

ANALYSIS OF PILE FOUNDATION PLANNING IN THE CONSTRUCTION OF THE PKK - DEKRANASDA BUILDING IN MAKASSAR CITY

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ABSTRACT

Concrete consists of cement, sand, gravel and water, with cement being the main binder that affects its quality. However, the increasing cost of raw materials and the environmental impact of lime mining and sand dredging are challenges in construction. To address this, the study proposed the use of bamboo fiber as an environmentally friendly and economical additive. This study tested the variation of 0%, 10%, and 15% pulung bamboo fiber waste on the compressive strength of concrete. The results showed that normal concrete without bamboo fiber had a compressive strength of 452 kN (fc' 26.08 MPa). The addition of 10% bamboo fiber decreased the compressive strength to 404 kN (fc' 23.32 MPa), while the addition of 15% decreased it further to 393 kN (fc' 22.68 MPa). The more bamboo fiber added, the more the compressive strength of the concrete decreased.

Keywords: Waste, Wulung Bamboo, Compressive Strength, Normal Concrete, Variety Concrete

INTRODUCTION

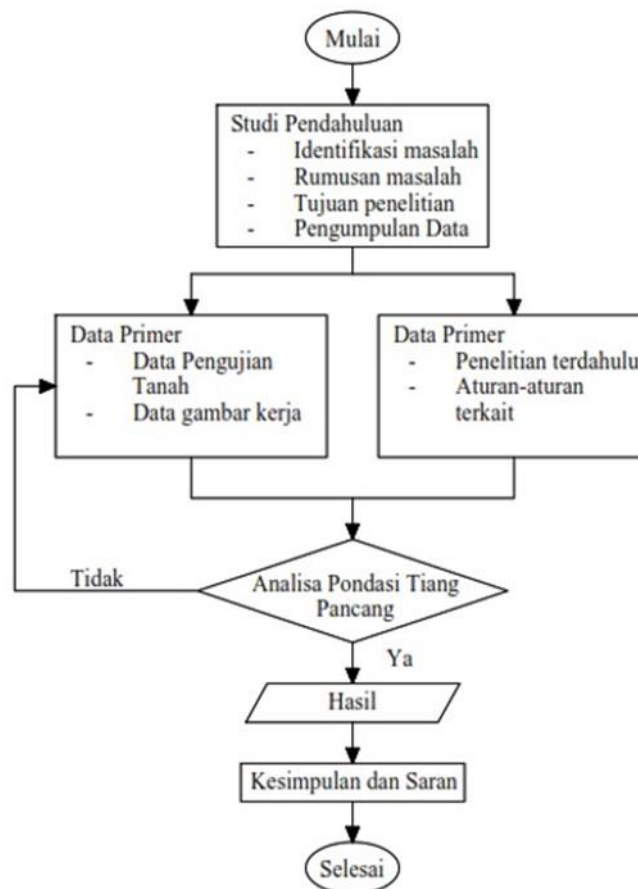
The foundation is the lowest building structure that supports its own load and all the loads of the structure above it. The foundation is also the most important structural part that needs to be considered in planning a building, be it a house, building, bridge and other civil infrastructure. Due to the important role of the foundation in the structure of a building, it is necessary to plan carefully and pay attention to the load aspects of the structure and also the soil conditions where the building stands. The foundation as a lower structure is divided into two types, namely: deep foundation and shallow foundation. The choice of foundation type depends on the type of upper structure whether it is a light load or heavy load structure and also depends on the type of soil. For light load construction and good soil conditions, shallow foundations are used, while for heavy building construction deep foundations are used. In determining the type of foundation it is very important to know the condition and type of soil on which a building will be erected. In planning the pile foundation using several methods, including the Terzaghi, Guy Sangrelat and Meyerhoff methods. In planning the pile foundation of the PKK-Dekranasda Building Development of Makassar City using calculations based on the strength of materials and sondir / CPT testing (Guy Sangrelat) and SPT testing (Mayerhoff). In this case, in order to be a comparison, the author will analyze the calculation of pile planning using the calculation method of sondir / CPT testing (Guy Sangrelat) and SPT (Mayerhoff) testing and validated with PLAXIS 2D Software.

METHODS

Broadly speaking, the data analysis plan that will be carried out based on data - sequential data according to the formulation of problems in this study includes:

- 1) Collection of research data which includes soil test data, working drawing data, structural loading data using etabs;
- 2) Analysis of foundation bearing capacity calculation;
- 3) Analysis of pile cap calculation;
- 4) Analysis of pile cap reinforcement;
- 5) Analyzing the bearing capacity of the foundation using 2D plaxis software.

