JACEP

Journal of Applied Civil Engineering and Practices

Online (e-ISSN): e-ISSN xxxx-xxxx || **Printed (p-ISSN)**: p-ISSN XXXX-XXXX
2025, Volume 1, No 1, pp.66 - 78

Analysis of Bored Pile Foundation Bearing Capacity Based on N-Spt Data: (A Case Study of At-Taqwa Mosque Tower Construction Project, Paciran, Lamongan, East Java)

Naufal Kusumawardana [a], **Yuli Fajarwati**[b]

[a]Universitas Negeri Yogyakarta, Department of Civil Engineering, Faculty of Vocational, Indonesia
[a]Universitas Negeri Yogyakarta, Department of Civil Engineering and Planning Education, Faculty of Engineering, Indonesia

*Corresponding Author: naufalkusumawardana.2019@student.uny.ac.id

To cite this article:
Kusumawardana, N. & Fajarwati, Yuli. (2025). Analysis of bored pile foundation bearing capacity based on N-SPT data: (a case study of At-Taqwa Mosque Tower Construction Project, Paciran, Lamongan, East Java). *Journal of Applied Civil Engineering and Practice*, 1 (1), Pp.66-78. doi: xx.xxxx/xxxxxx.xxxx.xxxxxx

To link to this article:
http://doi.org/ xx.xxxx/xxxxxx.xxxx.xxxxxx

Journal of Applied Civil Engineering and Practice by Department Bachelor of Applied Science in Civil Engineering, Faculty of Vocational, Universitas Negeri Yogyakarta.

2025, Volume 1, No 1, pp.66-78, e-ISSN XXXX-XXXX

Journal of Applied Civil Engineering and Practice

Journal homepage: https://journal.uny.ac.id/publications/jacep/index

Research paper

Analysis of Bored Pile Foundation Bearing Capacity Based on N-Spt Data: (A Case Study of At-Taqwa Mosque Tower Construction Project, Paciran, Lamongan, East Java)

Naufal Kusumawardana [a], **Yuli Fajarwati** [b]

[a]Universitas Negeri Yogyakarta, Department of Civil Engineering, Faculty of Vocational, Indonesia
[a]Universitas Negeri Yogyakarta, Department of Civil Engineering and Planning Education, Faculty of Engineering, Indonesia
*Corresponding Author: naufalkusumawardana.2019@student.uny.ac.id

ARTICLE INFO

Article History:
Received: March 16, 2025
Accepted: May 2, 2025
Published: May 23, 2025

Keywords:

Bored pile, N-SPT, Bearing Capacity

How To Cite:

Kusumawardana, N. & Fajarwati, Yuli. (2025). Analysis of bored pile foundation bearing capacity based on N-SPT data: (a case study of At-Taqwa Mosque Tower Construction Project, Paciran, Lamongan, East Java). *Journal of Applied Civil Engineering and Practice*, 1 (1), Pp.66-78. doi: xx.xxxx/xxxxxx.xxxx.xxxxxx

ABSTRACT

Purpose: The foundation serves as the structural base of a building and is typically located beneath the surface. In this study, the selected foundation type is a bored pile, commonly used in soft soils with low bearing capacity. The choice of bored pile foundations in this project was due to the densely populated surrounding area, making alternative foundation types less feasible. The objective of this research is to evaluate the bearing capacity of bored pile foundations at depths that do not reach the original design plan and to determine the required number of additional bored piles on certain pile caps.

Methods/Design: This study employs a data collection approach, gathering both primary and secondary data. These include soil investigation results (N-SPT data) and bored pile foundation design drawings.

Findings: The data were analyzed to assess the bearing capacity of the bored pile foundation using three methods: Reese & Wright (1977), O'Neil & Reese (1989), and Converse-Labarre (as cited in A'yun, 2022). The analysis revealed the need to increase the number of bored piles from 38 to 45 in order to enhance the total bearing capacity from 2402.33 kN to 3437.81 kN.

Practical Implications: Based on the results of the analysis, the efficiency of the bored pile foundation bearing capacity was found to vary across the three methods: (1) Reese & Wright (1977) yielded 500.28 kN, (2) O'Neil & Reese (1989) yielded 2424.87 kN, and (3) Converse-Labarre (A'yun, 2022) yielded 1778.23 kN. The addition of seven bored piles across the pile caps is considered sufficient in terms of meeting the desired bearing capacity.

