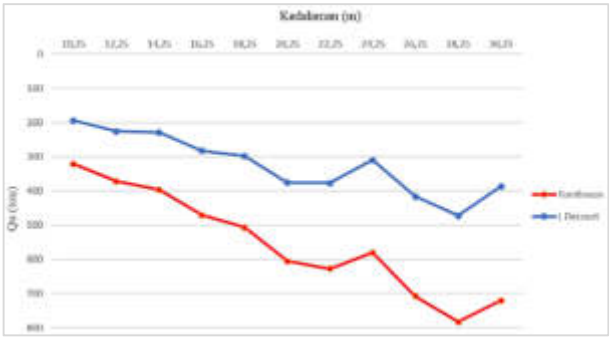

Figure 4 Ultimate Carrying Capacity and Point Depth B-38 by Various Methods

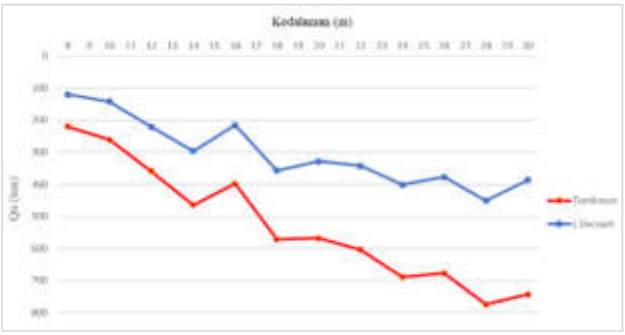

Figure 5 Ultimate Dukung Power and Point Depth PB-39 Various Methods

Spun Pile Carrying Capacity Analysis with PDA Data

1) Pile PSL 8-38

Solution :

$$F_{to} = 384{,}6\ t$$
$$ZV_{to} = 216{,}1\ t$$

$F_{(to+\frac{2l}{c})}$ = 90.2 t

$V_{(to+\frac{2l}{c})}$ = -76.3 t

$$Qtotal = \frac{1}{2}\left[(F - ZV)_{\left(to+\frac{2L}{c}\right)} + (F - ZV)_{(to)}\right]$$
$$= \frac{1}{2}\left[(90{,}2 - (-76{,}3)) + (384{,}6 + 216{,}1)\right]$$

= 383.2 t

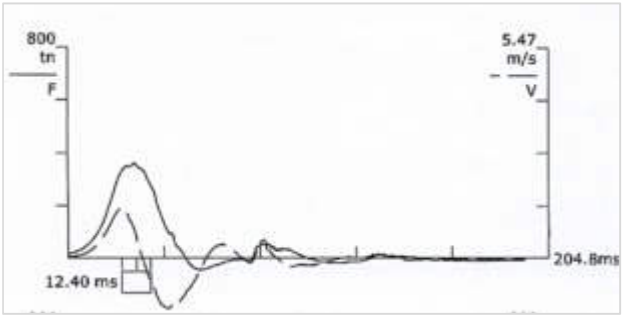

Figure 6 PDA Pile PSL 8–38 Results
(Source: PT Duta Graha Karya)

2) Pile PSL 8-39

Solution :

$$F_{to} = 351{,}2t$$
$$ZV_{to} = 198{,}1\ t$$

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$F_{(to+\frac{2l}{c})}$ = 92.6 t

$V_{(to+\frac{2l}{c})}$ = -71.3 t

$$Qtotal = \frac{1}{2}\left[(F - ZV)_{\left(to+\frac{2L}{c}\right)} + (F - ZV)_{(to)}\right]$$

$$= \frac{1}{2}\left[\left(92{,}6 - (-71{,}3)\right) + (351{,}2 + 198{,}1)\right]$$

= 356.6 t

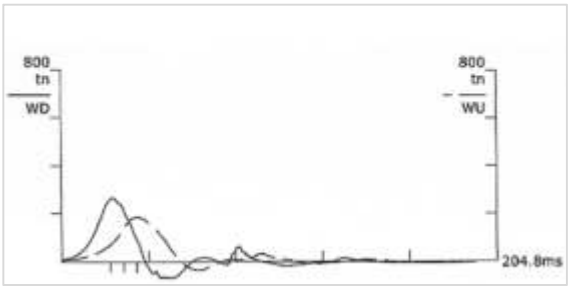

Figure 7 PDA Pile PSL 8–39 Results
(Source: PT Duta Graha Karya)

Spun Pile Carrying Capacity Analysis with Hiley Method Calendaring Data

The calculation of the carrying capacity of the spun pile is based on calendaring data with the Hiley method on the PSL 8-38 pile as follows.