The research stages as listed in the research flow chart are as shown in Figure 1 as follows:

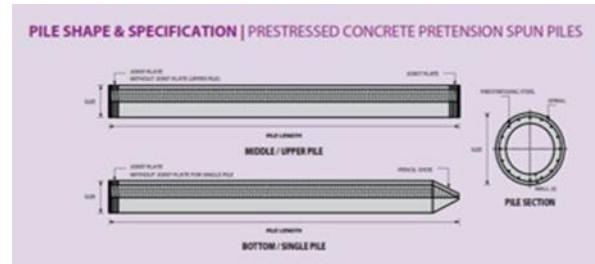


Source: Research Data Processing, 2024.

Figure 1. Research Flowchart

RESULTS AND DISCUSSION

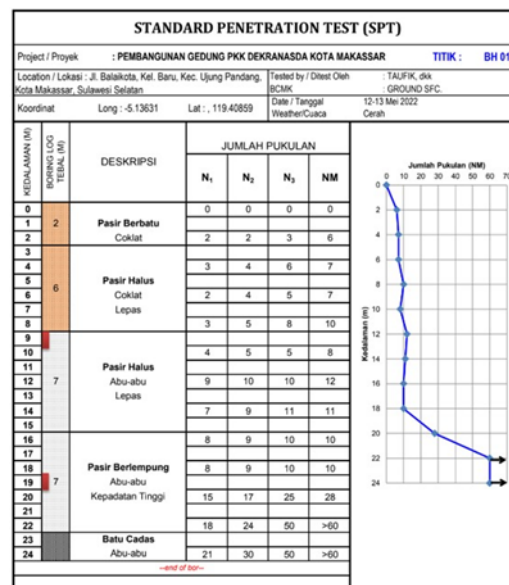
The construction project of the PKK-DEKRANASDA BUILDING located in Makasar City, South Sulawesi Province is a building planned as an office building. The foundation planning has the following specifications:



Source: Research Documentation, 2024.

Figure 2. Pile Shape

Materials & foundation materials, concrete quality = K-500, concrete compressive strength (f'_c) = 42.3 MPa, reinforcing steel quality = U-40, steel yield stress (f_y) = 400 MPa, concrete modulus of elasticity (E_c) = 30,569 MPa, reinforced concrete weight (w_c) = 25 kN/m³. Pile dimensions, diameter (D) = 0.5 m, length (L) = 22 m, distance between the center of the outermost steel pile = 0.4 m to the outer side of the pile-cap (a). Pile arrangement data, number of piles (n_y) = 1 unit, number of piles in 1 row (n_x) = 2 units, distance between piles in the X direction = 1 m.



Source: Research Documentation, 2024.

Figure 3. Standard Penetration Test Results

From the calculation data for the bearing capacity of piles with a diameter of 0.5 meters, it can be concluded as in Table 1 below.

Table 1. Recapitulation of Axial Bearing Capacity of Piles

	Daya Dukung Tekan (kN)	Daya Dukung Tarik (kN)
Guy Sangrelat	2110	1923
Meyerhoff	2020	126
Daya Dukung Aksial Kecil	2020	126

The force received by the concrete, obtained from the data of the loading analysis results through the ETABS application can be seen in Table 2 below.

Table 2. Recapitulation of Axial Bearing Capacity of Piles

				F1	F2	F3	M1	M2	M3
				KN	KN	KN	KN-m	KN-m	KN-m
13	Dead	Combination		10.5092	2.9657	1803.0086	-5.6271	13.6416	-0.1345
13	Live	Combination		18.8852	9.4216	826.6784	-12.5056	22.9909	-0.0884
13	Comb1	Combination		14.7128	4.1519	2524.2121	-7.8779	19.0982	-0.1882
13	Comb2	Combination	Max	42.8273	18.6334	3486.2958	-26.7614	53.1553	-0.3029
13	Comb3 Max	Combination	Max	52.0137	25.5758	3004.4511	12.9806	91.0461	1.1044
13	Comb3 Min	Combination	Max	10.9787	0.3851	2976.1263	-51.4968	12.3246	-1.604
13	Comb3- 1 Max	Combination	Max	42.1624	35.9448	3000.0412	39.6235	66.7887	1.0423