INTRODUCTION

In the Journal (Iswati, 2023), soil is the topmost layer of the earth which is formed from particles that have been further processed, due to the influence of air, water and various living and dead organisms. In Indonesia there are many different types of soil, because they have many factors such as volcanoes, coastal areas, hills, and other factors. Indonesia is also an archipelagic country dominated by soft land which reaches around 20 million hectares or around 10% of Indonesia's total land area and is found in coastal areas (Ministry of PUPR, 2002).

In this research location, the project location is located on the seashore and the type of soil at the project location is embankment. The embankment soil is composed of limestone and sand.

The foundation is a strong building base and is usually located below the surface of the land where the building is built (KBBI, 2008:414). The foundation is the lowest structural component of a building which transmits the building load to the soil or rock beneath it (Hardiyatmo, H.C., 2002:79).

The foundation is part of the lower building structure which is divided into 2 groups, namely deep and shallow foundations. Determining the type of foundation depends on whether the superstructure of the building is light or heavy and the type of soil available. Simple building construction usually uses shallow foundations because it has a construction load that tends to be light, while construction of complex buildings usually uses deep foundations because it has a heavy construction load (Hardiyatmo, H.C., 2002:80).

In general, deep foundation types have quite complex structures compared to shallow foundations. Therefore, I tried to concentrate this final project on deep foundations, namely bored pile foundations. Bored piles are used if the soil type is soft soil with low bearing capacity. Choosing a bored pile foundation is more recommended if the surrounding conditions contain high-rise buildings which can cause cracks in the building resulting from pile work (Jusi, 2015). Bored pile foundations, also known as drilled shafts or caissons, are a fundamental type of deep foundation utilized extensively in geotechnical engineering to transfer substantial structural loads through weak or compressible upper soil layers to deeper (Nguyen et all, 2023)

The choice of bored pile foundation was due to the condition around the project being full of residential buildings. In this research, an analysis of the bearing capacity of the bored pile foundation will be carried out to determine its strength and safety based on the results of SPT testing on the At-Taqwa Mosque Tower Construction Project, Paciran, Lamongan, East Java. The Standard Penetration Test (SPT) remains a cornerstone of subsurface soil investigation due to its simplicity, cost-effectiveness, and the extensive empirical correlations it provides for estimating various soil properties crucial for geotechnical design. Carried out within a borehole, the SPT involves recording the number of blows (N-value) required to drive a split-spoon sampler a specific distance into the soil, offering a measure of the soil's resistance to penetration (Prijasambada et all, 2024).

METHOD

This research uses primary and secondary methods. The data used in this research is quantitative and qualitative data. For quantitative data as follows: (1) Standard Penetration Test (SPT); (2)

Boring Log Data. Meanwhile, qualitative data is divided into several items as follows: (1) Literature study; (2) Field observations; (3) Monitoring bored pile; (4) Detailed engineering design; (5) Soil samples.

The analysis was conducted using analytical methods based on established geotechnical engineering principles and empirical correlations, incorporating soil parameters obtained from site investigations. (Sudrajat et al, 2024). Analysis of the bearing capacity of bored pile foundations is carried out after all data has been collected according to field conditions. The data obtained was processed and analyzed to determine the bearing capacity of the bored pile foundation at the At-Taqwa Paciran Mosque Tower project, Lamongan, East Java.

The location of the research was Jl. Raya Dandeles No.164, Paciran, Paciran District, Lamonga Regency, East Java Province.

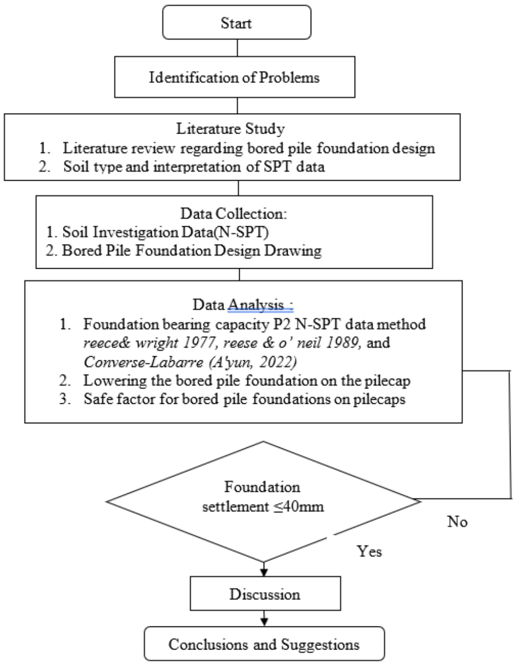

Figure 1. Research Flow Chart

This research was carried out by analyzing the bearing capacity of the foundation which was calculated using the Reece & Wright 1977, O'Neil & Reese 1989, and Converse-Labarre (A'yun, 2022) methods. In this research, the data taken used soil test data (N-SPT), bored pile monitoring data in the field, and planning foundation DED.

