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2023 ICCIM

THE THIRD

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of Construction, Infrastructure,and Materials

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KEYNOTE SPEAKER

27th July 2023
Universitas Tarumanagara
Jakarta - Indonesia

Dean of the Faculty of Engineering

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PREFACE

Dear Distinguished Speakers, Guests, and Colleagues

We are pleased to welcome you to the Third International Conference of Construction, Infrastructure, and Materials (ICCIM), held in 2023. After two-year restrictions due to the COVID-19 pandemic, we are glad to hold this offline conference at our campus, Universitas Tarumanagara, Jakarta. The Third ICCIM follows the success of the previous ICCIM, while this year, we chose the conference theme: “Civil Engineering for A Liveable Environment”. The topic has been brought to the attention of civil engineering to create a more humanized living environment.

We have received hundreds of abstracts and papers, which have been categorized into five different interests:

- Structural Engineering and Materials
- Geotechnical and Earth Sciences
- Green-construction Management
- Sustainable Transportation System
- Hydrological and Environmental Engineering
- Energy Friendly Infrastructure

Therefore, we acknowledge all authors that have dedicated their time to writing the papers and presenting them to this conference. Our gratitude is also conveyed to the distinguished keynote speakers who delivered an excellent speech: Prof. Dawn E. Lehman (University of Washington, USA); Assoc. Prof. Li Hai-Ting (Shanghai Jiao Tong University, China); Dr. H. R. Pasindu (University of Moratuwa, Srilanka); Dr. Wikke Novalia (Monash University, Australia); and Dr. Alfred J. Susilo (Universitas Tarumanagara, Jakarta).

We also appreciate the contributions from 9 university partners: Massey University (New Zealand), Nihon University (Japan), Universiti Tun Hussein Onn (Malaysia), Ubon Ratchathani University (Thailand), Universitas Kristen Petra (Surabaya), Universitas Atma Jaya Yogyakarta, Universitas Muhammadiyah Yogyakarta, Universitas Katolik Parhyangan (Bandung), dan Universitas Katolik Soegijapranata (Semarang), together with all sponsors of the ICCIM event.

We wish you a great conference and an enjoyable time in Jakarta. We hope to see you again at the next ICCIM.

Jakarta, 27 July 2023

Prof. Ir. Leksmono Suryo Putranto, M.T., Ph.D., IPM

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Analysis of different elevation buildings with heights of 4, 8, 12, 16, 20, and 24 floors on friction piles

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Abstract. Foundation is one of the most important parts of the structure. The design and selection of foundations must be carried out properly to strengthen the structure. Different elevation buildings require more careful foundation design than other structures. The bearing capacity and settlement of the soil acting on the pile foundation will be very important to be taken into consideration in the construction of different elevation buildings, because the different elevation buildings have different heights, so the placement of the foundation depths is also different. There is load data to be used, load data will vary according to the elevation of the building. The difference on structure elevation is four-storey buildings until it reaches 24 storey building. Each floor has a height of three meters. The foundation analyzed by using bored pile. The soil data is from Central Jakarta. The foundation will be analyzed under the following condition. The foundation will be placed at the same pile diameters which is one meter and uses different dephts. In this study, the bearing capacity and soil settlement analysis was carried out using bored piles on the conditions described before. The result of this research will provide information about bearing capacity and settlement that occurs on different elevation building if the foundation uses a friction piles. This research concludes that the use of friction piles in ineffective.

1 Introduction

The development of the era which includes economics and technology has made a lot of progress until now. The development of this era is accompanied by development progress in the field of construction. Infrastructure construction in Indonesia is currently developing. The development of increasingly advanced infrastructure makes people's needs increase. Creating an infrastructure is inseparable from building a foundation. Construction of different elevation buildings needs to pay attention to many things because there are elevation differences between structures. The different elevation buildings are a structure that has different elevations

In a 5-8 storey building construction project, deep foundations are usually used for the design of the lower structure. In different elevation buildings, it is necessary to pay close attention to the planning of the foundation because there are many factors that can affect the bearing capacity of the foundation and settlement, such as differences in structural elevation, load weight, soil conditions, etc. Based on the many conditions that affect the bearing capacity and settlement of the foundation, this research will seek the best conditions to be applied to terraced buildings based on the value of the foundation carrying capacity and the amount of soil settlement produced.

