

## Study on Calculation of Foundation Strength Structure of STAIN College Building, Sultan Abdulrahman, Bintan Islands

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### Abstract

Based on the results of the analysis obtained 1). Axial force on F 1 Single Pile pile  $1178.91 \leq 1200.00$ . And the lateral force on the pile obtained  $14.51 \leq 24.88$  2). Axial force on piles F 1 Single Pile Axial force on piles  $275.13 \leq 400.00$ . And the lateral force on the pile obtained  $0.62 \leq 17.77$ . The difference between the two F1 Single Piles lies in the axial force of the column due to factored load,  $P_{uk} = 1116.13 \text{ Kn}$ , x-direction moment due to factored load.  $M_{ux} = 18.85 \text{ kNm}$ , Y direction moment due to factored load.  $M_{uy} = 29.85 \text{ kNm}$ , And the other F1 Single Pile data: Column axial force due to factored load,  $P_{uk} = 247.02 \text{ Kn}$ , Moment x direction due to factored load.  $M_{ux} = 0.00 \text{ kNm}$ . The y-direction moment due to factored load.  $M_{uy} = 0.00 \text{ kNm}$ , and the axial force on the pile F2 is  $648.29 \leq 1200.00$ . And the lateral force on the pile is  $4.27 \leq 24.88$ . Thus, the construction is safe on the axial force on the pile and the lateral force on the pile. And F1 Single Pile remains safe even though the moment of direction due to different factors. Due to the location of the design F1 Single Pile.

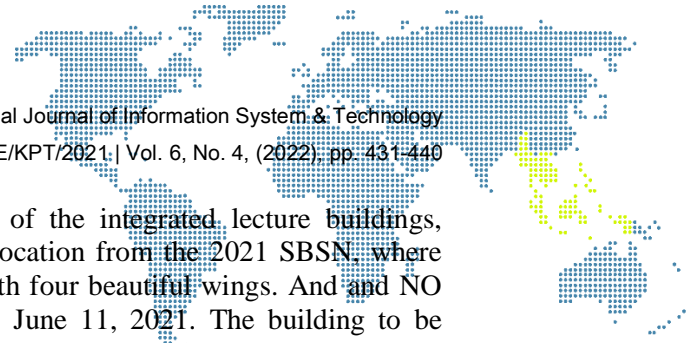
**Keywords:** Sondir, Pile, Axial Force.

### 1. Introduction

Bintan Island is an island in the Riau Archipelago province, where there is Tanjungpinang City, the capital of the Riau Archipelago Province. This island has three governments, the Tanjungpinang City Government located in Senggarang, the Bintan Regency Government located in Bandar Seri Bintan, and the Riau Islands Province Government on Dompok Island (Tanjungpinang). This island is adjacent to Singapore.

Bintan is the largest island in the Riau Archipelago, consisting of nearly 3,000 large and small islands, stretching across Singapore and Johor Baru, Malaysia. The island extends from Malacca to the North Natuna Sea. Tanjungpinang is the capital city of this province, located on the south west coast of Bintan. Strategically located on the southern peninsula of Malaysia at the mouth of the Straits of Malacca, the Riau archipelago, once in the first century AD, was a favorite place for Indian and Chinese merchant ships.

In 2011 the Bintan area was built the Sultan Abdulrahman State Islamic College (STAIN) precisely in Tembeling Tanjung District, Teluk Bintan. In 2011 the Bintan area was built the Sultan Abdulrahman State Islamic College (STAIN) precisely in Tembeling Tanjung District, Teluk Bintan. This is evidenced by the issuance of the Decree of the Regional Head of the Ministry of Religion and the Decree of the Riau Islands Provincial



