



## Analysis of Spun Pile Bearing Capacity Based on SPT Data Using the Luciano Decourt and Tomlinson Methods

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### Abstract

Spun pile foundations were used in the construction of the Mayor's Office Building in Jempong Village, Mataram City, West Nusa Tenggara Province, as elements that transfer structural loads to more stable soil. This study aims to analyze the bearing capacity of spun pile foundations manually to obtain the ultimate bearing capacity and allowable bearing capacity values by comparing the Luciano Decourt and Tomlinson methods based on SPT data. Through this analysis, it is hoped that the most efficient and appropriate method for application in the soil conditions in the area can be determined. Based on the calculation results, the Luciano Decourt method produced a bearing capacity and allowable bearing capacity of 137,344 tons and 54,938 tons, respectively, while the Tomlinson method produced a bearing capacity and allowable bearing capacity of 89,489 tons and 35,795 tons, respectively. It can be concluded that the most efficient and appropriate method to use in pile foundation planning for the soil conditions in the area is the Tomlinson method because it produces a more conservative bearing capacity. The use of this conservative bearing capacity can help avoid the risk of foundation failure.

## Introduction

The construction of the new Mataram mayor's office building requires accurate foundation planning to maintain the stability and safety of the structure (Roosmawati, N. (2024; Sedayu et al., 2022; Simanjuntak et al., 2025). In building construction projects located on layered soil, the selection of deep foundations such as spun piles is an effective solution for bearing capacity and structural stability requirements. Spun piles are believed to have the advantage of being able to withstand high tension because their quality is always controlled. Piles are also known to be very durable and able to last for a long time (Adisanjaya et al., 2021; Setyogroho et al., 2022; Asyiah et al., 2025). For example, research on the Princeton Boutique Living apartment construction project shows that spun piles provide sufficient support capacity based on SPT data (Hasibuan et al., 2024; Alim & Andreastuti, 2025).

One of the most popular parameters for soil characterization in foundation planning is the Standard Penetration Test (SPT) result, due to its ease of implementation and ability to represent soil conditions vertically (Sarifah et al., 2025; Salam et al., 2025). Data from SPT test results describe soil conditions and characteristics, which can then be used as a basis for

assessing the actual bearing capacity of spun piles at the site (Hutabarat, 2025). The use of SPT data as a basis for calculating foundation bearing capacity is a common practice in national literature (Wardani et al., 2022; Rahmawati et al., 2024; Wahyudi, A. C., & Mulyono, 2023; Cunha et al., 2025; Jinan et al., 2025; Pradana, 2025; Ibtisamah et al., 2025). For example, in a study of a toll road construction project, the Luciano Decourt calculation method based on SPT data was used to calculate the bearing capacity of spun piles, which was then compared with the results of the Pile Driving Analyzer (PDA) interpretation (Fadilla & Pradiptiya, 2022). The study showed that the use of the Luciano Decourt method based on SPT data provided results that were close to the field interpretation (Prativi et al., 2022; Hildayani et al., 2024; Firmansyah & Farichah, 2025).

The Luciano Decourt method is widely used in the field because it has a simple procedure and is directly based on SPT test results. However, the bearing capacity produced is essentially only an estimate, so it does not reflect the actual bearing capacity (Zakahfi & Kusumawardani, 2018). Meanwhile, the Tomlinson method generally provides more conservative results because it is based on a simple correlation with soil parameters, so it is considered safer to use as an initial estimate (Syahputri et al., 2025).

This study aims to analyze the differences in the calculation results of the bearing capacity of spun pile foundations obtained from the Luciano Decourt method compared to the Tomlinson method based on Standard Penetration Test (SPT/N-SPT) data. Through this analysis, it is hoped that the most efficient and appropriate method for application in the soil conditions in the region can be determined (Hajar & Arma, 2024; Putra, 2025).