Based on what has been said on the background of the problem, it will produce the following problem formulation:

Calculating the amount of required bearing capacity in a different elevation building on single pile and group pile if using a friction piles.

Calculating the amount of settlement that occurs in a different elevation building on single pile and group pile if using a friction piles.

Analyze the bearing capacity and settlement of the foundation that occurs in a different elevation building if using a friction piles.

Based on the formulation of the problem, the objectives of this study are as follows:

1. Determine of the effect of the difference in the depth of single pile and group pile on the bearing capacity of the foundation in a different elevation building if using a friction piles.

Determine of the effect of the difference in the depth of single pile and group pile on the amount of the settlement in a different elevation building if using a friction piles.

Conclude the results of the analysis of the bearing capacity and settlement of the foundation if using friction piles.

1.1 Literature

The foundation is a part of building construction which is the lower structure of a building [1]. The foundation functions as a low structural component of the building whose role is to transmit the load from the upper

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structure to the ground evenly [2]. Foundation type, depth, shape, and material will influence many factors in foundation design. External factors that affect the design of the foundation, namely soil conditions, structural loads, and time required can also affect the selection of the foundation to be used. Deep foundations are used for buildings with four floors or more than four. In different elevation buildings, the foundations that can be used are pile and bored pile foundations. The use of these two piles is determined from factors derived from soil data or conditions on site.

1.2 Different elevation buildings

Different elevation buildings are a structure that has different elevations. Differences in the elevation of the structure make the required carrying capacity and settlement that occurs will be different. Different elevation buildings require a special foundation design because there are elevation differences between the structures. Different elevation buildings can be seen in the illustration of Fig. 1.

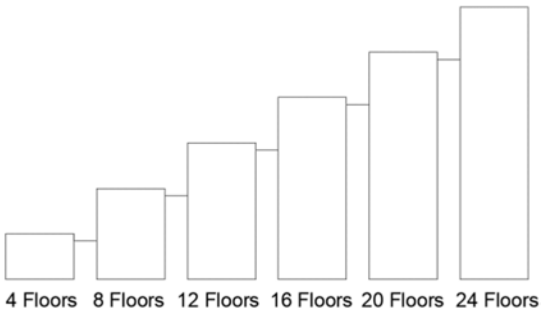

Fig. 1. Illustration of the configuration of different elevation buildings with various heights.

1.3 Deep foundation

Deep foundations are structures that have the function of channeling building loads to the ground at a predetermined depth [3]. According to Hardiyatmo [4] deep foundations can be reviewed based on how they support the load, namely:

1. Friction pile

   Friction pile is a type of pile whose bearing capacity is determined by the shear force. The shear force acts between the wall of the pile and the ground surrounding the pile.

2. End bearing pile

   End bearing pile is a type of pile whose bearing capacity is determined by the consistency of the soil at the end of the pile. Generally this pile will be placed on a layer of hard soil.

1.4 Point bearing capacity (Q_p)

In this research, the bearing capacity of the drilled pile foundation will be sought. The bearing capacity of the pile ends is determined using two methods, namely the Meyerhoff method and the CPT method. Meyerhoff's method can be seen as Equation 1.

$$Q_p = 9 \text{ Su Ap} \quad (1)$$

with Q_p = Point bearing capacity (kN), S_u = undrained pile end cohesion (kN), A_p = surface area (m2).

The CPT method can be seen as Equation 2.

$$\text{Qp} = \frac{\text{Ap x P}}{\text{SF}} \quad (2)$$

with Q_p = Point bearing capacity (kN), A_p = Surface area (m2), P = average cone value of sondir results (kN/cm2), SF = Safety factor.

1.5 Frictional resistance (Q_s)

In this study the carrying capacity of the pile blankets was sought using two methods, namely the Alpha method and the Reese & Wright method. Alpha method can be seen as Equation 3.

$$Q_s = \Sigma\, \alpha \text{ Su Kp } \Delta H \quad (3)$$

with Q_s = Frictional resistance (kN), α = empirical adhesion factor derived from cu correlation, Kp = pile circumference (m), ΔH = layer thickness (m).