Government Number 139 of 2009. SBSN is one of the integrated lecture buildings, STAIN Kepri which gets a development budget allocation from the 2021 SBSN, where the building is designed like a bee's wing paired with four beautiful wings. And and NO SPK INITIAL B~1003/Sti.20/1.1/KS.01.1/06/2021, June 11, 2021. The building to be built is the first of the four wings planned by the STAIN Establishment Management Agency. comes from several lecturers of Islamic universities in Riau Islands. The main target is that in the Riau Islands region there will be a state Islamic religious university, so that in the future it may develop into an IAIN (State Islamic Religion Institute) and even an Islamic State University. Whether this load will be supported by the upper structure and distributed to the lower structure related to soil conditions. Soil as a support for the building must be known by soil testing. Sondir soil testing describes the bearing capacity of the soil and the variables supporting the soil to determine the dimensions of the substructure to the load owned by the building. Structural calculation is a calculation to analyze the loads that work on the building or that affect the stability of the building and produce output in the form of structural dimension requirements, both dimensions of beams, columns, foundations, concrete slab thickness, reinforcement requirements, position of column points, beam grids, and foundation points so that whether it is necessary to use a footing or pile foundation, as well as an effective foundation depth, in the hope of producing a strong, safe, and economical structural design. Building structures without proper calculations will result in wasted costs because the dimensions of the building structure are too large. But what is more dangerous is the weakness of the building against the loads force on the building. Not calculating budgets, work methods and only using soil investigations with sondir

## 2. Research Methodology

### 2.1. Sondir

Sondir test is a penetration test that aims to determine the bearing capacity of the soil in each layer and to determine the depth of the supporting layer, i.e. the hard soil layer. This is intended so that in designing the foundation which will be used as a support for the column of the building above it has a high safety factor so that the building above it remains strong and does not experience settlement or settlement that can endanger the safety of the building and the occupants in it.

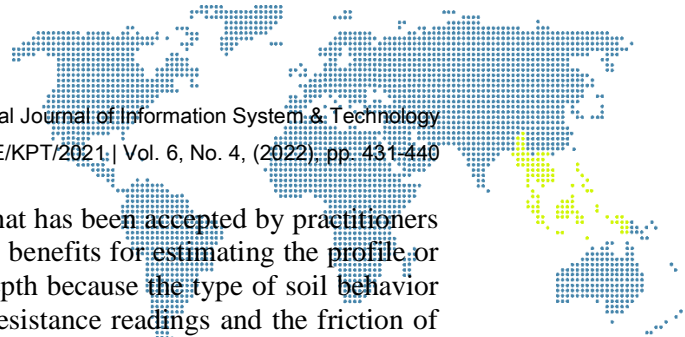
There are many structural failures (collapsed buildings) due to this Soil Test, for that it is recommended to Undertake this soil test, so that a safe and effective type of foundation can be designed according to the soil characteristics of the building to be built.

Sondir is a cylindrical tool with a conical tip. Usually used is a bi-conus Begemann type equipped with a blanket/jacket to measure local adhesive resistance (side friction) with the following dimensions:

- a) Conus angle: 60'
- b) Conus cross-sectional area: 10.00 cm<sup>2</sup>
- c) Blanket/jacket area: 150 cm<sup>2</sup>.

In the sondir test, the handlebar of this tool is pressed into the ground and then the resistance of the soil to the end of the sondir (end resistance) and the friction in the cylinder blanket (cover) is measured. This tool has long been in Indonesia and has been used in almost every soil investigation in civil engineering work because it is relatively easy to use, fast and very economical.

Sondir test tool is a representation or model of a pile foundation on a small scale. The technique of trial location or depth of hard soil with a rod has long been practiced since ancient times. An early version of this trial technique was developed in Sweden in 1917 by Swedish State Railways and later by Danish Railways in 1927. Due to the soft soil conditions and many trials of pile foundations, in 1934 the Dutch introduced the sondir device as we know it. know now [1].



The sondir test is currently one of the field tests that has been accepted by practitioners and geotechnical experts. This sondir test has shown benefits for estimating the profile or layering (stratification) of the soil with respect to depth because the type of soil behavior can be identified from the combination of the end resistance readings and the friction of the blanket. The important quantity measured in the sondir test is the tip resistance which is taken as the penetration force per unit cross-sectional area of the sondir tip ( $q_c$ ). The magnitude of this force often indicates the identification of the soil type and its consistency. In sandy soils, the tip resistance is much greater than in fine-grained soils. Use the formula:

The basic principle of the static penetration test in the field is the assumption that the law of action and reaction applies, as used for the calculation of cone resistance and shear resistance values below.

