

PAPER • OPEN ACCESS

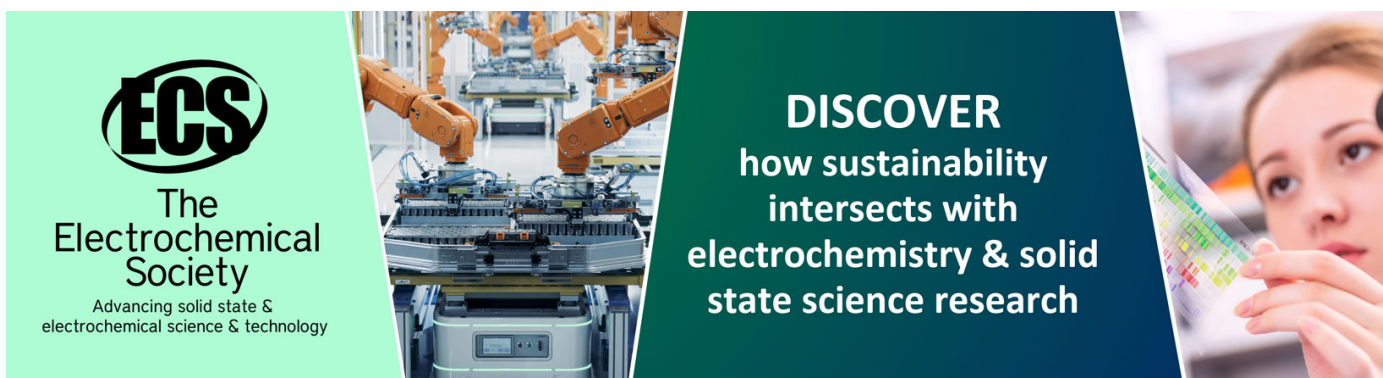
Pile Foundation Analysis on High – Rise Building using Finite Element-Spring Method on Sandy Clay Soil

To cite this article: D K Fitriyah *et al* 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **462** 012045

View the [article online](#) for updates and enhancements.

You may also like

- [Thermodynamic study of -\(BEDT-TTF\)₂Ag\(CN\)₂H₂O under pressures and with magnetic fields](#)
N Tokoro, O Kubota, S Yamashita et al.
- [High Gain Characteristics of an Erbium-Doped Fiber Amplifier Pumped in the 800 nm Band](#)
Yasuo Kimura, Eiji Yoshida Eiji Yoshida and Masataka Nakazawa Masataka Nakazawa
- [N₂O-Gas Sensing Using a Gas Polarographic Oxygen Sensor](#)
Toshio Usui, Akiyoshi Asada, Kohsei Ishibashi et al.



ECS
The
Electrochemical
Society
Advancing solid state &
electrochemical science & technology

DISCOVER
how sustainability
intersects with
electrochemistry & solid
state science research

Pile Foundation Analysis on High – Rise Building using Finite Element-Spring Method on Sandy Clay Soil

D K Fitriyah¹, J Propika¹, L L Lestari¹, H Istiono¹, D Pertiwi¹, and R Sekartadji¹

¹Institut Teknologi Adhi Tama Surabaya

Abstract. It is a common thing used by a planner to get the pile foundation needs with the finite element program. The output generated from the finite element program is then processed to produce the required number of piles on the planned structure. The finite element program that is often used is SAP2000. From several cases in the field, there were differences in the results of the number of piles needed between the analysis using the manual calculation method with the Nakazawa method. So, in this paper a comparison of the need for piles based on the manual calculation method with Nakazawa method will be compared, which is devoted to soft soil material according to soil data. The results showed that the number of pile requirements based on the Nakazawa method (n = 244 pieces) was much smaller than the manual calculation method (n = 320 pieces). This shows that the analysis of pile needs is more effective with the use of the Nakazawa method.

