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FIVE-STOREY BUILDING FOUNDATION PLANNING : BANJARMASIN CUSTOMS REGIONAL OFFICE

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ABSTRACT

The Customs Regional Office in Banjarmasin City functions as an institution responsible for the supervision of goods entering and leaving a country, especially the South Kalimantan region. In connection with the rapid development of goods entering and leaving the South Kalimantan region, the customs needs a new office in a new location.

The planning method is carried out by referring to soil investigation data at the project site, including the results of SPT *(Standard Penetration Test)* and other soil parameters. The analysis includes the calculation of axial and lateral bearing capacity, as well as the evaluation of the capacity of the pole group based on SNI and relevant geotechnical theories, as well as the calculation of safety factors for the workload.

From the results of the calculations, the design of the building foundation was obtained using precast concrete piles with a cross-section of 40 × 40 cm with a depth of 40 m. Based on the results of the analysis, the pile has an axial bearing capacity of 988.167 kN and a lateral bearing capacity of 61.391 kN.

Keywords: Piling, Soft Soil, Carrying Capacity, Tax Return, Foundation Planning.

ABSTRACT

The Regional Customs Office in Banjarmasin functions as an institution responsible for monitoring the movement of goods entering and exiting the country, particularly in the South Kalimantan region. Due to the increasing volume of goods traffic in the region, the customs authority requires a new office at a different location.

The foundation design method refers to the soil investigation data at the project site, including the results of the Standard Penetration Test (SPT) and other soil parameters. The analysis includes calculations of axial and lateral bearing capacity, evaluation of pile group capacity based on Indonesian National Standards (SNI), and the calculation of safety factors against working loads.

Based on the calculations, the building foundation is designed using precast concrete pile foundations with a cross-section of 40 × 40 cm and a depth of 40 meters. The analysis results show that the pile has an axial bearing capacity of 988.167 kN and a lateral bearing capacity of 61.391 kN.

Keywords: Pile Foundation, Soft Soil, Bearing Capacity, SPT, Foundation Design.
Keywords:

1. INTRODUCTION

The condition of the soil that a building bears affects how it stands. In a development, the land must receive special attention. Soil conditions also affect the type of foundation used in the building. If the depth of the soil capable of supporting the building is greater than the width of the foundation, a shallow (direct) foundation cannot be used on the building and a deep foundation calculation must be performed.

In connection with the rapid development of goods entering and leaving the South Kalimantan region, the customs needs a new office in a new location. The land where this new office is built has soft soil characteristics based on the results of soil investigations at the location. Therefore, foundation planning should take into account the thickness of the soft soil and the depth of the hard soil.

Foundation planning must consider the type of top structure to be built, such as columns, beams, and floor plates, in order to ensure that the foundation can safely and efficiently distribute these loads to the ground (Zamroni, 2023).

2. THEORETICAL FOUNDATION

Building Load

In foundation planning, the load that is taken into account includes dead load, live load, and wind load. Dead load is the permanent weight of all structural and non-structural components of a building, calculated based on the type of material and dimensions of building elements according to SNI 03-1727-1989. Living load is a variable load that can change over time and location, and must be taken into account to ensure the stability of the foundation, referring to SNI 1727-2020. Meanwhile, wind load as a lateral force that works on buildings, especially in high-rise buildings, is designed based on SNI 1727-2013 so that the foundation is able to safely channel these forces to the ground.

Pile Foundation

Pile foundation is a type of deep foundation that is commonly used for multi-storey buildings on less stable ground or when hard soil is at great depths. The planning requires a thorough analysis of the bearing capacity of the poles, which can be tested through Static Load Test (SLT) or Dynamic Load Test (DLT) to ensure the ability of the pole to deliver the load to the strong ground below.

Pile Support Capacity

The bearing capacity of piles is an important aspect in geotechnical engineering, which affects the stability and safety of building structures. Various studies have shown that the characteristics and design of piles can significantly affect their carrying capacity (Wang et al., 2022).