**a) Conus Resistance ( $q_c$ )**

The value of the cone resistance ( $q_c$ ) with only the tip of the cone being pushed, is calculated using the equation:

$$P_{konus} = P_{piston}$$

$$q_c \times A_c = C_w \times A_{pi} \tag{1}$$

$$q_c = C_w \times A_{pi} / A_c \tag{2}$$

$$A_{pi} = \pi (D_{pi})^2 / 4 \tag{3}$$

$$A_c = \pi (D_c)^2 / 4 \tag{4}$$

**b) Slide Resistance ( $f_s$ )**

The value of the local shear resistance is obtained when the cone tip and the shear plane are pushed together, and is calculated using the equation

$$P_{konus} + P_{geser} = P_{piston} \tag{5}$$

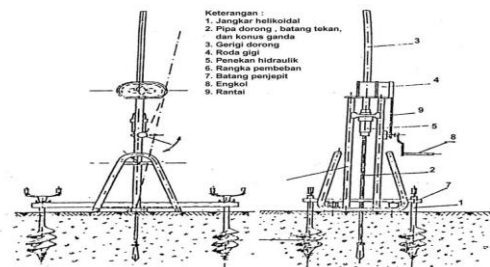
$$(q_c \times A_c) + (f_s \times A_s) = T_w \times A_{pi}$$

$$(C_w \times A_{pi}) + (f_s \times A_s) = T_w \times A_{pi}$$

$$f_s = K_w \times A_{pi} / A_s \tag{6}$$

$$A_s = \pi D_s L_s \tag{7}$$

$$K_w = (T_w - C_w) \tag{8}$$



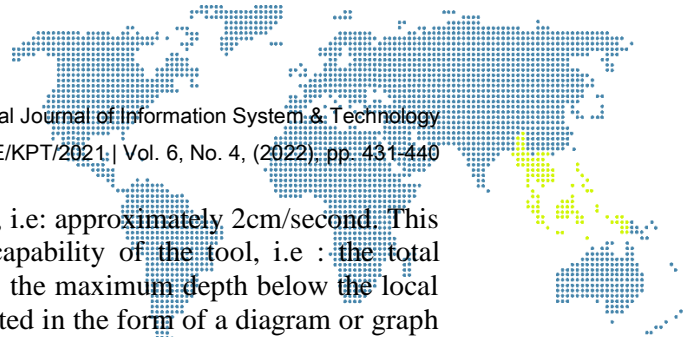
**Figure 1.** Cone penetration tool series (sondir Belanda)

**2.2. Bearing Capacity Connection with Sondir Data ( $q_c$ )**

The Connection between cone resistance ( $q_c$ ) and soil consistency is as follows:

- a) very soft soil value  $q_c < 5 \text{ kg/cm}^2$ ,
- b) soft 5-10  $\text{kg/cm}^2$ ,
- c) solid 10-20  $\text{kg/cm}^2$ ,
- d) chewy 20-40  $\text{kg/cm}^2$ ,
- e) very chewy 40-80  $\text{kg/cm}^2$ ,
- f) hard 80-150  $\text{kg/cm}^2$ , dan
- g) very hard  $> 150 \text{ kg/cm}^2$ .

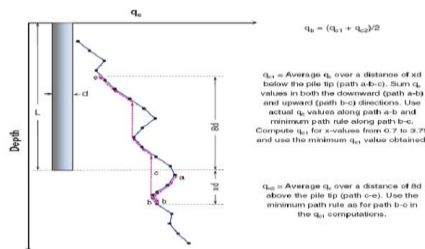
The implementation of this sondir test refers to the ASTM.D.3441 procedure, where the value of the conus resistance ( $q_c$ ) and the value of local adhesive resistance or side friction ( $f_s$ ) are observed every 20 cm depth interval with the penetration speed when



reading the values of  $q_c$  and  $f_s$ , trying to be constant, i.e: approximately 2cm/second. This test is undertaken until it reaches the maximum capability of the tool, i.e : the total pressure value or  $q_c = 250\text{kg/cm}^2$  or until it reaches the maximum depth below the local soil surface. The results of this sondir test are presented in the form of a diagram or graph of the connection between depth and  $q_c$ ,  $f_s$ , total friction and friction ratio.