This research is expected to serve as an additional reference for practitioners and academics in determining the calculation method for the bearing capacity of spun pile foundations, especially in soil conditions with similar characteristics (Nguyen et al., 2023; Caglar et al., 2024; Cheng et al., 2023; Bos et al., 2022; Albahri et al., 2022; Saeed et al., 2022; Salgado, 2022). Additionally, this research aims to enhance the understanding and competence of prospective civil engineers regarding the differences in results between methods, enabling them to make more accurate planning decisions for future construction projects (Miswar et al., 2017; Alt et al., 2023; Huilan et al., 2024; Lai et al., 2022).

## Literature Review

The bearing capacity calculation of foundations in this study was performed using two empirical approaches, namely the Luciano Decourt method and the Tomlinson method.

### Analysis of Spun Pile Foundation Bearing Capacity Using the Luciano Decourt Method

From the results of soil investigation using the SPT test, the N-SPT value obtained was then used to calculate the foundation bearing capacity using the Luciano Decourt equation. The principle of bearing capacity in the Luciano Decourt method uses coefficient values based on the type of soil at the end of the pile and the coefficient value on the pile skin (Farnetta & Risdianto, 2022). The basic formula for calculating the ultimate bearing capacity using the Luciano Decourt method is as follows:

$$Q_u = Q_p + Q_s$$

(1)

With,

$Q_u$  : ultimate bearing capacity (tons)

$Q_p$  : pile tip bearing capacity (tons)

$Q_s$  : pile cap bearing capacity (tons)

**Pile tip bearing capacity ( $Q_p$ )**

$$Q_p = \alpha \times \overline{Np} \times K \times Ab \quad (2)$$

With,

$Q_p$  : end bearing capacity of the pile (tons)

$\alpha$  : pile base coefficient

$\overline{Np}$  : average N-SPT around 4D above to 4D below the pile base

K : characteristic soil coefficient above the foundation (kPa)

12 t/m<sup>2</sup> = 117,7 kPa, for clay

20 t/m<sup>2</sup> = 196 kPa, for clayey sand

25 t/m<sup>2</sup> = 245 kPa, for sandy silt

40 t/m<sup>2</sup> = 392 kPa, for sand

$$Ab = \frac{1}{4} \times \pi \times d^2 \quad (3)$$

With,

Ab : cross-sectional area of the pile tip (m<sup>2</sup>)

d : pile diameter (m)

Table 1. Basic Pile Coefficient  $\alpha$

Soil/Pile	Driven Pile	Bored Pile
Clay	1,00	0,85
Intermediate Soils	1,00	0,60
Sands	1,00	0,50

Source: Wahyudi, 1999

**Pile cap bearing capacity ( $Q_s$ )**

$$Q_s = \beta \times \left( \frac{\overline{Ns}}{3} + 1 \right) \times As \quad (4)$$

With,

$Q_s$  : pile cap bearing capacity (tons)

$\beta$  : pile skin coefficient

$\overline{Ns}$  : average N-SPT of the embedded pile

$$As = \pi \times d \times \text{pile length} \quad (5)$$

With,

As : pile skin area (m<sup>2</sup>)

d : pile diameter (m)

Table 2. Pile Cover Coefficient  $\beta$

Soil/Pile	Driven Pile	Bored Pile
Clay	1,00	0,85
Intermediate Soils	1,00	0,60
Sands	1,00	0,50

Source: Wahyudi, 1999

### Permissible bearing capacity ( $Q_a$ )

$$Q_a = \frac{Q_u}{S_f} \quad (6)$$

With,

$Q_u$  : ultimate bearing capacity (tons)

$S_f$  : safety factor = 2,5 for piles

### Analysis of Spun Pile Foundation Bearing Capacity Using the Tomlinson Method

One empirical method used to calculate pile bearing capacity based on standard penetration test (SPT) values is the Tomlinson method (Syahputri et al., 2025). This method separates bearing capacity into two components:

1. Pile tip resistance ( $Q_p$ )
2. Pile skin friction resistance ( $Q_s$ )

According to Hardiyatmo (2020), the basic formula for calculating the ultimate bearing capacity using the Tomlinson method is as follows:

$$Q_u = Q_p + Q_s \quad (7)$$

With,

$Q_u$  : ultimate bearing capacity (tons)

$Q_p$  : pile tip resistance (tons)

$Q_s$  : friction resistance of the pile cap (tons)