In calculating the maximum and minimum axial force imposed on a concrete pole, use the following equation:

1) Maximum axial force

$$P_{Maks} = \left(\frac{P}{n}\right) + \left(\frac{M_y \times X_{Max}}{\sum X^2}\right) + \left(\frac{M_x \times Y_{Max}}{\sum Y^2}\right) \dots 1$$

2) Minimum axial force

$$P_{Min} = \left(\frac{P}{n}\right) - \left(\frac{M_y \times X_{Max}}{\sum X^2}\right) - \left(\frac{M_x \times Y_{Max}}{\sum Y^2}\right) \dots 2$$

In the calculation of the estimated time of pile foundation settlement based on the SPT test value according to SNI 8460:2017 through the following stages.

The SPT value at a depth of 22 meters is 60

H = 22 meters

N = 60

Consolidation coefficient Cv

$$C_v = \frac{0,0043 \times N}{9,81 \times \log(H)} = 0.0196 \text{ m}^2 / \text{year}$$

Consolidation time

$$t = \frac{H^2}{C_v} = 24.694 \text{ years}$$

Analysis of pile cap reinforcement, calculation of pile cap force and moment. In the calculation, the planned ultimate force is obtained from the largest force in the loading combination. While the dimensions of the planned pile cap are as in Table 3. Ultimate Force and Concrete Plan Dimensions.

Table 3. Ultimate Force and Concrete Plan Dimensions

<u>Gaya Ultimate Maksimum</u> <u>(P_{umax})</u>	<u>Dimensi Rencana Bagian Beton</u>				
<u>(kN)</u>	<u>Lx/Bx</u> <u>(m)</u>	<u>Ly/By</u> <u>(m)</u>	<u>L₁ dan L₂</u> <u>(m)</u>	<u>Shape</u> <u>(m)</u>	<u>h</u> <u>(m)</u>
1787,14	2	0.50	0,73	1	0,5

The analysis of the calculation of the planned ultimate moment is as follows:

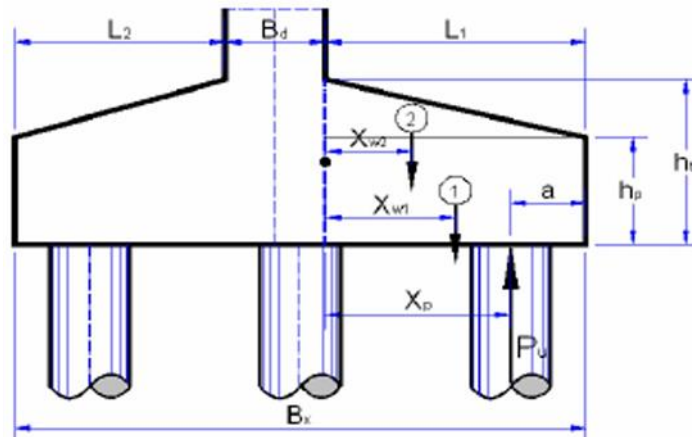


Figure 4. Side View of Pile Foundation

$$\text{Volume} = 0.4 \text{ m}^3,$$

$$W_s = W_c \cdot V = 25 \cdot 0.4 = 9.063 \text{ kN}$$

$$X_w = b/2 = 0.73/2 = 0.363 \text{ m}$$

$$M_s = W_s \cdot X_w = 9.063 \cdot 0.363 = 3.285 \text{ kNm}$$

$$\text{Ultimate load factor } K = 1.3$$

$$\text{Ultimate moment due to pile cap weight (} M_{us} \text{)} = K \cdot M_s = 1.3 \cdot 3.285 = 4.27 \text{ kNm}$$

$$\text{Ultimate shear force due to pile cap weight (} W_{us} \text{)} = K \cdot W_s = 1.3 \cdot 9.036 = 11.78 \text{ kN}$$

$$\text{The thickness of the bottom column, } B_d = B_x - L_1 - L_2 = 2 - 0.73 - 0.73 = 0.55 \text{ m}$$

$$\text{Number of pile rows } n_y = 1 \text{ unit}$$

$$\text{Maximum pile cap moment due to steel pile reaction, } M_p = n_y \cdot P_{\max} \cdot X_p = 1 \cdot 1787.14 \cdot 0.325 = 580.82 \text{ kNm.}$$

$$\text{Ultimate pile cap design moment (} M_{ur} \text{)} = 580.82 - 4.27 = 576.55 \text{ kNm.}$$

$$\text{Ultimate pile cap design moment per meter of width (} B_y = 1 \text{ meter)}$$

$$\text{Pile cap design shear force, } V_{ur} = n_y \cdot P_{\max} - W_{us} = 1 \cdot 1787.14 - 11.78 = 1775.36 \text{ kN.}$$

$$\text{Ultimate shear force design per meter width (} V_u \text{)} = V_{ur} / B_y = 1775.36 / 1 = 177.36 \text{ kN.}$$