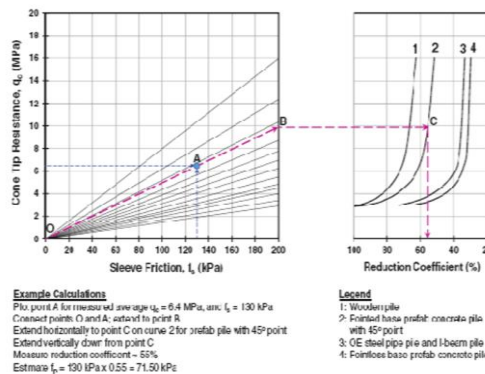
### 2.3. Begemann Method (1963, 1965)

Begemann (1963, 1965) suggested that  $q_b$  for piles with a base located on two different soil types is the average  $q_c$  of the two soil layers, and it can be concluded that the soil above and below the pile contributes almost the same as the pile  $q_b$ . Begemann suggested that it is usual to take the average  $q_c$  from the pile tip to the top as far as  $8D$  and for the bottom layer  $3.5D$  below the pile tip. Nottingham (1975) mentions that this method is more refined to account for the presence of thin layers or zones of soft soil (Figure 2).



**Figure 2.** Procedure for predicting  $q_b$  Begemann method (Source: Begemann 1963)

Begemann (1965, 1969) developed a curve to predict the frictional capacity of the pile based on the measurement of the load test results and the CPT measurement of the adhesion penetrometer. The curve can be seen in Figure 2.3

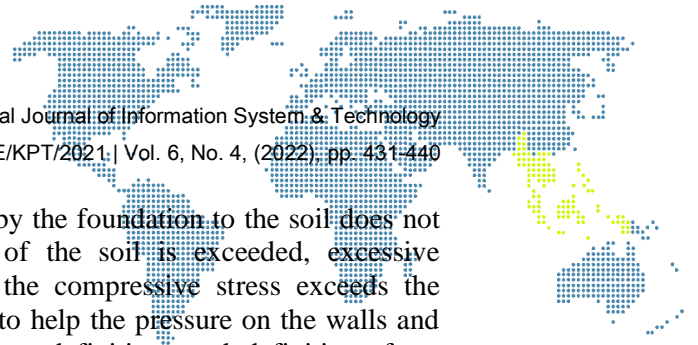


**Figure 3.** Graph of the Begemann Method for predicting  $f_p$  (Source: Begemann 1965)

### 2.4. Foundation

The foundation is part of a sub-structure system that supports its own weight and all the force loads from the superstructure, then distribute it to the soil and rock layers below it. The load from the column acting on this foundation must be spread over a large enough surface area so that the soil can carry the load safely.

The foundation is part of an engineering system that distribute the load supported by the foundation and its own weight into the soil and rock that lies below it. The construction of the building foundation must be taken into account and ensure the stability of the building against its own weight, useful loads and external forces, such as wind pressure, earthquakes and others, and there must be no localized settlement of the foundation or a uniform settlement of the foundation more than a certain limit.



A plan that is said to be correct if the load built by the foundation to the soil does not exceed the strength in question. If the strength of the soil is exceeded, excessive subsidence or collapse of the soil will occur. If the compressive stress exceeds the permissible pressure, it can use the help of the pile to help the pressure on the walls and columns in the building structure. The following are definitions and definitions from several book sources:

According to Sardjono (1988), the foundation is one of the constructions located at the bottom of a construction, a foundation that has an important role in a building, which builds all construction loads on top of the soil layer at the bottom.

According to Gunawan (1991), the foundation is a part of the construction that puts and puts the load on the superstructure to the soil which is strong enough to support it.

According to Hardiyatmo (2002), the foundation is the lowest structural component of the building above the building to the soil or rock beneath it.

Designing must be based on several aspects, among others; the function of the building, the type of soil, the depth of the hard soil supporting the foundation, as well as from the cost (financial) aspect. The explanation of each foundation selection is as follows:

- a) The condition of the foundation soil. The state of the soil under the foundation of the findings with the type of foundation. This is because each type of foundation has a different shape and load transportation depending on the soil conditions. Factors taken into account include soil type, soil parameters, bearing capacity, hard soil depth and so on.
- b) Limitations due to the structure above it. The load conditions of the superstructure can include the total load due to the superstructure, the direction of the load forces, both vertical and horizontal loads and the distribution of loads and the dynamic properties of the structure.
- c) Limitations of the surrounding environment. The environmental constraints referred to in this point are the environmental conditions surrounding the project. Because in undertaking a development, it is expected that it is necessary to pay attention to the conditions of the surrounding environment, so that in undertaking building work it does not disturb and endanger the surrounding environment or buildings that already exist in the vicinity.
- d) Cost and time of work. The cost and time of undertaking the work need to be considered because it is included in the management of a building and is closely related to the right and economical condition factors.