### Pile tip resistance ( $Q_p$ )

$$Q_p = q_p \times A_p \quad (8)$$

$$q_p = N \times 4,5 \quad (9)$$

$$A_p = \frac{1}{4} \times \pi \times d^2 \quad (10)$$

With,

$A_p$  : area of the pile tip (m<sup>2</sup>)

N : blow count  
d : pile diameter (m)  
4,5 = for sandy silt soil

**Pile skin friction resistance ( $Q_s$ )**

$$Q_s = \sum_{i=1}^n q_{s,i} \times A_s \tag{11}$$

$$q_{s,i} = N \times 0,45 \tag{12}$$

$$A_s = \pi \times d \times \Delta L \tag{13}$$

With,

$A_s$  : cross-sectional area of the pile (m<sup>2</sup>)

N : blow count

0,45 = for sandy silt soil

d : pile diameter (m)

$\Delta L$  : pile segment length (2 m)

**Permissible bearing capacity ( $Q_a$ )**

$$Q_a = \frac{Q_u}{S_f} \tag{14}$$

With,

$Q_u$  : ultimate bearing capacity (tons)

$S_f$  : safety factor = 2,5 for piles

**Methods**

This research was conducted on the construction project of the Mayor's Office Building in Jempong Village, Mataram City, West Nusa Tenggara Province, with geographical coordinates -8.61777 LS and 116.09694 BT. This location was chosen because the main support of the building uses spun pile foundations, with varying soil layers. The location of this research can be seen in Figure 1 below.



Figure 1. Research Location

Source: Google Earth, 2025

The coastal area of Mataram, especially around Ampenan, is geotechnically characterized by young alluvial deposits with variations in sand, silt, and clay materials that have not been fully consolidated. Therefore, in planning foundations for multi-story buildings in this area, it is recommended to use deep foundations (Robbani et al., 2024).

This research was conducted through several stages that were arranged systematically. The data collection stage was carried out, which included obtaining secondary data from the results of standard penetration tests (SPT) and data from spun pile foundations in the field. This data became the basis for calculating the ultimate bearing capacity of the spun pile foundation.

Next, the calculation analysis was carried out manually using the Luciano Decourt and Tomlinson methods, which are commonly applied in empirical approaches for deeps by utilizing the N-SPT value at each depth. Then, the calculations were compared to identify differences and determine the method most suitable for the soil conditions at the research location. For more details, see Figure 2 below.

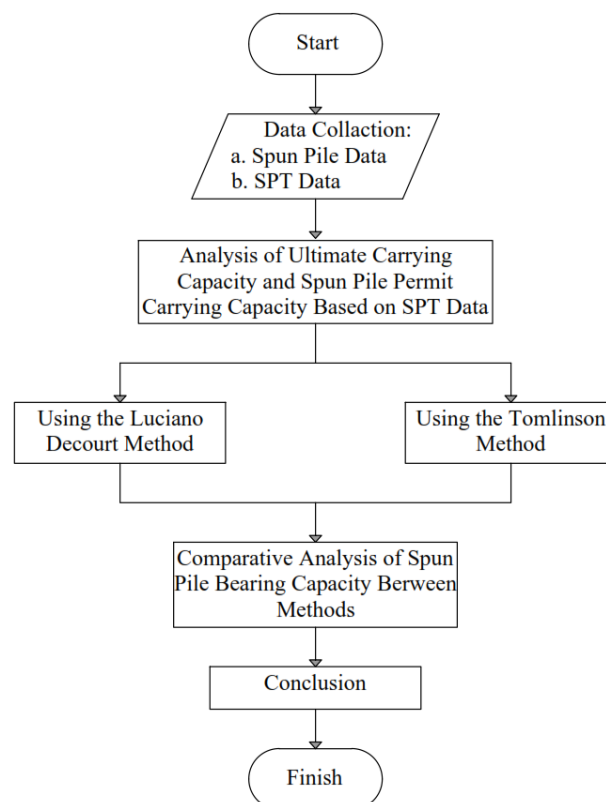


Figure 2. Research Flowchart

## Results and Discussion

In analyzing the bearing capacity, the Standard Penetration Test (SPT) data was used as the main basis, then calculated using the Luciano Decourt and Tomlinson empirical approaches. The initial stage involved rearranging the N-SPT values at each depth, which were then used to determine the maximum bearing capacity and allowable bearing capacity of the spun pile foundation in stages.