The Reese & Wright method can be seen as Equation 4.

$$Q_s = \Sigma f_s \text{ L p} = \Sigma A_s\, f_s \quad (4)$$

with Q_s = Frictional resistance (kN), fs = $\alpha\, S_u$, α = adhesion factor derived from soil type L = soil depth (m), p = circumference (m).

1.6 Settlement

In this study, land subsidence will be sought. Settlement consists of elastic settlement and primary consolidation settlement. Elastic reduction using the Vesic method. Based on Das's book [3] the Vesic method is divided into 3 components, namely:

1. Shortening of the elastic of the pile ($S_{e(1)}$)

The settlement of the pile tip due to the working load ($S_{e(2)}$)

Settlement due to friction of the pile cover along the pile due to the working load ($S_{e(3)}$)

The settlement formula can be calculated using the following Equations 5-14.

$$S_e = S_{e(1)} + S_{e(2)} + S_{e(3)} \quad (5)$$

$$S_{e(1)} = \frac{(Q_{wp} + \xi Q_{ws})L}{A_p\, E_p} \quad (6)$$

$$F_{Qs} = \frac{Q_s}{Q_p + Q_s} \quad (7)$$

$$F_{Q_p} = \frac{Q_p}{Q_p + Q_s} \quad (8)$$

$$Q_{WP} = \frac{F_z}{n\, F_{Q_p}} \quad (9)$$

$$Q_{WS} = \frac{F_z}{n\, F_{Q_s}} \quad (10)$$

$$S_{e(2)} = \frac{q_{wp}\, D}{E_s}(1 - \mu_s^2) I_{wp} \quad (11)$$

$$S_{e(3)} = \quad (12)$$

$$\left(\frac{Q_{ws}}{p\,L}\right)\frac{D}{E_s}(1-\mu_s^2)I_{ws} = \frac{Q_{ws}\,C_s}{L\,q_p}$$

$$q_{wp} = \frac{Q_{wp}}{A_p} \quad (13)$$

$$I_{ws} = 2 + 0{,}35\sqrt{\frac{L}{D}} \quad (14)$$

with S_e = elastic settlement (m), $S_{e(1)}$ = elastic shortening of the pile (m), $S_{e(2)}$ = settlement of the pile tip (m), $S_{e(3)}$ = settlement due to friction of the pile cover (m), Q_{wp} = load acting on the ends of the pile (kN), Q_{ws} = load acting on the friction of the pile cover (kN), ξ = value of skin friction (0,5-0,67), q_{wp}= load area at the end of the pile, n = total pile, E_s = soil elastic modulus (kN/m^2), I_{wp} dan I_{ws}= influence factor, C_s = empirical factor, P = pile perimeter (m).

The following Equations 15-19 is the formula for primary consolidation:

- Normally consolidated

$$S_c = \frac{C_c H_c}{1+e_o}\log\frac{\sigma'_o + \Delta\sigma'}{\sigma'_o} \quad (15)$$

- Over consolidated

  Condition $\sigma'_o + \Delta\sigma' \le \sigma'_c$

$$S_c = \frac{C_s H_c}{1+e_o}\log\frac{\sigma'_o + \Delta\sigma'}{\sigma'_o} \quad (16)$$

  Condition $\sigma'_o + \Delta\sigma' > \sigma'_c$

$$S_c = \frac{C_s H_c}{1+e_o}\log\frac{\sigma'_c}{\sigma'_o} + \frac{C_c H_c}{1+e_o}\log\frac{\sigma'_o + \Delta\sigma'}{\sigma'_c} \quad (17)$$

  Compressibility index and expansion index

$$C_c = \frac{e_1 - e_2}{\log\left(\frac{\sigma'_2}{\sigma'_1}\right)} \quad (18)$$

$$Cs = \frac{1}{5} \sim \frac{1}{10}\,C \quad (19)$$

with S_c = Settlement primary consolidation (m), e0 = initial void ratio, C_c = compressibility index, C_s = expansion index, H_c = depth of soil (m), σ'_o = effective overburden pressure (kN/m^2), σ'_c = preconsolidation pressure (kN/m^2), Δσ' = difference of the pressure (kN/m^2).