Figure 2. *Bored pile* conditions in the field

FINDING

A. Soil Conditions

Soil description from Standard Penetration Test (SPT) drilling results including visual observations of soil type, color and relative soil density. From observations at each drill point, the soil layers at the research location were identified in table 1.

Table 1 BH-01 Point Machine Drill Test Results

Depth (m)	Type of soil/rock
0 – 11.70	Soil filled with limestone mixed with sand with a density level of very loose to medium dense
11.70 – 19.80	Gray clay with a consistency of very soft to very chewy
19.80 – 20.45	Brown Medium Gravel Sand With Loose Density Level
20.45 – 30.00	Fine brown sandy clay with a consistency level of very chewy to hard (UDS 1 at a depth of 9.50m-10.00m)

B. Foundation Plan

The foundation plan in Figure 3 is a picture of the initial planning for the bored pile and pile cap before undergoing any changes. This research takes bored piles which have decreased and added points because in the implementation of bored pile drilling there is a complex problem of the drilling depth factor not reaching the depth planned by the consultant.

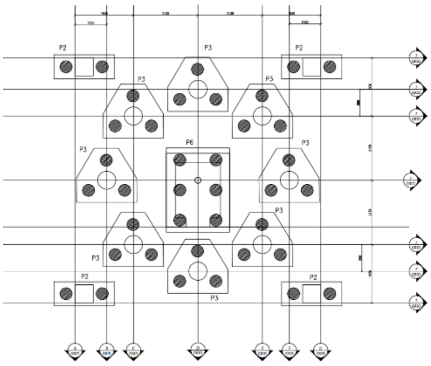

Figure 3. Initial Planning Foundation Plan

C. Data Analysis

1. *Bored pile* specification data

Bored pile specifications used in the At-Taqwa Paciran Mosque Tower construction project, Lamongan are in table 2.

Table 2. Spesifikasi Rencana *Bored Pile*

Description	Information
Bored pile depth(L)	22 m
Ground water level	6 m
Diameter *Bored Pile* (D)	40 cm
Concrete quality (Fc')	30 MPa
Weight of reinforced concrete, (Wc)	24 kN/m^3
Thick concrete cover	5 cm
Quality of reinforcing steel	SNI-TS420B
Diameter of reinforcing steel	- D10 (threaded iron 10 mm) - D16 (threaded iron 16 mm)
Foundation type	*Bored Pile*
Implementation method	Dry and wet drilling methods (using water when drilling)
Type of testing	-

2. Land specification data and N-SPT

Soil specifications and N-SPT bored pile values for the At-Taqwa Paciran Lamongan SPT Mosque Tower construction project are in table 3.

Table 3. Nilai SPT *bored hole*-1

Dept H (m)	N-SPT	N_{60}	γ (kN/m²)
0	-	-	-
2	15	13.8	19.9
4	12	11.04	19.4
6	12	11.04	19.4
8	6	5.52	15.2
10	10	9.2	15.8
12	4	3.68	18.2
14	2	1.84	17.9
16	3	2.76	18.1
18	25	23	21.4
20	25	23	21.4
22	60	55.2	26.6
24	-	-	-

3. Calculation of the bearing capacity of piles using the *reece & wright 1977* method

In calculating the bearing capacity of the pile using the N-SPT value, using the Reece & Wright 1977 method (Livia & Suhendra, 2018). The ultimate bearing capacity of a single bored pile is stated in equation 16 as follows;

Qu = Qp + Qs (1)

The ultimate bearing capacity at the end of the drilled pile is as follows;

For cohesive soil:

Qp = 9 x Cu x A (2)

Cu = Nspt x 2/3 x 10 (3)

Qp = qp x Ap (4)

Where :

Qp = Bearing capacity of pile tip (tons)

qp = end resistance per unit area (t/m2)

Ap = cross-sectional area of the pole (m2)

For non cohesive soil :

Qp = 7 x N x Ap (5)

The bearing capacity of bored pile blankets is stated as follows;

For cohesive soil :