Standard Penetration Test (SPT) testing in the field was only conducted at one point with a total testing depth of 44 meters. SPT (Standard Penetration Test) testing was conducted in



The test results were then presented in a table of N values from the SPT test at every 2 meters depth, along with the bearing capacity calculations, to facilitate the process of reading and interpreting the data. Referring to the field data obtained, the N values from the SPT test in the field can be seen in Table 3 below.

Table 3. N values at every 2-meter depth

<b>Spun Pile Diameter = 0,6 m</b>			
<b>Depth (m)</b>	<b>Elevation (m)</b>	<b>N-SPT</b>	<b>Soil Type</b>
2,00	-2,00	3	Silty sand
4,00	-4,00	4	
6,00	-6,00	6	
8,00	-8,00	9	Clay silt
10,00	-10,00	17	Sandy silt
12,00	-12,00	7	Clay silt
14,00	-14,00	11	Sand
16,00	-16,00	21	
18,00	-18,00	1	Sandy silt
20,00	-20,00	0	
22,00	-22,00	1	
24,00	-24,00	2	Silty clay
26,00	-26,00	2	
28,00	-28,00	2	Clay silt
30,00	-30,00	2	
32,00	-32,00	3	
34,00	-34,00	5	
36,00	-36,00	5	
38,00	-38,00	7	Silty clay
40,00	-40,00	52	Silty sand
42,00	-42,00	54	
44,00	-44,00	58	Sandstone

Source: PT. Mitra Cipta Sasana Consultant, 2025

### **Analysis of *Spun Pile* Foundation Bearing Capacity Using the Luciano Decourt Method**

The estimated bearing capacity of *spun pile* foundations was calculated using SPT test data, referring to the approach developed by Luciano Decourt. The data was collected at the test site.

Known:

- $\alpha = 1,00$
- $\beta = 1,00$
- Pile diameter = 0,6 m
- Depth = 10 m
- N-SPT value= 17
- N-SPT value at a depth of 7,6 m (4D above the pile base)

$$= 6 + \left( \frac{7,6-6}{8-6} \right) x (9 - 6)$$

$$= 8,4$$

– N-SPT value at a depth of 12,4 m (4D below the pile base)

$$= 7 + \left( \frac{12,4 - 12}{14 - 12} \right) \times (11 - 7)$$

$$= 7,8$$

$$- \overline{Np} = \frac{8,4 + 9 + 17 + 7 + 7,8}{5}$$

$$= 9,84$$

$$- \overline{Ns} = \frac{3 + 4 + 6 + 9 + 17}{5}$$

$$= 7,8$$

$$- K = 25 \text{ t/m}^2$$

$$- Ab = \frac{1}{4} \times \pi \times d^2$$

$$= 0,25 \times 3,14 \times 0,6^2$$

$$= 0,2826 \text{ m}^2$$

$$- As = \pi \times d \times \text{pile length}$$

$$= 3,14 \times 0,6 \times 10$$

$$= 18,84 \text{ m}^2$$

The depth/length of the pile (10 m) used in this study was chosen because at that depth the N value (17) was greater than the N value at depths of 12 to 14 meters. In addition, this depth was also chosen considering the cost efficiency of construction and the effectiveness of construction in the field. Based on Tables 1 and 2, the pile base coefficient ( $\alpha$ ) and pile skin coefficient ( $\beta$ ) values were selected based on the type of foundation used (driven pile) and the soil type at a depth of 10 meters (intermediate soils). Since the N values at depths of 7.6 m (4D above the pile base) and 12.4 m (4D below the pile base) are not listed in Table 3, interpolation was performed to obtain the N values at those depths. From these values, the average N-SPT value around 4D above to 4D below the pile base ( $\overline{Np}$ ). Meanwhile, the soil characteristic coefficient (K) value was selected based on the soil type at a depth of 10 meters, which is sandy silt.