Allowable Drops

The decline of a building is influenced by the type, height, rigidity, and function of the structure, as well as the size and distribution of its decline. Slow decline allows the structure to adjust without damage, so the decline criteria differ between sandy soil and clay soil. Based on SNI 8460-2017 Article 9.2.4.3, the allowable descent is < 15 cm + b/600 (b in cm), and the difference in differential settlement must be ≤ 1/300 so that the structure remains safe and functions as planned.

3. METHOD

Foundation planning was carried out for the five-storey building of the Customs Regional Office in Banjarmasin, based on soil data from the Tax Return from Somif Borneo Perkasa which showed soft soil with a hard layer at a depth of ±40 meters. The analysis of the upper structure was carried out with SAP2000 to obtain the forces on the columns, which were then used as the basis for the pile planning. The pile capacity was calculated using the Meyerhof and Luciano Decourt & Quaresma methods, and was evaluated against dropping, lateral force (Broms method), group efficiency, and pile cap design so that the foundation could safely withstand the load of the structure.

4. RESULTS AND DISCUSSION

Single Pole Bearing Capacity

The calculation of the carrying capacity of the foundation is determined based on the results of N-SPT data. The method used in this calculation is the method of Meyerhof and Luciano Decourt. N-SPT data can be seen in the table below.

N-SPT data table

Depth	Layer Thickness	Soil Description	NSPT
0 - 20	20	Grey spider	0
20 - 25	5	Clayey grey marsh	7

25 - 28	3	Sandy gray clay	9
28 - 32	4	Gray clay	38
32 - 34	2	Coastal gray clay	60
34 - 38	4	Grey fine sand	54
38 - 40	2	Grey fine sand	60
40 - 46	6	Fine to coarse clayy sand	60

Planning Data

Pile data:

Dimension = 40/40 cm

Cross-sectional Area (Ap) = W x W = 1600 cm2

Circumference (K) = 4 x W = 160 cm

Depth (Z) = 4000 cm

Pole Blanket Area (As) = K x Z = 640000 cm2

Forces That Occur on the Pole

The maximum axial force that occurs in each type of Pile Cap is:

Type PC-1 = 740.455 kN

PC-4 type = 3081.23 kN

PC-6 type = 4102.97 kN

PC-9 type = 5663.96 kN

PC-12 type = 6626.26 kN

Axial Bearing Capacity Calculation of Mayerhof Method 1956

$$Qult = Qb + Qs$$

$$Qult = 40 . Nb. Ap + 0.2 . N. As$$

where:

Qult (tone)

Nb : Tax return value at the base elevation of the pole

Ns : Average N-SPT value along the pole

Ap : Cross-sectional area of the base of the pole (m^2)

Axle : Pole blanket area (m^2)

- Calculation of Pole End Bearing Capacity (Qb)

End-Bearing (Nb)

4D = 4 (0.5) = 2m (taken 2m down)

8D = 8 (0.5) = 4m (taken 4m and above)

N1 : 32

N2 : 14

N3 : 39

The end resistance is calculated using :

$$\text{Nb} = \frac{(N1+N2+N3)}{3} = 28{,}333 \text{ m}$$

$$\text{Qb ultimit} = 40\ x\ N\ x\ Ap = 181{,}333 \text{ tons}$$

- Calculation of the bearing capacity of the pole blanket

The blanket resistance along the pole is calculated using :

$$\text{Nfriksi } (\overline{Nc}) = \frac{1+1+1+1+1+1+1+1+1+1+1+1+3+6+5+8+8+31+34+14+31+39}{20}$$

$$\text{Nfriksi } (\overline{Nc}) = 9{,}450 \text{ m}$$

$$\text{Qs ultimit} = 0{,}2\ x\ N\ x\ As$$

$$\text{Qs ultimit} = 120{,}96 \text{ ton}$$

- Ultimate bearing capacity (Qu)

$$\text{Qult} = Qb\ ult + Qs\ ult$$

Qult= + = 302,293 tons181,333 120,96

Permit Carrying Capacity (Qizin)

$$Q_{izin} = \frac{Q_{ult}}{SF} = 100{,}764 \text{ tons} \frac{302{,}293}{3}$$

Pole Configuration

$$P_{max} = \frac{Pu}{n\ tiang} \pm \frac{My.X_{max}}{nx.\sum x^2} \pm \frac{Mx.Y_{max}}{ny.\sum y^2}$$