Keyword : *high rise building, pile foundation, spring*

1. Introduction

1.1. Background

High rise building can stand firm because it is supported by strong under construction of buildings. Foundation is the most important part of building construction. The foundation serves to hold all the loads in the building and forward them to the ground. [1]

So, considering the needs of the piles is most important. Commonly, to calculate the need for piles, only use manual calculations that only consider axial resistance. Whereas in some cases, it is also necessary to calculate the piles which requires consideration of the resistance of elastic forces due to soil conditions and the loading that occurs. Seeing the conditions that have happened, it is necessary to have a comparative analysis of the need for piles based on the Nakazawa method (1994) with the finite element program.

The research with the topic "Analysis of High-Level Building Pole Needs with Finite Element Spring Analysis on Sandy Soft Soil" is expected to be a consideration in modeling the construction of under construction of buildings.

1.2. Purpose

Based on the background described in section 1.1, the purpose of this paper was to obtain the need for piles that can withstand axial and elastic forces using the Nakazawa method using spring finite elements and manual calculations as validation. The detailed objectives of the research are described as follows:

1. Getting efficient pile needs
2. Obtain displacemen



2. Literature Review

2.1. Modeling a High Rise Building Structure

This high-rise building structure modeling is carried out with Sap2000 structure analysis program. This modeling is in the form of a 10-storey building that functions as an office building with a calculation of the load according to the Indonesian National Standard (SNI). This modeling is intended to get the reaction of the base in the building that will be used in foundation planning.

2.2. Calculation of Soil Capacity

By using the N-SPT data at the location of the high-rise building, the carrying bearing capacity (QL) is calculated. to calculate bearing capacity the pile method is used by **Luciano Decourt** (1996): [2]

$$Q_u = Q_p + Q_s = K \cdot A_p \cdot N_p \cdot \alpha + \left(\frac{N_s}{3} + 1 \right) \cdot A_s \cdot \beta \quad (1)$$

$$Q_{ijin\ 1\ tiang} = \frac{Q_u}{SF} \quad (2)$$

Information :

Q_u = The carrying capacity of the ultimate pole

K = soil characteristic coefficient

- sand soil: 40 T / m²

- sandy silt soil: 25 T / m²

- clay silt soil: 20 T / m²

- clay: 12 T / m²

A_p = base area of pole (m²)

N_p = Average value of SPT (N) along 4D above to 4D below the end of the pole

α = Correction factor at the end of the pile = 1

β = Correction factor on pile blanket = 1

N_s = Mean value (N) along the pole with a value of $3 \leq N \leq 50$

A_s = Pile blanket value (perimeter x pole length)

SF = Safety factor

Factor for piles efficiency in groups, based on Converse-Labarre: [5]

$$E_{LA} = 1 - \theta \frac{m(n-1)+n(m-1)}{90mn} \quad (3)$$

Information :

E_{LA} = Efficiency of pile groups

m = Number of pile lines

n = Number of piles in 1 row

θ = arc tg d / s

s = Distance of the center of the pole to the center

d = Pole diameter

2.3. Control of Pile Resistance to Horizontal Force

The foundation of the pile also needs to be controlled for horizontal forces. Deflection that occurs is not allowed to exceed the specified limits. The following is a formula to determine the deflection that occurs at the stake. [3]

$$\delta_p = F_\delta \left(\frac{PT^3}{EI} \right) < 2,54\ cm \quad (4)$$

$$T = \left(\frac{E \times l}{f} \right)^{1/5}$$

2.4. Estimated K Coefficient From Horizontal Force

The following is the equation for estimating the coefficient of soil reaction in a vertical force based on technical standards in Japan. [4]

$$\begin{aligned} k &= k_0 \cdot y^{-\frac{1}{2}} \\ k_0 &= 0,2 \cdot E_0 \cdot D^{-3/4} \end{aligned} \quad (5)$$

Information :

k_0 = Value k if the shift on the surface is made 1 cm (kg / cm²)

y = The amount of shift to be searched (cm)

E_0 = Modulus of foundation soil deformation, usually estimated from $E_0 = 28$ N using N prices from standard penetration experiments (standard penetration test)

D = Piles diameter (cm)

2.5. Estimated K_V Coefficient From The Vertical Force

Estimated K_V (spring constant) in the vertical force of the pile is an elastic constant which is expressed as a force in the vertical direction and can cause displacement on the mast head. K_V is used in the calculation of the size of the pole head reaction or elastic decline that occurs. Here is the empirical formula for estimating K_V constants.