Pile Foundation Analysis Using Plaxis 2D V20 Program

PLAXIS 2D program analysis is a form of simulation of loading on pile foundations such as conditions in the field. Where in this laboratory building project using piles while researchers try to redesign with bored pile foundations with dimensions of 0.5 meters with a length of 22 m loaded by the main column above it of 1787.14 kN (ETABS results). The following are the stages in analyzing using the PLAXIS 2D v20 program.

1) Structural geometry modeling

Structural modeling involves the arrangement of piles and the distance between piles, with soil data obtained from the results of drilling tests at point H1 (BH 01). To model the foundation and pilecap structure, a plate material model is used, which is then applied to the specified nodes, with a foundation image up to a depth of 22 m and a diameter of 0.5 meters. In loading, point loads are used. The following is a modeling image using Plaxis 2D v.20.

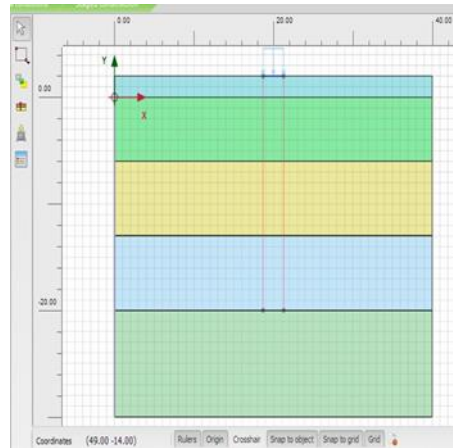


Figure 5. Soil Modeling, Pile Cap and Pile

2) Input data of materials used as follows

Soil parameters used for input of soil material and foundation structure in PLAXIS. The input process of soil material and structure can be done easily using the drag and drop method, namely by dragging soil material or structure directly into the structure profile or cluster.

3) Conducting loading analysis

The output of settlement results shows changes in height or movement of soil along a particular structure or area. This is important to assess soil deformation that may occur due to structural loads or environmental changes. The results of this settlement are usually presented in the form of graphs or numerical reports, allowing researchers to evaluate their impact on related structures. The following are the results of the loading calculation analysis in Plaxis 2D v.20.

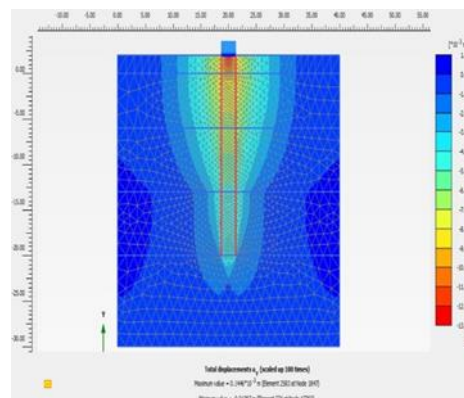


Figure 6. Loading Analysis Results

Based on Figure 6 above, the settlement generated by PLAXIS 2D shows a total settlement of 0.01287 meters.

4) Conducting loading analysis with safety factor

The safety factor measures the extent to which a structure or system is safe from failure. In the context of Plaxis 2D v20, the safety factor is generally used to assess the stability of retaining walls, foundations, or other geotechnical structures against various load and geotechnical conditions. A higher safety factor indicates that the structure is more stable and has a greater margin of safety against failure. The following are the results of the loading calculation analysis with the Safety factor in Plaxis 2D v.20

Name	Value
General	
Deformation control parameters	
Numerical control parameters	
Reached values	
Reached total time	0.000 day
CSP - Relative stiffness	1.041E-3
ForceX - Reached total force	0.000 kN
ForceY - Reached total force	0.000 kN
Pmax - Reached max pp	0.000 kN/m ²
ΣM _{stage} - Reached phase p	0.000
ΣM _{weight} - Reached weight	1.000
ΣM _{sf} - Reached safety fact	3.489