1.7 Permission of the settlement

Based on SNI 8460:2017 [5] the amount of the settlement that occurs and the difference in the settlement that is permitted based on the function and stability of the structure has the conditions total settlement < 15 cm + b/600.

2 Research method

The data collection method used is data collection using documentation techniques, the documentation technique is collecting data from a project as a reference for the soil profile which will be used to calculate the bearing capacity and settlement in this journal. In addition, the literature method is used to find information that supports this topic from books and journals.

The data analysis method begins by looking for theoretical basis and data sources from journals and books to obtain formulas for calculating the carrying capacity and land subsidence. The data analysis method will look for the best depth to use based on the results of bearing capacity and settlement. The foundation will use friction pile.

3 Result and analysis

3.1 Project data

To calculate the bearing capacity of foundation and soil settlement, the project data is used in the form of boring logs, sondir, laboratory data in the Central Jakarta area. The project data consists of 2 drill points with a depth of 30 meters, 6 sondir points, and laboratory data. From this project data, final parameters will be made which will conclude the soil conditions at the case study location. The final parameters of the soil can be seen in Table 1-2.

Table 1. Soil parameters.

Elevation (m)	Soil Type	Consistency	PI (%)	γ_{sat} (kN/m^3)	γ_{wet} (kN/m^3)	e_0	C_c	C_s	φ' (°)
0-5	Clayey Silt	Soft	65	18	15	0.75	0.3	0.16	24
5-12	Clayey Silt	Soft	60	18	15	0.5	0.7	0.14	24
12-20	Cemented Silt	Very Stiff to Hard	40	19	15	2	0.6	0.32	40
20-29	Clayey Silt	Very Stiff	30	18	15.5	1.5	0.5	0.14	26
29-30	Cemented Silt	Very Stiff to Hard	30	18	16	1.5	0.5	0.14	41

Table 2. Soil parameters (continued).

Elevation (m)	S_u (kPa)	C' (kPa)	OCR	Pc' (kPa)	Eu & E'	N-SPT	qc
0-5	20	6	2	100	10	7	12
5-12	40	8	1	80	10	5	20
12-20	180	36	8	1100	55	50	250
20-29	60	12	1.5	400	20	25	250
29-30	160	30	3.5	1100	50	40	250

3.2 Building size and load weight

The different elevation building has a configuration of 24 m × 12 m. All floors of the different elevation buildings use the same building configuration. Configuration illustration can be seen in Fig. 2.

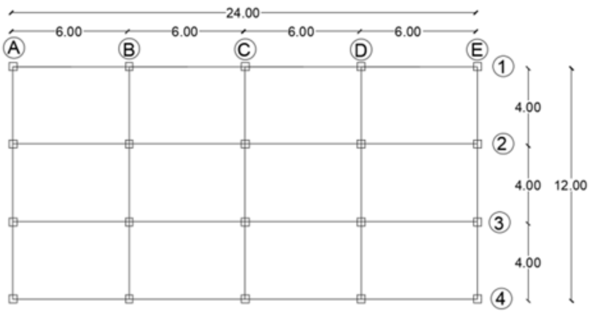

Fig. 2. Building configuration.

The load weight to be used for each floor can be seen in Table 2.

Table 2. Structure load.

Floor	Load Conversion (kN)	Column Load (kN)	Column Load (ton)
4	8697.6	434.88	44
8	17395.2	869.76	88
12	26092.8	1304.64	131
16	34790.4	1739.52	175
20	43488	2174.4	219
24	52185.6	2609.28	262

3.3 Calculation of point bearing capacity (Q_p)

The bearing capacity of the foundation needs to consider of wind forces, earthquake forces, and others. The selection of an effective foundation is chosen by considering the depth of the foundation piles to hard soil [6]. The bearing capacity of the foundation takes into account the point bearing capacity and the frictional resistance. Calculation of the point bearing capacity will be calculated with friction pile foundations with different depths. The calculation of the point bearing capacity will use two methods, namely the Meyerhoff method and the CPT method. The results to be used from these two methods are taken to be the minimum in order to determine the smallest pile tip bearing capacity to avoid design failure. Calculation of the bearing capacity will be applied to all floors to be analyzed. Following are the results of the final calculation of the point bearing capacity can be seen in Table 3.