- Spun pile diameter (D) = 60 cm
- Pole length = 29 m
- Concrete quality = 52 MPa
- Piling area (A) = 2826 cm2
- Overall mast weight (Wp) = 9 tons
- Hammer weight (Wr) = 6.5 tons

-Fall height (H) = 250 cm

- Penetration per stroke (S) = 1.2 cm
- Rebound magnitude (K) = 1.0 cm
- Coefficient of restitution (n) = 0.5

The ultimate carrying capacity is calculated, namely:

Qu = $\frac{2W_r\ x\ H}{S+K}\ x\ \frac{W_r+n^2+W_p}{W_r+W_p}$

Qu = $\frac{2\ x\ 6{,}5\ x\ 250}{1{,}2+1{,}0}\ x\ \frac{6{,}5+\ 0{,}5^2+9}{6{,}5+9}$

Qu = 830.5 t

Qijin$\frac{830{,}5}{4}$ = = 207.6 t

Table 7 Calculation of Carrying Capacity of Spun Pile with Hiley Method Calendaring Data

No Pillar	Wr (ton)	Wp (ton)	H (cm)	n²	S (cm)	K (cm)	Qu	Qijin
PSL 8-38	6,5	9	250	0,25	1,2	1,1	830,5	207,6
PSL 8-39	6,5	9	250	0,25	1,1	1	863.2	244,5

Spun Pile Carrying Capacity Analysis **with Data Calendaring ENR Method**

The calculation of the carrying capacity of the spun pile is based on calendaring data using the *Engineering News-Records* (ENR) method on the PSL 8-38 pile with the following data.

- Spun pile diameter (D) = 60 cm
- Pole length = 29 m
- Concrete quality = 52 MPa
- Piling area (A) = 2826 cm2
- Overall mast weight (Wp) = 9 tons

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- Hammer weight (Wr) = 6.5 tons
-Fall height (H) = 250 cm
- Penetration per stroke (S) = 1.2 cm
- *Diesel hammer efficiency* (e_h) = 1.0
- Coefficient of restitution (n) = 0.5

The ultimate carrying capacity is calculated, namely:

$$Qu = \frac{e_h \, x \, W_r \, x \, H(W_r + n^2 + W_p)}{(S+0{,}25)(W_r + W_p)}$$

$$Qu = \frac{1{,}0 \, x \, 6{,}5 \, x \, 250(6{,}5 + 0{,}5^2 + 9)}{(1{,}2+0{,}25)(6{,}5 + 9)}$$

Qu = 630.6 t

Qijin$\frac{630{,}6}{6}$ = = 105.1 t

Table 8 Calculation of Carrying Capacity of Spun Pile with ENR Calendaring Data

No Pillar	Wr (ton)	Wp (ton)	H (cm)	n²	S (cm)	Eh	Qu	Qijin
PSL 8-38	6,5	9	250	0,25	1,2	1	630.6	10 5.1
PSL 8-39	6,5	9	250	0,25	1,1	1	684,1	136,2

(Source: Calculation Result)

Comparison of *Spun Pile Carrying Capacity* Based on SPT Data with PDA Interpretation

The following is a *spun pile* used in the calculation of SPT and PDA Test data :

1) PB – 48
2) PB – 49
3) PSL 8 – 38
4) PSL 8 – 39

The following is an example of calculating the percentage difference in the carrying capacity of PDA Test with SPT data on Pile PB-48, as follows:

1) The Luciano Decourt Method with PDA

Difference = PDA test interpretation - SPT L Decourt
= 383.2 – 150.6
= 233 tons

Percentage =$\frac{Selisih}{Interpretasi\ PDA} x\ 100\%$

= $\frac{233}{383{,}2}\ x\ 100\%$

= 61%

2) Tomlinson Method with PDA

Difference = PDA test interpretation - Tomlinson
= 383.2 – 117.2
= 266.4 tons

Percentage = $\frac{Selisih}{Interpretasi\ PDA} x\ 100\%$

= $\frac{266{,}4}{383{,}2}\ x\ 100\%$

= 69%

Table 9 Calculation of Percentage Difference in Carrying Capacity of Spun Pile PDA Data with SPT Data

Pile Name	Qu Interpretation PDA (ton)	SPT method	Depth (m)	Point	Qall SPT (ton)	Difference (tons)	Percentage
PSL 8-38	383,2	L Decourt	22,25	PB-48	150,6	233	61%
		Tomlinson			117,2	266,4	69%
PSL 8-39	356,6	L Decourt	22,25	PB-49	136,9	243	62%
		Tomlinson			114,1	269	68%

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Comparison of *Spun Pile* Carrying **Capacity based on Calendaring Data with PDA Interpretation**

The following is an example of calculating the percentage difference in the carrying capacity ofPDA Test with Calendaring data on Pile PSL 8-38, as follows:

1) Hiley's method with PDAs

Difference = PDA Interpretation - Hiley Calendaring

= 383.2 – 207.6

= 175.6 tons

Percentage = $\frac{Selisih}{Interpretasi\ PDA} x\ 100\%$

= $\frac{175,6}{383,2}\ x\ 100\%$

= 46 %

2) ENR method with PDA

Difference = PDA Interpretation - ENR Calendaring

= 383.2 – 244.5

= 138.7 tons

Percentage = $\frac{Selisih}{Interpretasi\ PDA} x\ 100\%$

= $\frac{138,7}{383,2}\ x\ 100\%$

= 36 %

Table 10 Calculation of Percentage Power Difference Support PDA Spun Pile Data with Data Calendaring