### **3. Results and Discussion**

#### **3.1. Foundation Designing**

Undertaken the calculation of the bearing capacity of a foundation structure and the strength of the material. For the bearing capacity aspect, calculations were undertaken based on the results of soil investigation tests in the field, namely Sondir / Dutch Cone Penetration.

Based on the conditions in the site and the results of soil tests obtained, it is determined that the foundation system used was the deep foundation system in the form of square piles measuring 30x30 cm in the column structure K1 and K2, and square piles measuring 25x25 for column K3 with a minimum concrete quality of K-300. / $f_c$  25 MPa.



Figure 1. Foundation Design

### 3.2. Calculation of Foundation Strength

#### a) Soil Data

Table 1. Soil Data

No	Test Result Data		Sondir	
	Depth z <sub>1</sub> (m)	z <sub>2</sub> (m)	q <sub>r</sub> (kN/m)	q <sub>c</sub> (kN/m <sup>2</sup> )
1	0.00	2.00	53.94	1471.00
2	2.00	4.00	137.29	6374.32
3	4.00	6.00	147.10	3922.66
4	6.00	8.00	171.62	7845.32
5	8.00	10.00	58.84	11767.98

#### b) Material Data

Table 2. Material Data

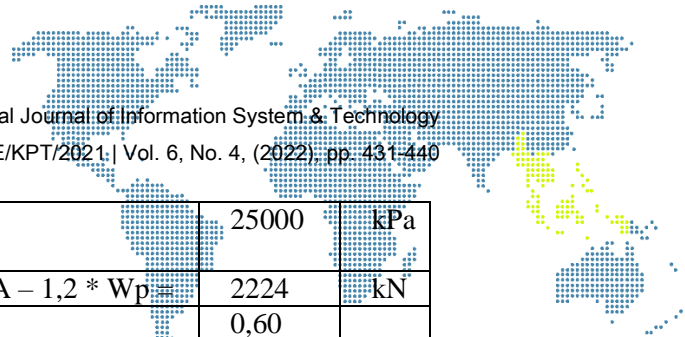
Pile type: Reinforced concrete circle			
Pile dimension size	S =	0,30	M
Pile length	L =	10,00	M
The compressive strength of the concrete pile	f <sup>'</sup> c =	25	Mpa
The weight of reinforcing concrete	W <sub>c</sub> =	24	kN/m <sup>3</sup>

### 3.2. Axial Resistance of Piles

#### a) Based on Material Strength

Table 1. Material strength

Pile cross-sectional area	A =	0,0900	m <sup>2</sup>
Pile weight	W <sub>p</sub> = A * L * W <sub>c</sub> =	21,60	kN



The compressive strength of the concrete pile	$f'c =$	25000	kPa
Pile nominal bearing capacity	$P_n = f'c * A - 1,2 * W_p =$	2224	kN
Strength reduction factor	$f =$	0,60	
Resistance of pile action	$f * P_n =$	1334,45	kN

### b) Based on Sondir Test Results (Bagemann)

#### 1) Edge Resistance

The nominal end resistance is calculated by the formula

$$P_b = w * A_b * q_c \quad (9)$$

$w$  = reduction factor of nominal end resistance value of pile

$A_b$  = area of the bottom end of the pile ( $m^2$ )

$q_c$  = static cone penetration resistance which is the average value 8.D on the base of the pillar until 4.D under the base of the pile ( $kN/m^2$ ).

#### 2) Friction Resistance

**Table 4.** Friction resistance

No.	Depth		$L_1$ (m)	$A_s$ ( $m^2$ )	$q_f$ ( $kN/m^2$ )	$P_s$ (kN)
	$z_1$ (m)	$z_2$ (m)				
1	0,00	2,00	2,00	2,4000	53,94	129,45
2	2,00	4,00	2,00	2,4000	137,29	329,50
3	4,00	6,00	2,00	2,4000	147,10	353,04
4	6,00	8,00	2,00	2,4000	171,62	411,88
5	8,00	10,00	2,00	2,4000	58,84	141,22
$P_s = S [ A_s * q_f ] =$						1365,09

The nominal frictional resistance according to Skempton is calculated by the formula:

$A_f$  = Surface area of the pile wall segment ( $m^2$ ).