Qs = α x cu x around the pole x Li (6)

For non cohesive soil :

Qs = 0.2 x Nspt x around the pole x Li (7)

According to Reece & Wright (1977) the value (fs) is oriented to the type of soil and shear strength. For cohesive and non-cohesive soils, you can use the formula equation 15 as follows:

$$f = \alpha \times cu \qquad (8)$$

Where;
α = adhesion factor
cu = soil cohesion (tons/m2)

Reece factor revealed an adhesion value of 0.55. Meanwhile, for non-cohesive values, the f value can be obtained from NSPT. In cohesive soils, q is taken as 9 times the soil shear, the amount of which can be determined based on the Nspt value, while in non-cohesive soils, it is taken as 7 times the soil shear. Reece proposed a correlation of the qp and Nspt values. Based on this formula, planning for the ultimate bearing capacity of a single drilled pile can be used with the following results:

Depth 18 meters with diameter (D) = 0.4 m

Bearing capacity of pile tip

Qp : qp x Ap

Qp : 12.756 x N-SPT

Ap : **0.1256 m²**

qp : 12.756 x 23.6 => **301.041 t/m²**

Qp : 301.041 x 0.1256

Qp : **37.81 ton**

Bearing capacity of concrete blanket

Qs : f x L x p (9)

P : π x D => 3.14 x 0.4 = **1.256 m**

f : α x Cu=>0.73 x 9.99 = **7.2927 t/m²**

Qs : 7.2927 x 20 x 1.256

Qs : **183.17 ton**

Ultimate bearing capacity of single drilled pile

Qu : Qp + Qs

Qu : 37.81 + 183.17

Qu : **220.98 ton**

Depth 18 meters with diameter (D) = 0.8 m

Bearing capacity of pile tip

Qp : qp x Ap

Qp : 10.5 x N-SPT

Ap : 0.5024 m2

qp : 10,5 x 23.6 => **247.8 t/m2**

Qp : 247.8 x 0.5024

Qp : **94.57 ton**

Bearing capacity of concrete blanket

Qs : f x L x p

P : π x D => 3.14 x 0.8 = **2.512 m**

f : α x Cu=>1.4972 x 9.99 = **14,957 t/m2**

Qs : 14.957 x 20 x 2.512

Qs : **156.85 ton**

Ultimate bearing capacity of single drilled pile

Qu : Qp + Qs

Qu : 124.56 + 375.73

Qu : **500.28 ton**

Based on the results of these calculations, the ultimate bearing capacity of a single bored pile using the Reese & Wright 1977 method with a field depth of ±18 meters is Qu = 500.28 tons

4. Calculation of bored pile axial resistance

The calculation of bored pile axial resistance is obtained as follows:

Perimeter of bored pile cross section (P)

P : Π x D (10)

P : 3.14 x 0.40

P : 1.256 m

Bored pile cross-sectional area (Ab)

Ab : $\frac{\pi}{4}\ x\ D^2$ (11)

Ab : $\frac{3.14}{4}\ x\ 0.40^2$

Ab : 0.1256 m^2

Difference between depths (Hi)

Hi : 2 m

Weight *bored pile* (Wb)

Wb : A x L x Wc (12)

Wb : 0.1256 x 18 x 24

Wb : 54.259 kN

Compressive strength of bored pile concrete (fc)

Fc : 33 Mpa

Bored pile nominal bearing capacity (Pn)

Pn : $0.30\ x\ fc'x\ A - 1.2\ x\ Wb$ (13)

Pn : 0.30 x33000 x 0.1256 – 1.2 x 54.259

Pn : 1178.329 kN

Strength reduction factor

(SNI 03 2847-2002), ϕ : 0.60

Axial resistance of piles

ϕ x Pn : 0.60 x 1178.329

: 706.997 kN

5. Calculation of ultimate friction resistance using the reese & o'neil 1989 method

Table 4. Recap of calculation of ultimate friction resistance (Qs)

H (m)	**Qs (kN)**	**∑Qs (kN)**
0	-	-
2	57.7	57.7
4	117.7	175.4
6	234.4	409.8
8	104.4	514.3
10	314.4	828.6
12	341.2	1169.9
14	362.0	1531.9
16	373.4	1905.2
18	380.5	2285.7
20	382.0	2667.8
22	379.1	3046.8

Calculation of ultimate bearing capacity using the reese & o'neil 1989 method

Uplift (U)

U : A x (L – MAT) x γwa (14)