Pile Name	Qu Interpretation PDA (ton)	Calendaring Method	Qall Kalendering (ton)	Difference (tons)	Percentage
PSL 8-38	383,2	Hiley	207,6	175,6	46%
		ENR	105,1	278,1	36%
PSL 8-39	356,6	Hiley	244,5	112,1	31%
		ENR	136,2	220,4	62%

Comparison of Spun Pile Carrying Capacity based on Calendaring Data with Average SPT

Comparison of the carrying capacity value of the spun pile based on calendaring data with the average SPT data is carried out on the pile:

1) PB – 48

2) PB – 49

The following is an example of a comparison of the carrying capacity of spun pile on Pile PSL 8-38 using the Hiley Method with Average SPT Data:

1) Hiley Method with Average Tax Return Data

Difference = Hiley – Average tax return

= 207.6 – 108.96

= 98.6 tons

Percentage = $\frac{Selisih}{Interpretasi\ PDA} x\ 100\%$

= $\frac{98,6}{207,6}\ x\ 100\%$

= 48 %

2) ENR Method with Average SPT Data

Difference = ENR – Average SPT

= 188.5 – 108.96

= 79.5 tons

Percentage = $\frac{Selisih}{Interpretasi\ PDA} x\ 100\%$

= $\frac{79,5}{244,5}\ x\ 100\%$

= 42 %

Table 11 Calculation of the Percentage Difference in the Carrying Capacity of Spun Pile Kalendering Data with Average SPT Data

Pile Name	Calendaring Method	Qall Kalendering (ton)	Point	Depth (m)	Average Qall SPT (tons)	Difference (tons)	Percentage
PSL 8-38	Hiley	207,6	PB 38	22,25	108,96	98,6	42%
	ENR	105,1				79,5	48%
PSL 8-39	Hiley	244,5	PB 39	22,25	108,96	135,5	49%
	ENR	136,2				27,2	55%

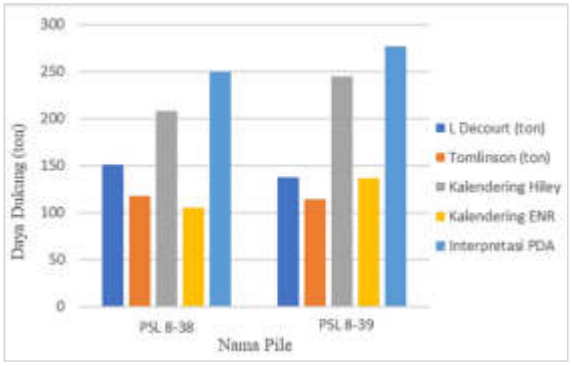

Figure 8 Differences in Carrying Capacity with Various Data

This research uses several piles in the KATARAJA project including PB-48, PB-49, PSL 8-38, and PSL 8-39. SPT test calculations were performed on PB-48 and PB-49 piles. While the calculation of Calendaring and PDA Test tests is carried out on PSL 8-38 and PSL 8-39 piles.

From the results of the previous calculation analysis, the difference between the PDA Interpretation value data and SPT data using the Luciano Decourt method was obtained, and Tomlinson obtained the smallest average percentage difference that is, the method of Luciano Decourt. In the results of the pile carrying capacity calculation analysis using Calendaring data and PDA data, the analysis using the Hiley method obtained the smallest percentage results compared to using the ENR method. Based on the results of the difference analysis of the average percentage of tax return data with Calendaring data, it was found that the Hiley method obtained the smallest percentage difference when compared to the ENR method. In this case, it can be seen that the results of calculating the carrying capacity of spun piles using the Hiley method have the most accurate results and are closest to the results of the calculation of carrying capacity spun pile from tax return data.

4. CONCLUSION

The result of the comparison between the carrying capacity of spun pile data Interpretation of PDA values with SPT data obtained the closest percentage result, namely by using SPT data Luciano Decourt's method. The result of the comparison between the carrying capacity of the PDA value interpretation spun pile data with the Kalendering data obtained the closest percentage result, namely by using the Hiley method Calendaring data. The results of the comparison between the carrying capacity of the average SPT spun pile data from the Luciano Decourt and Tomlinson methods with the Kalendering data obtained the closest percentage result, namely by using Kalendering data Hiley's method. From the results of calculations and spun pile carrying capacity analysis carried out, it can be seen that the Hiley method gets the lowest percentage results compared to using other methods. Using Luciano Decourt's SPT data method and Hiley's Calendaring method data, it can be suggested to be used in designing spun pile carrying capacity planning in areas with clay soil conditions, accompanied by PDA test data results that can be used as an evaluation of the carrying capacity of the Spun Pile plan.

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