Therefore:

The bearing capacity at the end of the pile ( $Q_p$ ) is calculated based on equation (2)

$$Q_p = \alpha \times \overline{Np} \times K \times Ab$$

$$= 1 \times 9,84 \times 25 \times 0,2826$$

$$= 69,52 \text{ tons}$$

The bearing capacity of the pile cap ( $Q_s$ ) is calculated based on equation (4)

$$Q_s = \beta \times \left( \frac{\overline{Ns}}{3} + 1 \right) \times As$$

$$= 1 \times \left( \frac{7,8}{3} + 1 \right) \times 18,84$$

$$= 67,824 \text{ tons}$$

Ultimate bearing capacity ( $Q_u$ ) is calculated based on equation (1)

$$\begin{aligned} Q_u &= Q_p + Q_s \\ &= 69,52 + 67,824 \\ &= 137,344 \text{ ton} \end{aligned}$$

Permissible bearing capacity ( $Q_a$ ) is calculated based on equation (6)

$$\begin{aligned} Q_a &= \frac{Q_u}{s_f} \\ &= \frac{137,344}{2,5} \\ &= 54,938 \text{ ton} \end{aligned}$$

### Analysis of Spun Pile Foundation Bearing Capacity Using the Tomlinson Method

N-SPT data is used as the main parameter, with several simple correlation equations. In this analysis, pile data with a diameter of 0,6 m is used.

Known:

- Pile diameter = 0,6 m
- $A_p = \frac{1}{4} \times \pi \times d^2$

$$\begin{aligned} &= 0,25 \times 3,14 \times 0,6^2 \\ &= 0,2826 \text{ m}^2 \end{aligned}$$

- Pile segment length = 2 m
- $A_s = \pi \times d \times \Delta L$

$$\begin{aligned} &= 3,14 \times 0,6 \times 2 \\ &= 3,77 \text{ m}^2 \end{aligned}$$

Therefore:

The end resistance of the pile ( $Q_p$ ) is calculated based on equation (8-9)

$$\begin{aligned} q_p &= N \times 4,5 \\ &= 17 \times 4,5 \\ &= 76,5 \text{ tons/m}^2 \\ Q_p &= q_p \times A_p \\ &= 76,5 \times 0,2826 \\ &= 21,619 \text{ tons} \end{aligned}$$

The pile skin friction resistance ( $Q_s$ ) is calculated based on equation (11-12)

$$\begin{aligned} q_{s,2} &= N \times 0,45 \\ &= 4 \times 0,45 \\ &= 1,8 \text{ tons/m}^2 \\ Q_{s,2} &= q_{s,2} \times A_s \end{aligned}$$

$$= 1,8 \times 3,77$$

$$= 6,79 \text{ tons}$$

Using the same equation, the values of the pile cap resistance at depths of 4 m, 6 m, 8 m, and 10 m can be seen in Table 4 below.

Table 4. Calculation of Pile Jacket Resistance per Segment

Depth (m)	N	$q_s$ (t/m <sup>2</sup> )	As (m <sup>2</sup> )	$Q_s$ (t)
2,00	4	1,8	3,77	6,79
4,00	4	1,8	3,77	6,79
6,00	6	2,7	3,77	10,18
8,00	9	4,05	3,77	15,27
10,00	17	7,65	3,77	28,84
<b>Total</b>				67,87

$$Q_s = Q_{s,2} + Q_{s,4} + Q_{s,6} + Q_{s,8} + Q_{s,10}$$

$$= 6,79 + 6,79 + 10,18 + 15,27 + 28,84$$

$$= 67,87 \text{ ton}$$

Ultimate bearing capacity ( $Q_u$ ) is calculated based on equation (7)

$$Q_u = Q_p + Q_s$$

$$= 21,619 + 67,87$$

$$= 89,489 \text{ ton}$$

Permissible bearing capacity ( $Q_a$ ) is calculated based on equation (14)

$$Q_a = \frac{Q_u}{s_f}$$

$$= \frac{89,489}{2,5}$$

$$= 35,795 \text{ ton}$$

To see a comparison of the bearing capacity at the pile tip ( $Q_p$ ) and the bearing capacity at the pile cap ( $Q_s$ ) of spun pile foundations based on the calculation results between the Luciano Decourt method and the Tomlinson method, see Figure 5 below.