$$K_V = \alpha \cdot \frac{A_P \cdot E_P}{l} \quad (6)$$

For a steel pipes

$$\alpha = 0,027 (l/D) + 0,2$$

For prestressed concrete

$$\alpha = 0,041 (l/D) - 0,27$$

For Cast in Situ

$$\alpha = 0,022 (l/D) - 0,05$$

Information :

A_P = Net cross-sectional area of pole (cm²)

E_P = Modulus of elasticity of the pole (cm²)

l = Pole length (cm)

D = pole diameter (cm)

The formula above is used when $l/D \geq 10$.

3. Research Methodology

The following is an explanation at the step of this research.

What was done for the first time was collecting land data at the construction site of a high-rise building in Surabaya. The selected high-rise building is a building with office functions. Then modeling high-rise building structures using SAP2000. From the structural modeling, the placement reaction at the bottom of the building can be used to analyze the needs of the number of piles using the spring finite element method based on the type of soil obtained from secondary data.

By using the Nakazawa method (1994) the number of effective piles will be produced, with validation using manual calculation method. In addition, from this study, found piles that are resistant to axial forces and elastic forces.

4. Data and Analysis Result

4.1. Structure Planning Data

The building structure data analyzed in this paper are as follows:

1. Location = Surabaya

2. Building function = Office
3. Building height = 10 floors + 1 roof top floor
4. Material = Concrete
5. Concrete quality = 30 MPa (plates and beams)
= 35 MPa (Column)
6. Column dimensions = 1000 x 1000 mm
7. Dimensions of the beam = 50 x 70 mm
8. Distance of column = 8000 mm

4.2. Modeling of Structure Building with SAP2000

In this study high-rise buildings were modeled with the properties of the materials used in accordance with the discussion in Section 4.1. By using SAP2000, the building structure is modeled and given the loads that work on the structure (Figure 2). Structure modeling can be seen in Figure 1.

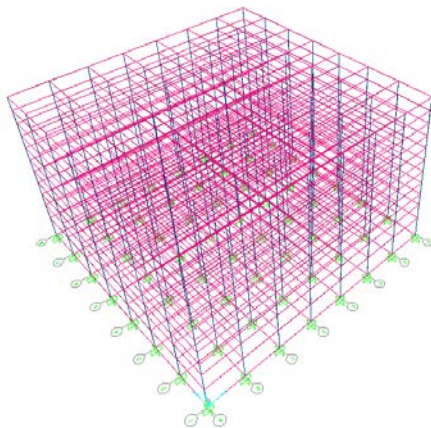


Figure 1. Show undeformed shape.

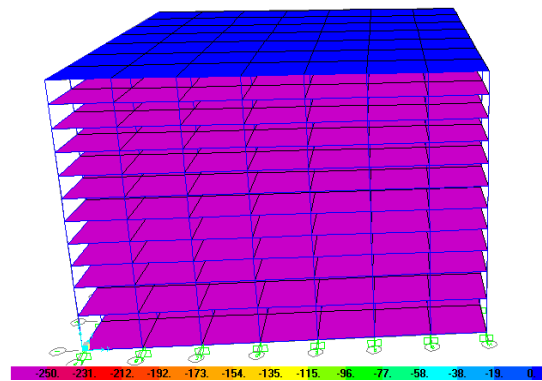


Figure 2. Show Area loads, Uniform load to frame contours.

To analyze the need for number of piles, resistance to axial forces and elastic forces, as well as displacements that occur in the horizontal direction, analysis is needed with spring analysis modeling. For modeling with the spring finite element method as shown in Figure 3.