Figure 7. Safety Factor Value

- 5) Calculation of the bearing capacity of the pile foundation based on the results of the 2D Plaxis v.20 analysis

In addition to calculating the settlement of bored piles, the PLAXIS 2D program can also calculate the safety factor and bearing capacity of the pile foundation. Based on the analysis shown in Figure 7, the value of $\Sigma\text{-Msf} = 3.489$, which can be used to determine the ultimate bearing capacity of bored piles (Q_u) with the following equation:

$$Q_{all} = P_{all} = \frac{Q_u}{\Sigma\text{Msf}}$$

$$Q_u = P_{all} \times \Sigma\text{Msf} = 528,74 \cdot 3,489 = 1844,77 \text{ kN}$$

Based on the calculation above, the bearing capacity of the pile foundation based on the analysis on the Plaxis 2D v.20 software is 1844.77 kN.

Recapitulation of Pile Foundation Calculation Analysis

From the Analysis of the Calculation of the bearing capacity of piles with a diameter of 0.5 meters and a length of 22 meters using the Guy Sangrilat, Meyerhoff and Plaxis 2D Methods, it can be concluded as in the following table.

Table 4. Recapitulation of Pile Axial Bearing Capacity

Metode	Daya Dukung (kN)
<i>Guy Sangrelat</i>	2110
<i>Meyerhoff</i>	2020
<i>Plaxis 2D</i>	1845

From the calculation analysis, the estimated total settlement time lasted for 24,694 years, while the settlement of pile groups with a diameter of 0.5 meters and a length of 22 meters using the Guy Sangrilat, Meyerhoff and Plaxis 2D methods can be concluded as in the following table.

Table 5. Recapitulation of Pile Group Subsidence

Metode	<u>Penurunan</u> (Meter)
<u>Guy Sangrelat</u>	0,0224
<u>Meyerhoff</u>	0,0217
<u>Plaxis 2D</u>	0,0341

CONCLUSIONS

Based on the overall calculation of the bearing capacity and settlement of pile foundations in the construction of the PKK-Dekranasda building in Makassar City using the Guy Sangrilat and Meyerhoff methods and validated with PLAXIS 2D software. For the calculation of the bearing capacity of the pile foundation, the bearing capacity of the pile foundation using the Guy Sangrilat method is 2110 kN, while the bearing capacity of the pile foundation using the Meyerhoff method is 2020 kN, and the bearing capacity of the pile foundation using PLAXIS 2D v.20 software is 1845 kN, based on the results of the analysis of the bearing capacity of the pile foundation depending on the nature of cohesive clay soil. For pile foundation settlement, the analysis results show that pile foundation settlement using the Guy Sangrilat Method is 0.0224 meters, while pile foundation settlement using the Meyerhoff Method is 0.0217 meters, and pile foundation settlement using PLAXIS 2D v.20 Software is 0.0341 meters based on SNI 03-1726-2019, foundation settlement should not exceed 0.04 meters, and soil consolidation time with a foundation depth of 22 meters based on SNI 8460:2017 takes 24.694 years.

REFERENCES

- Rodji, A. P., Sihombing, S. M., & Ramadhan, M. R. (2022, May). Analisis Pondasi Bored Pile Pada Proyek Metrostater Depok Jawa Barat: Analisis Pondasi Bored Pile Pada Proyek Metrostater Depok Jawa Barat. In *FORUM MEKANIKA* (Vol. 11, No. 1, pp. 11-21).
- Lydia, D., Sahat, S., & Yonas, P. (2023). PENGARUH ELEKTROSMOSIS TERHADAP KUAT GESER TANAH LEMPUNG. *Konferensi Nasional Teknik Sipil (KoNTekS)*, 1(6).
- MEYERHOF, G. G. (1976). "Bearing Capacity and Settlement of Pile Foundations," *Journal of theGeotechnical Engineering Division, American Society of Civil Engineers*, Vol. 102, No. GT3,pp. 197–228
- Rumbyarso, Y. P. A. (2025). BUKU AJAR MEKANIKA BAHAN.
- Pribadi, G., & Rumbyarso, Y. P. A. (2023). Analisis Perbandingan Daya Dukung dan Penurunan Pondasi Tiang Bor Dengan Perhitungan Manual dan Software ALLPILE. *Jurnal TESLINK: Teknik Sipil Dan Lingkungan*, 5(2), 16-20.
- Hardiyatmo, H.C. (2003). "Mekanika Tanah II", Gadjah Mada University Press, Yogyakarta