From these results, the Luciano Decourt method produced a higher value of  $Q_p$ , namely 69,52 tons, indicating that this approach assesses the soil layer at the end of the pile as capable of providing higher bearing capacity. Conversely, the Tomlinson method produced a lower value of  $Q_p$ , namely 21,619 tons, indicating that this method is more conservative in assessing the capacity of the pile end. This significant difference is due to the fact that the calculation of the bearing capacity of the pile cap ( $Q_p$ ) using the Luciano Decourt method requires an average N-SPT value around 4D above to 4D below the pile base ( $\overline{Np}$ ) and a fairly large soil characteristic coefficient (K) value, so that the bearing capacity of the pile cap ( $Q_p$ ) produced by the Luciano Decourt method is greater than that of the Tomlinson method.

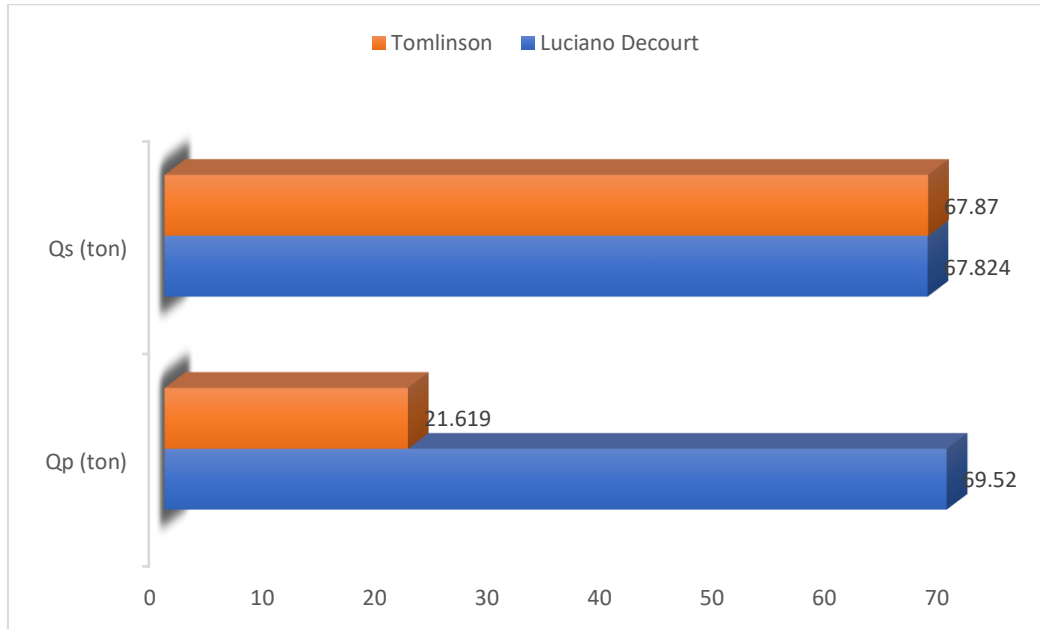


Figure 5. Comparison of Point Bearing Capacity ( $Q_p$ ) and Envelope Bearing Capacity ( $Q_s$ ) of Spun Piles

In contrast to the value of  $Q_p$ , the bearing capacity of the pile cap ( $Q_s$ ) using the Luciano Decourt method and the Tomlinson method shows fairly similar results, namely 67,824 tons and 67,87 tons. This is because both methods use an empirical approach based on N-SPT correlation and apply moderate assumptions of skin friction, resulting in estimates of ultimate bearing capacity ( $Q_s$ ) that are within a similar range. To compare the results of the *spun pile* foundation bearing capacity calculations, a comparative analysis was conducted between the Luciano Decourt method and the Tomlinson method. The summary of the ultimate bearing capacity ( $Q_u$ ) and allowable bearing capacity ( $Q_a$ ) of the spun pile foundation can be seen in Figure 6 below.