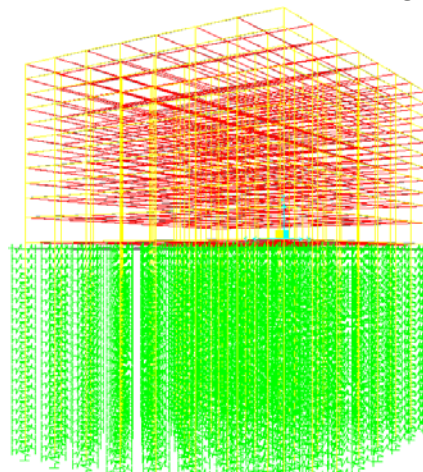


Figure 3. Show undeformed shape.

4.3. Calculation of Soil Capacity

The calculation of the bearing capacity of the soil against the pole includes the calculation of the endbearing carrying capacity and the carrying capacity of the positive and negative skin friction blankets. Before calculating the capacity, the NSPT value is first corrected to water level and to soil pressure overburden. [6]

4.4. Control Strength material of Piles

The pile is planned with the tip pinched by a flat foundation against the subgrade. So that the material strength control is carried out on the axial force and moment force. The location of the pile pinch point from the ground surface (Z_f) is 3.0 m.

Axial force (P_{max}) is obtained at 130.09 Ton. So that this axial force must be smaller than the Pall pile based on specifications. The pile is planned to use dimensions $\varnothing$ 50 cm class C with Pall which is 169 Ton at a depth of 41 m.

4.5. Pile Needs Analysis

Analysis of the pile using the Nakazawa method, namely the Spring Fimite Element analysis will be validated using the Luciano Decourt (1996) method, can be seen in Table 1.

Table 1. Pile Needs Analysis

Method	Pile need	P_{max}
Luciano Decourt	320	644.00
Nakazawa	244	130.09

From the table above, it is found that the needs generated from the Nakazawa method are spring analysis which results in a smaller pole requirement compared to the Luciano Decourt method. Due to the considerable differences in styles of the two methods above.

5. Conclusion

The conclusion of this study is that the need for piles is more effective with the Nakazawa method, because the number of pile requirements is much smaller than the results of manual calculations in the same case study.

6. Acknowledgement

The author would like to thank PT. ITSC which has allowed the use of secondary data in this study.

7. Bibliography

- [1] Pardoman Silitongan, Ary dan Iskandar Rudy *Perbandingan Daya Dukung Pondasi Tiang Pancang Metode Analitis dan Loading Test Terhadap Metode Elemen Hingga Menggunakan Model Mohr-Coulomb dan Soft Soil pada Bore-Hole I (Studi Kasus Pembangunan Rusunawa Jatinegara Barat Jakarta Timur)* (Sumatra Utara : Universitas Sumatera Utara)
- [2] Ath Thaariq, Brilliant Joko Wahyu Adi, Tri dan Trihanyndio rendy Satrya 2013 *Analisa Pemilihan Alternatif Sistem Pondasi pada Gedung Kampus ABC Balikpapan – KALTIM Ditinjau dari Aspek Teknis, Biaya dan Waktu* (Surabaya : Institut Teknologi Sepuluh Nopember (ITS))
- [3] Ilham Gumilang S, M B. Mochtar, Indrasurya, dan Lastiasih, Yudhi 2016 *Perencanaan Pondasi Tiang Pancang dengan Memperhitungkan Pengaruh Likuifaksi pada Proyek Pembangunan Hotel di Lombok* (Surabaya : Institut Teknologi Sepuluh Nopember (ITS))
- [4] Nakazawa, Kazuto, et al 1994 *Mekanika Tanah & Teknik Pondasi* Kazuto Nakazawa, et al, Suyono Sosrodarsono (Jakarta : PT Pradnya Paramita)

- [5] Anaya Nabilla Antari Terenggana, S 2014 *Analisa Perhitungan Pile – Raft Foundation Pada Proyek The 18 Office Park Jakarta* (Sumatera Selatan : Universitas Sriwijaya)
- [6] Kurniawan, Ali B. Mochtar, Indrasurya dan Lastiasih Yudhi 2016 *Alternatif Perencanaan Pondasi Tiang untuk Gedung Tinggi di Atas Tanah Lunak pada Proyek Pembangunan Kota Baru Summarecon-Bandung* (Surabaya : Institut Teknologi Sepuluh Nopember (ITS))