$q_f$  = average static cone frictional resistance ( $kN/m$ ).

#### 3) Pile axial resistance

Nominal pile resistance,	$P_n = P_b + P_s =$	201353	kN
Strength reduction factor	$f =$	0,60	
Pile axial resistance	$f * P_n =$	1208,12	kN

#### 4) Pile Calculation

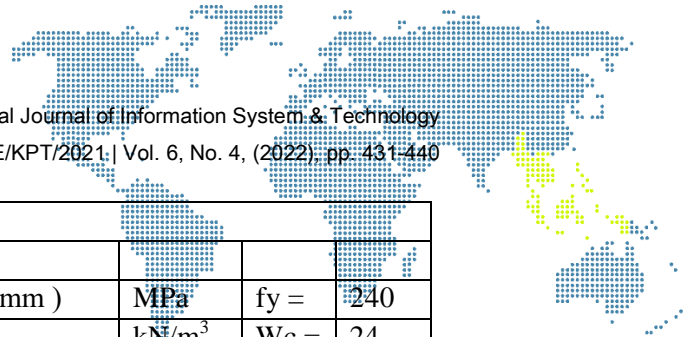
**Table 2.** Pile calculation

No.	Description of axial resistance of piles	$f * P_n$	
1	Based on the strength of the material	1334,45	
2	Based on the results of sondir test (Bagemann)	1208,12	
Smallest axial bearing capacity		$f * P_n =$	1208,12 kN
Take the axial resistance of the pile		$f * P_n =$	1200,00 kN

### 3.3. Calculation of Strength (foundation code = F 1 Single Pile )

**Table 3.** Pilecap Material Data And Foundation Dimension Data (F1)

Pile Cap Material Data			
Concrete compressive strength	MPa	$f'c =$	20
Yield strength of deformed reinforcing steel ( $\varnothing > 12$ )	MPa	$f_y =$	360



<b>Pile Cap Material Data</b>			
mm)			
Yield strength of plain reinforcing steel ( $\varnothing \leq 12$ mm )	MPa	$f_y =$	240
The weight of reinforcing concrete	$\text{kN/m}^3$	$W_c =$	24
Pile cap width	m	$s =$	1,00
<b>Data Dimensi Fondasi Foundation Dimension Data</b>			
X direction column width,	m	$b_x =$	0,50
Y direction column width,	m	$b_y =$	0,50
The distance between the edge of the pile and the outside of the concrete,	m	$a =$	0,35
Pile cap thickness	m	$h =$	0,40
The thickness of the soil above the pile cap	m	$z =$	1,50
The weight of the soil volume above the pile cap	$\text{kN/m}^3$	$W_s =$	18,00
Column position (in =40, edge i = 30, angle = 20)		$a_s =$	40

**Table 4.** Data beban fondasi (F1)

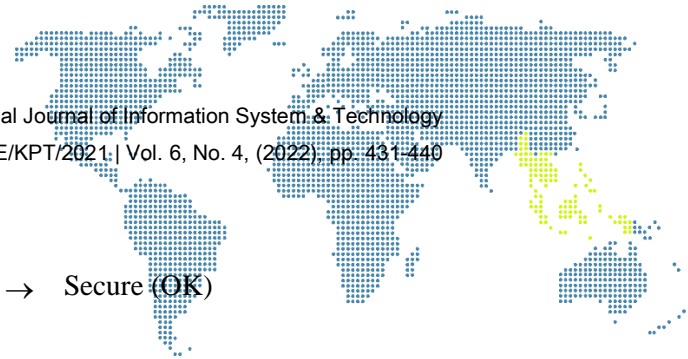
<b>Foundation Load Data</b>			
Column axial force due to factored load,	$P_{UK}$	1116,13	kN
X-direction moment due to factored load	$M_{UX}$	18,85	kNm
The y-direction moment due to factored load,	$M_{UY}$	29,85	kNm
X-direction lateral force due to factored load,	$H_{UX}$	12,20	kN
The y-direction lateral force due to factored load,	$H_{UY}$	7,85	kN
Pile axial resistance,	$f * P_n$	1200,00	kN
Pile lateral resistance,	$f * H_n$	24,88	kN
Width of pile cap in x direction,	$L_x$	1,00	m
The width of the pile cap in the y direction,	$L_y$	1,00	m