An example of PC-4 calculation is as follows:

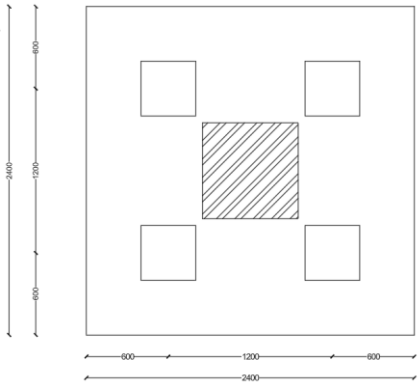
Qizin : 988,167 kN

The load used is taken from the largest axial force of all PC-4 type foundations, i.e. point 51 foundations.

Fz : 3081.23 kN

Mx record : 62.66 kN

My - -290.221 kN



PC-4 Type Pole Configuration Picture

The data on the pile arrangement can be seen in the table below.

PC-4 type foundation pile arrangement table

X-direction pile arrangement				X-direction pile arrangement			
Yes	n	x	n*x2	and	n	y	n*y2
1	2	0.6	0.72	1	2	0.6	0.72
2	2	-0.6	0.72	2	2	-0.6	0.72
n	4	$\sum x^2$	0.72	n	4	$\sum y^2$	0.719681

P-4 foundation load distribution table

Post	x(m)	y(m)	P
1	-0.6	-0.6	865.1211
2	0.6	-0.6	623.2703
3	-0.6	0.6	917.3422
4	0.6	0.6	675.4914
			3081.225

Ultimate load working on pole number 3 :

$P_{max} = \frac{Pu}{n\ tiang} \pm \frac{My.X_{max}}{nx.\sum x^2} \pm \frac{Mx.Y_{max}}{ny.\sum y^2}$ = 917,342 kN

Control: Qizin > Pmax

988,167 kN > 917,342 kN Aman.

The next calculation can be seen in the Table below.

Maximum Load Table of Pole Configuration

Type	Multiple Pillars	Pmax	Qizin	Control

PC-1	1	450.797	988.167	SAFE
PC-4	4	917.342	988.167	SAFE
PC-6	6	794.088	988.167	SAFE
PC-9	9	691.051	988.167	SAFE
PC-12	12	576.584	988.167	SAFE

Calculation of Lateral Bearing Capacity by Broms Method (1964)

- Planning Data :

  Pole diameter (d) = 0.4 m

  Pole length (L) = 40 m

  SF (Safety Factor) = 2.5

  Concrete quality (fc') = 30 Mpa

  = 305.92 kg/cm2

  Distance of lateral load to land level (e) = 0 m

  Elastic modulus of pole (Ep) $= 4700.\sqrt{30}$

  = 25742.96 Mpa

  = 262506.11 kg/cm2

  Pole cross-sectional moment of inertia (Ip) $= \frac{1}{12}.b.h^3$

  $= \frac{1}{12}.0{,}4.0{,}4^3$

  = 213333.33 cm4

Terzaghi Subgrade Modulus Table

Konsistensi	Kaku	Sangat kaku	Keras
kohesi undrained c_u			
kN/m^2	100-200	200-400	>400
kg/cm^2	1 – 2	2 - 4	>4
k_1			
MN/m^3	18 – 36	36 -72	>72
kg/cm^3	1,80 - 3,60	3,60 - 7,20	>7,2
k_1 direkomendasikan			
MN/m^3	27	54	>108
kg/cm^3	2,70	5,40	>10,80

$K_h = \frac{k1}{1{,}5}$ = 72 kg/cm2

Pole Deflection Coefficient $\beta = \frac{kh\,.D}{\sqrt[4]{4.Ep.Ip}} = 0{,}00423$

The criteria for the type of pole are obtained, namely:

$\beta . L = 0{,}00423 . 4000 = 16{,}937$ ..... (β . L > 2.5 poles including long pole type)

Nominal lateral housing of pole (H) :