3.4 Calculation of frictional resistance (Q_s)

The calculation of the frictional resistance will be calculated with friction pile foundations with different depths. The calculation of the frictional resistance will use two methods, namely the alpha method and the Reese & Wright method. The results to be used from these two methods are taken to be the minimum in order to find out the smallest pile cover bearing capacity to avoid design failure. Calculation of the bearing capacity will be applied to all floors to be analyzed. The following results of the final calculation of the pile cover carrying capacity can be seen in Table 4.

Table 3. Results of the final calculation of the point bearing capacity.

Depth (m)	Q_p Meyerhoff (ton)	Q_p CPT (ton)	Q_p Minimum (ton)
4	15	10	10
6	29	13	13
8	29	13	13
10	29	13	13
12	29	13	13
14	128	73	73
16	128	73	73
18	128	73	73
20	128	73	73
22	43	103	103
24	43	103	103
26	43	103	103
28	43	103	103
30	114	121	121

Table 4. Results of the final calculation of the frictional resistance.

Depth (m)	Q_p Alpha (ton)	Q_s Reese & Wright (ton)	Q_s Minimum (ton)
4	27	14	14
6	44	25	25
8	64	39	39
10	84	53	53
12	104	66	66
14	155	129	129
16	206	191	191
18	258	254	254
20	309	316	316
22	329	337	337
24	350	358	358
26	371	379	379
28	392	399	399
30	425	437	437

3.5 Calculation of bearing capacity on bored pile foudantion (Q_{all})

Based on the calculation of the point bearing capacity and frictional resistance, the value of the foundation bearing capacity can be generated. The following results of the Q_{all} calculation can be seen in Table 5. The correlation between the weight of the load and Q_{all} can be seen in Table 6.

3.6 Calculation of group pile

Based on the results of the calculation of the bearing capacity of the pile foundation, on several floors it is necessary to use group piles because the carrying capacity of a single pile is not strong enough to support the weight of the load on several floors. The group pile will use two piles. The method to be used to calculate group piles is block failure. Following are the results of group pile calculations and the final results of carrying capacity calculations can be seen in Table 7.

Table 5. Summary of bearing capacity.

Depth (m)	Q_p CPT (ton)	Q_s Reese & Wright (ton)	Q_{all} (ton)
4	10	14	10
6	13	25	13
8	13	39	13
10	13	53	13
12	13	66	13
14	73	129	73
16	73	191	73
18	73	254	73
20	73	316	73
22	103	337	103
24	103	358	103
26	103	379	103
28	103	399	103
30	121	437	121

Table 6. Correlation of load weight with Qall.

Floor	Column Load (ton)	Qall Single Pile (ton)
4	44	109
8	88	109
12	131	147
16	175	Use Group Pile
20	219	Use Group Pile
24	262	Use Group Pile

3.7 Calculation of settlement

The calculation of the settlement value for the deep foundation will use the Vesic method. Calculation of settlement will be carried out at a predetermined depth in the bearing capacity calculation. The calculation of settlement consists of elastic settlement and primary consolidation settlement. The following results of the calculation of land subsidence can be seen in Table 8.

Table 7. The result of the foundation bearing capacity.

Floor	Load Weight (ton)	Single Pile (ton)	Single Pile Depth (m)	Group Pile (2 tiang) (ton)	Group Pile Depth (m)	Check
4	44	109	18	-	-	Ok
8	88	109	18	-	-	Ok
12	131	147	22	-	-	Ok
16	175	-	-	218	18	Ok
20	219	-	-	260	20	Ok
24	262	-	-	294	22	Ok

Table 8. Result of settlement.