U : 0.1256 x (22 – 6) x 10

U : 20.096 kN

Bored pile weight due to uplift (Wb')

Wb' : Wb - U (15)

Wb' : 54.259 – 20.096

Wb' : 34.163 kN

Ultimate bearing capacity (Qu)

Qu : Qb + ∑Qs – Wb' (16)

Qu : 173.328 + 2285.7 – 34.163

Qu : 2424.865 kN

Ultimate support capacity (Qall)

Qall : Qu/sf (17)

Qall : 457.615/2.5

Qall : 1010.36 kN

So the permit carrying capacity for the At-Taqwa Paciran Lamongan Mosque Tower construction project using the O'Neil & Resse 1989 method obtained is 1010.36 kN.

6. Calculation of the efficiency of the pile bearing capacity using the *converse-labarre (A'yun, 2022)* method

Table 5. Pile bearing capacity efficiency (Qg)

No.	Story	Joint	N (piece)	Qg (kN)
1.	BASE	9	2	1778.23
2.	BASE	15	2	1778.23
3.	BASE	17	3	2546.10
4.	BASE	20	3	2546.10
5.	BASE	24	3	2546.10
6.	BASE	51	3	2546.10
7.	BASE	56	3	2546.10
8.	BASE	75	3	2546.10
9.	BASE	79	3	2546.10
10	BASE	82	3	2546.10
11.	BASE	84	2	1778.23
12.	BASE	90	2	1778.23
13.	SW		6	4061.64

From table 5, it can be seen that the number of bored pile poles required for initial planning is seen from the efficiency value so that the required number of poles for each pile is obtained. After that, the bored pile point is added to the specified pile cap so that the results of the bearing capacity calculation in the field are obtained in table 6.

Table 6. Requirements for the number and carrying capacity of bored piles in the field

No.	Story	Joint	Number of poles (n) (peice)		Qg (kN)
1.	BASE	9	2.05	3	2546.10
2.	BASE	15	2.02	2	1778.23
3.	BASE	17	2.99	4	2829.008
4.	BASE	20	3.06	4	2829.008
5.	BASE	24	3.01	4	2829.008
6.	BASE	51	2.91	4	2829.008
7.	BASE	56	2.83	3	2546.10
8.	BASE	75	3.02	3	2546.10
9.	BASE	79	2.97	3	2546.10
10	BASE	82	2.98	3	2546.10
11.	BASE	84	2.02	2	1778.23
12.	BASE	90	2.00	2	1778.23
13.	SW		5.81	8	5334.70
			Total =	**45**	

D. Discussion

The implementation of bored pile work on the At-Taqwa Paciran Lamongan Mosque Tower construction project in the field did not go smoothly as planned. There are unexpected deviations from previous plans, resulting in obstacles/problems that need to be readjusted. Some of these obstacles include:

The drill bit was unable to penetrate the rock, which resulted in the drilling not reaching the planned bored pile depth target of 22 m, so the depth reached was at a depth of 18 m.

The cast concrete does not match the quality of the concrete, namely K350. There are several tests where the compressive strength does not meet the quality of the concrete.

1. Comparison of planned and field bored pile carrying capacity

After calculating the carrying capacity for conditions in the field, a comparison of the planned and field carrying capacity values is carried out as follows:

Table 7. Comparison of the planned bored pile carrying capacity with the field

Description	Unit	Plan	Field
Weight, Wb	kN	66.317	54.259
Pn	kN	1163.86	1178.329
Axial resistance	kN	698.316	706.997
As	m^2	2.512	2.512
z	m	21	17
β		0.38	0.49
po’	kN/m^2	53.2	42.8
Σpo’	kN/m^2	426.6	330.6
Po’ average	kN/m^2	400	309.2
Qs	kN	379.1	380.5
ΣQs	kN	3046.8	2285.7
Qu	kN	3416.59	2424.865
Qall	kN	1366.64	1010.36

Based on table 7, after the addition of bored pile points, there is an increase in the value of axial resistance and the carrying capacity of the planned bored pile permit (Qall) with the field. Initially the planned axial resistance was 698.316 kN, increased to 706.997 kN. The same thing happened to the permit carrying capacity (Qall), which increased with a value of the difference between the two of 356.28 kN.

This shows that differences in depth factors (H) and concrete quality (fc') can significantly influence the bearing capacity of bored pile foundations.