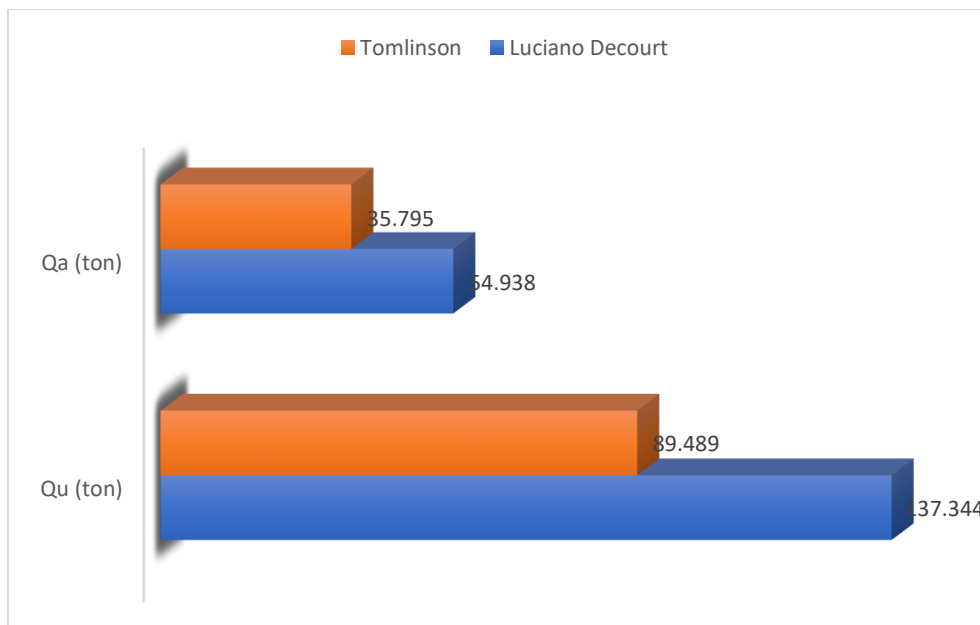


Figure 6. Comparison of Ultimate Bearing Capacity ( $Q_u$ ) and Allowable Bearing Capacity ( $Q_a$ ) of Spun Piles

Based on the comparison of the bearing capacity of the *spun pile* foundations, the differences between the two methods are clear. The Luciano Decourt method produces a greater bearing capacity, namely an ultimate bearing capacity of 137,344 tons and a allowable bearing capacity of 54,938 tons, while the Tomlinson method gives a smaller estimate, namely an ultimate bearing capacity of 89,489 tons and an allowable bearing capacity of 35,795 tons. This significant difference is due to the fact that in analyzing the bearing capacity of foundations using the Luciano Decourt method, especially in calculating the bearing capacity at the pile tip ( $Q_p$ ), a soil characteristic coefficient (K) value that is quite large and acts as a multiplier of the available data is required. Therefore, the ultimate bearing capacity and allowable bearing capacity values from the Luciano Decourt method are greater than those from the Tomlinson method.

Standard Penetration Test (SPT) data plays an important role in calculating the ultimate bearing capacity of pile foundations using the Luciano Decourt and Tomlinson methods. In the Luciano Decourt method, the N-SPT value is used directly as the basis for calculating end resistance and skin resistance, which requires additional variables to be used in the analysis as explained earlier. In contrast, the Tomlinson method does not use additional variables in the analysis of tip resistance and skin resistance. This difference in approach causes the Tomlinson method to tend to produce more conservative bearing capacity values compared to the Luciano Decourt method, even though both methods rely on SPT data as the main input.

## Conclusion

The results of this study show that the Luciano Decourt method produces a greater bearing capacity compared to the Tomlinson method. Therefore, from these two methods, it can be concluded that the most efficient and appropriate method to use in pile foundation planning for soil conditions in the region is the Tomlinson method because its analysis results are more conservative than the Luciano Decourt method. The use of this conservative approach aims to ensure that the foundation works safely even if there are undetected variations in soil properties. The use of a small bearing capacity can also help avoid the risk of foundation failure, such as excessive settlement, overstress on the piles, or soil shear failure. Thus, the building structure can be ensured to be safe and stable.

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