**a) Axial force on pile**

The weight of the soil above the pile cap,		27,00	kN
Pile cap weight,	$W_c = L_x * L_y * h * w_c =$	9,60	kN
The total factored axial force,	$P_u = P_{uk} + 1,2 * W_s + 1,2 * W_c =$	1160,05	kN
Maximum arm of pile direction x to center,	$X_{max} =$	0,10	m
Minimum pile arm x direction to center,	$X_{min} =$	0,00	M
The maximum and minimum axial forces on the pile,			
$P_u \text{ max} =$	$P_u/n + M_{UX} =$	1178,91	kN
$P_u \text{ min} =$	$P_u/n + M_{UX} =$	1178,91	kN
Specification			
$P_u \text{ max} \leq f * P_n$			
1178,91 $\leq$ 1200,00			$\rightarrow$ Secure (OK)

**b) Lateral force on pile**

The x-direction lateral force on the pile,	$h_{ux} = H_{ux} / n =$	12,20	kN
The y-direction lateral force on the pile,	$h_{uy} = H_{uy} / n =$	7,85	kN
Two-way combined lateral force,	$h_{u_{max}} = O (h_{ux}^2 + h_{uy}^2) =$	14,51	kN



Specification  
 $hu_{\max} \leq f * Hn$   
 $14,51 \leq 24,88 \rightarrow \text{Secure (OK)}$

#### 4. Conclusion

Based on the results of the analysis obtained

- a) Axial force on F 1 Single Pile pile  $1178.91 \leq 1200.00$ . And on the lateral force on the pile obtained  $14.51 \leq 24.88$ . Axial force on piles F 1 Single Pile Axial force on piles  $275.13 \leq 400.00$ . And the lateral force on the pile obtained  $0.62 \leq 17.77$
- b) The difference between the two F1 Single Piles lies in the axial force of the column due to factored load,  
 $Puk = 1116.13 \text{ kN}$ , X-direction moment due to factored load.,  $Mux = 18.85 \text{ kNm}$   
 Y-direction moment due to factored load.,  $Muy = 29.85 \text{ kNm}$   
 X-direction lateral force due to factored load,  $Hux = 12.20 \text{ kN}$   
 The y-direction lateral force due to factored load,  $Huy = 7.85 \text{ kN}$   
 Axial resistance of piles,  $f * Pn = 1200.00 \text{ kN}$   
 Pile lateral resistance,  $f * Hn = 24.88 \text{ kN}$   
 Width of pilecap x direction,  $Lx = 1.00 \text{ m}$   
 Pilecap width in y direction,  $Ly = 1.00 \text{ m}$
- c) And another F1 Single Pile data:  
 Column axial force due to factored load,  $Puk = 247.02 \text{ kN}$   
 X-direction moment due to factored load,  $Mux = 0.00 \text{ kNm}$   
 Y-direction moment due to factored load.,  $Muy = 0.00 \text{ kNm}$   
 X-direction lateral force due to factored load,  $Hux = -0.15 \text{ kN}$   
 The y-direction lateral force due to factored load,  $Huy = 0.60 \text{ kN}$   
 pile axial resistance,  $f * Pn = 400.00 \text{ kN}$   
 pile lateral resistance,  $f * Hn = 17.77 \text{ kN}$   
 Width of pilecap x direction,  $Lx = 0.80 \text{ m}$   
 Pilecap width in y direction,  $Ly = 0.80 \text{ m}$
- d) The axial force on the pile F2 is  $648.29 \leq 1200.00$ . And Lateral force on pile  $4.27 \leq 24.88$   
 Thus, the construction is safe on the axial force on the pile and the lateral force on the pile.  
 Thus, the construction is safe on the axial force on the pile and the lateral force on the pile. And F1 Single Pile remains safe even though the moment of direction due to different factors. Due to the location of the designed F1 Single Pile.

Considering its geomorphological conditions, Bintan Island is a modified rock such as mica gneiss, meta siltstone, volcanic rocks such as tuff, lithic tuff, tuffaceous sandstone scattered in the eastern part of the Riau Archipelago, breakthrough rocks such as muscovite granite can be found in sedimentary rocks such as sandstone shale, metagabro, which are scattered There are also old alluvial rocks consisting of clay, gravel sand, and young alluvium rocks such as mud, silt, and gravel, so the follow-up study on settlement is calculated.

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