1. Requirements for the number and efficiency of field bored pile pile bearing capacity

Calculation of the efficiency of bored pile carrying capacity in field conditions using different methods, so that the number of bored pile piles needed is known in terms of the carrying capacity efficiency value in table 8.

Table 8. Requirements for the number and efficiency of field bored pile carrying capacity

No.	Story	Joint		Number of poles (n) (piece)	Qg (kN)	Qg > P
1.	BASE	9	2.05	3	2546.10	OKE
2.	BASE	15	2.02	2	1778.23	OKE
3.	BASE	17	2.99	4	2829.008	OKE
4.	BASE	20	3.06	4	2829.008	OKE
5.	BASE	24	3.01	4	2829.008	OKE
6.	BASE	51	2.91	4	2829.008	OKE
7.	BASE	56	2.83	3	2546.10	OKE
8.	BASE	75	3.02	3	2546.10	OKE
9.	BASE	79	2.97	3	2546.10	OKE
10	BASE	82	2.98	3	2546.10	OKE
11.	BASE	84	2.02	2	1778.23	OKE
12.	BASE	90	2.00	2	1778.23	OKE
13.	SW		7.81	8	5334.70	OKE
			Total =	**45**		

From Table 8 it is known that the total number of bored piles needed in the field is 45 points, each of which has met its carrying capacity efficiency. This condition shows the addition of 7 points from 38 pile points to 45 pile points. This occurs due to differences in the bearing capacity of bored piles in field conditions due to changes in depth and quality of concrete.

4. Conclusion

Based on the calculation results of the bored pile foundation planning for the At-Taqwa Paciran mosque tower construction project, Lamongan, East Java, several conclusions can be drawn as follows:

1. Calculation of the efficiency of bored pile bearing capacity in field conditions using different methods by adding 7 bored pile points to 45 points to increase the bearing capacity of the P2 pile cap by 1778.23 kN to 2546.10 kN. Calculation of the efficiency of bored pile carrying capacity in field conditions using the same method, so that it is known that the required number of bored pile piles in terms of the carrying capacity efficiency value is sufficient.

2. Addition of the number of bored pile points to each pile cap that has been determined is 7 points.

3. The bearing capacity of the bored pile foundation at a depth of 18 m using the Reese & Wright 1977 method is 500.28 kN, O'Neil & Reese 1989 is 2424.865 kN, and Converse-Labarre (A'yun, 2022) is 1778.23 kN.

REFERENCE

Iswati, R. K. (2023). *Comparative analysis of the carrying capacity of bored pile foundations based on N-SPT and PDA test data for the Kasih Ibu Hospital Building Construction Project, Surakarta* [Undergraduate thesis, Bangun Nusantara University]. Retrieved from https://eprints.univetbantara.ac.id/id/eprint/14

Ministry of PUPR. (2002). *Formation process and basic properties of soft soil geotechnical guide I*. Department of Settlements and Regional Infrastructure.

Jusi, U. (2015). *Analisa Kuat Dukung Pondasi Bore Pile Berdasarkan Data Pengujian Lapangan (Cone and N-Standart Penetration Test)* [Skripsi tidak diterbitkan]. Sekolah Tinggi Teknologi Pekanbaru. https://www.researchgate.net/publication/332068327

Livia., & Suhendra, A. (2018). Drilled pile capacity study based on the Pile Driving Analyzer (PDA) and Load Cell Method. *Civil Engineering Partner Journal*. Retrieved from https://journal.untar.ac.id/index.php/jmts/article/view/2245/1301

Sudrajat, K. M., Jumantoro, I., Isradi, M., Prasetijo, J., Rifai, A. I., & Sobirin, M. (2024). Analysis of Bearing Capacity of Bored Pile Foundation: Case Study of Jakarta – Bandung Station, Karawang High-Speed Railway. *European Journal of Science, Innovation and Technology*, *4*(4), 145-161. Retrieved from https://ejsit-journal.com/index.php/ejsit/article/view/499

Nguyen, T. T., Le, T. A., & Bui, T. Q. (2023). Sustainable design and optimization of pile foundations using metaheuristic algorithms. *Applied Sciences*, *13*(3), 1487.

Prijasambada, P., Tunafiah, H., & Natadipura, R. K. (2024). Analysis of Bearing Capacity of Bored Pile Foundation: Case Study of Jakarta – Bandung Station, Karawang High-Speed Railway. *European Journal of Science, Innovation and Technology*, *4*(4), 145-161. https://ejsit-journal.com/index.php/ejsit/article/view/499