Hn $= \frac{y_0 . kh . D}{4.\beta(e.\beta.1)} = 4532.739$ kN

Lateral pole housing:

Hn . = 4532,739 . 0.0135 kN = 61.391 kN = 6.26 tonsϕ

Maximum lateral force :

The maximum moment force is taken, which is at point 60 :

Because at point 60 60 piles are needed, the maximum moment force is divided by 6.

hmax = tone$\sqrt{hux^2 + huy^2} = \sqrt{-5{,}61^2 + -0{,}33^2} = 5{,}62$

Lateral force control:

hu max Hn . ≤ ϕ

5.62 ton 6.26 ton ... safe.≤

The next calculation can be seen in the Table below.

Table of Maximum Lateral Forces of Each Type of Pile Cap

Immediate Decline

$$S_i = \frac{q.B}{E}(1 - \mu^2)I_p$$

Gasket	Fx	Fy	Number of posts	Lateral Detention	Combination Lateral Style	Control
239	-29.13	-32.024	1	61.39138465	43.29080129	SAFE
51	-135.5	172.427	4	61.39138465	54.82356094	SAFE
60	-330.16	-19.394	6	61.39138465	55.12152051	SAFE
54	-174.26	144.472	9	61.39138465	25.15107596	SAFE
36	-190.74	-40.488	12	61.39138465	16.24915078	SAFE

Where:

The = immediate decline

q = pressure on the foundation base

B = width of the foundation

E = Elastic modulus of sandy clay soil: 30000-42500 kN/m2. (Hardiyatmo, 2010)

μ = Poisson number of sandy clay: 0.2 – 0.3. (Terzaghi, 1943 in

Hardiyatmo, 2010)

Ip = Influence factor Rectangular foundation: 0.82

Foundation influence factor (L/B = 1.5): 1.06

The following is an example of the calculation at point 33

Calculating voltage :

$q = \frac{Q}{L.B}$ = 302.95

Calculate the immediate decrease :

$Si = \frac{q.B}{E}(1-\mu^2)Ip$ = 0.0348 m

Limit of downgrade permits:

The decrease occurred < 15 cm + W / 600 (SNI 8460 – 2017)

0.0348 m < 0.15 + 3.6/600

0.0348 m < 0.156 m ... Safe.

(Terzaghi, 1943 in Hardiyatmo, 2010)

The calculation of the decrease at other points can be seen in the Table below

Maximum Immediate Drop Table for Each Pile Cap Type

Point	Q(kN)	L (m)	B (m)	The	Permit Limits	Check the Permit Limit (Si < Permit Limit)
21	740.455	1.2	1.2	0.01989	0.152	SAFE
12	2589.69	2.4	2.4	0.03479	0.154	SAFE
60	4102.97	3.6	2.4	0.03638	0.154	SAFE
54	5663.96	3.6	3.6	0.05072	0.156	SAFE
36	6626.26	4.8	3.6	0.04406	0.156	SAFE

5. CONCLUSION

The results of the foundation planning for the five-storey building of the Banjarmasin Customs Regional Office show that the 40×40 cm and 40 m long precast concrete piles are able to safely withstand the load of the structure. The axial bearing capacity of 988.167 kN of the Meyerhof method (1956) and the lateral bearing capacity of 61.391 kN of the Broms method (1964) are qualified for the load of the upper structure. The maximum decrease of 0.05072 m was also within the tolerance limit of

SNI 8460:2017. Thus, the designed foundation can withstand vertical, lateral, and subsidence loads that occur in soft soil conditions.

REFERENCES

Adib Zamroni, Muhammad, Yusuf Arif Windarto, Trias Widorini, and Ngudi Hari Crista. 2023. "P Structural Planning of Lecture Buildings and 7-Story Halls." *Journal of Civil Engineering Study* 3(02): 71–79. doi:10.34001/ces.v3i02.723.

Wang, Xiaolei, Zeyuan Wang, Changfeng Yuan, and Libo Liu. 2022. "Study on the Horizontal Bearing Characteristic of a New Type of Offshore Rubber Airbag Branch Pile." *Sustainability (Switzerland)* 14(12). doi:10.3390/su14127331.