Type	Floor	Pile Depth (m)	Total Settlement (mm)	Settlement Permit (mm)
Single Pile	4	18	59.7283	151.6667
Single Pile	8	18	113.0052	151.6667
Single Pile	12	22	86.3351	151.6667
Group Pile	16	18	45.9882	151.6667
Group Pile	20	20	49.6628	151.6667
Group Pile	24	22	72.5863	151.6667

3.8 Analysis of the calculation on bearing capacity and settlement

Based on the calculation results (Fig. 3), it is known that the result of the resulting foundation bearing capacity will be greater with each increase in elevation but there are irregularities in the 4-storey building, where the bearing capacity of the 4-storey building foundation is the same as the carrying capacity of the 8-storey building foundation. This is due to adjustments to the depth of the foundation in a 4-storey building. Actually, the weight of a 4-storey building can be carried if the foundation is placed at a depth of 14 meters, but the settlement that occurs at a depth of 14 meters exceeds the permit limit based on SNI 8460:2017 so the foundation needs to be deepened so that land subsidence does not exceed the permit reduction limit. It was found that at a depth of 18 meters the settlement that occurred did not exceed the permit limit, but the resulting foundation bearing capacity was twice the weight of the load to be carried. Land subsidence that occurs is relatively moderate at a certain height but does not exceed the permit limit.

4 Conclusions

Based on the calculations performed, it can be concluded that:

1. Based on the results of the calculation on the bearing capacity of foundation, it is known that the deeper the pile depth, the greater the resulting bearing capacity of foundation.
2. Based on the results of the calculation on the settlement on the friction pile, the result of settlement is not too big and does not exceed the permit limit
3. Based on soil data and calculations, it can be concluded that the use of friction pile is ineffective. The reason is the bearing capacity on four-storey building is twice the weight of the load to be carried.

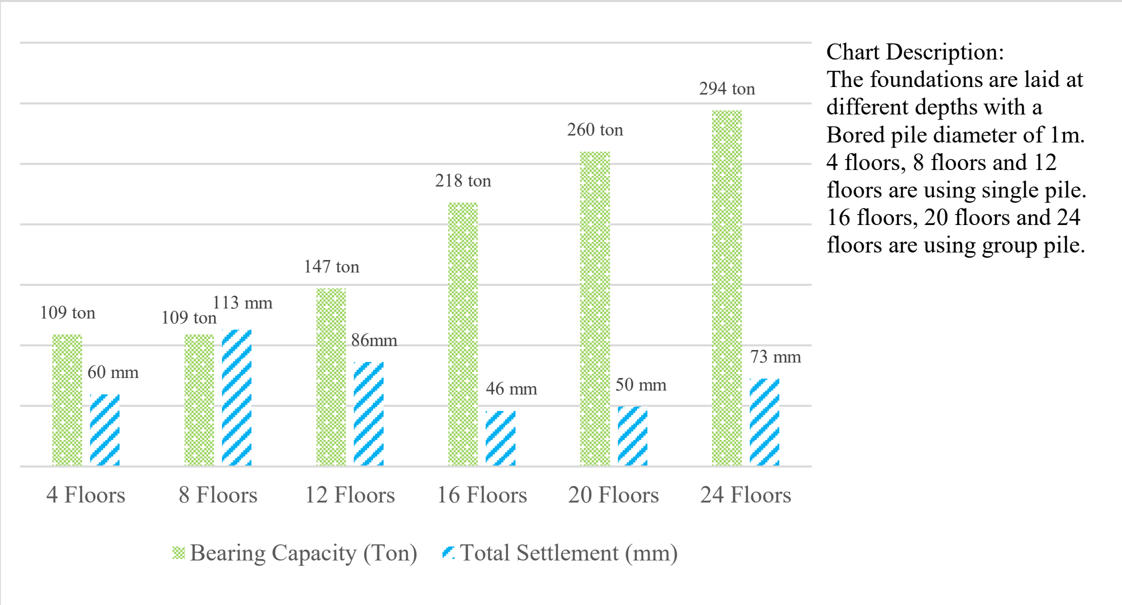

Fig. 3. Graph of foundation bearing capacity and settlement.

5 Recommendations

Based on the results of the research conducted, the authors can provide suggestions:

1. Calculations can be checked using a calculation application to find out accurate results.
2. An analysis of foundation construction in terms of cost can be carried out to provide information in terms of the cost.

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