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Study on the Allowable Pressure of Soft Clay in the Construction land of Kota Cinema Mall Banjarmasin

[1]Hikmad Lukman, [2]Titik Penta Artiningsih
[12]Civil Engineering Study Program, Faculty of Engineering, Universitas Pakuan, Bogor, Indonesia.

ABSTRACT: Most of the soil layer on the islands of Kalimantan and Sumatra, especially on the coast is in the form of peat soil, consisting of soft clay and stretches of peat land originating from plant humus with a large thickness. The nature of peat soil has great compressibility, low shear force, low permeability coefficient and has a low bearing capacity. In this study, the research was carried out on the land where the KOTA Cinema Mall Banjarmasin building will be built on Jalan Belitung Banjarmasin, South Kalimantan Province. The cone stress results in the Sondirtest obtained up to a depth of 30m are of small value (1 - 15 kg / cm²) which indicates that the soil layer is soft. Based on the results of the allowable stress calculation using the De Beer method, for a depth of 1.5 m, the allowable soil pressure for shallow foundation soils is only 0.084 kg/cm². To increase the bearing capacity, a soil improvement method is needed using *dolken* wood recesses. Based on the results of the calculation of the bearing capacity of the deep foundation for a collection of *dolken* piles with a diameter of 10 cm with varying lengths from 7.5 to 9.0 m, it is found that the bearing capacity of the combination of shallow and deep foundations increases the amount of bearing capacity to 0.42 kg/cm². The amount of allowable pressure for the combination of shallow foundations and the use of *dolken* piles increases to 0.51 kg/cm^2. Furthermore, based on the calculation of the amount of land subsidence due to immediate subsidence and consolidation with an external load of 3.5 t/m^2, it is obtained 71 cm for the load at once or 36 cm for the assumption that the load works gradually.

KEYWORDS: *soft clay, peat soil, dolken, allowable soil pressure*

I. INTRODUCTION

1.1 Background

As it is known that Indonesia consists of many islandswhich include Kalimantan Island which the condition of the land is a stretch of peat land and soft clay soil layers.

Soft soil in the form of peat soil and soft clay comes from organic matter with a thickness of up to tens of meters and has poor physical and mechanical behavior, which has a lowallowable soilpressure, high compressibility and low permeability.

The results of Sondirtest from the Laboratory of Soil Mechanics and Transportation of Banjarmasin State Polytechnic obtained a classification of very soft to soft soil with a soft clay soil thickness of approximately 30m, with a cone stress value of about 1 - 4 kg/cm^2, while hard soil layers were found at a depth of 36.0 m.

The availability of *dolken* wood as a local culture material helps increase the allowable pressure of the soil as an effort for Soil Improvement activities.

1.2 Purpose of the Study

The purpose of this study is to calculate the amount of allowable pressure (bearing capacity) of the existing soil using the Shallow foundation formula and to calculate the bearing capacity amount of the *dolken* pile foundation group.

Moreover, this study also attempted to find ways to increase the allowable pressure for Shallow foundations by carrying out soil improvement works using *dolken* piles around the Shallow foundation path. The allowable soil pressure is increased by combining the allowable soil pressure for the shallow foundation with the bearing capacity of the *dolken* pile.

1.3 CalculationMethodology

This study calculates the allowable pressure for shallow foundation using static formulas from several methods and calculating the bearing capacity of the *dolken* pile group based on the formulas for the bearing capacity of the deep foundation. The calculation process uses several scenarios of foundation width. The amount of allowablepressure for the land is taken from the smallest value resulting from the work in this scenario.

1.4 Limitation of the Problem

There are several limitations of the problem discussed in this study. First, soil improvement using a pole material from *dolken*wood measuring D.10 cm, the distance from the axle to the axle is taken as 30 cm (3d). Second, the soil parameters used are derived from the results of soil investigations from the Geotechnical and Transportation Laboratory of Banjarmasin State Polytechnic.

II. LITERATURE REVIEW

2.1 Shallow Foundation

Shallow foundation with the criteria according to Terzaghi with the formula Df / B ≤ 1, in general, this foundation is used for the foundation of a 3-story building. The load received by the foundation will be transferred to the surrounding soil through the foundation form: rectangular, square and continuous.

Soil pressure that occurs at the base of the foundation must be less than the allowable soil pressure and land subsidence that occurs must be less than the allowable subsidence.

The amount of allowable soil pressure depends on the magnitude of the limit pressure (ultimate), where the limit ofpressure is obtained from the calculation of the Static method and the dynamic method using soil parameters from soil investigations both in the laboratory and in the field. Many methods are used to calculate the bearing capacity of these limits.

Allowable Soil Pressure Calculation:

The amount of allowable soil pressure (Bearing Capacity) on shallow foundations can be obtained from the results of soil investigations in the field. Based on the experimental results of the Sondir tool, De Beer proposes an empirical equation to determine the allowable soil stress for shallow foundations.

1. Types of Path and Square foundations:
   - $q_a = q_c/30$ (kg/cm^2), for B ≤ 1,2 m
   - $q_a = q_c.[1 + (1/B)]^2/50$ (kg/cm^2), for B > 1,2 m
2. Types of shallow foundations in general:
   $q_a = q_c/40$ (kg/cm^2)

The amount of bearing capacity of Shallow foundations on clay soil using laboratory results data according to the Terzaghi formula based on local general collapse, can use the formula:

- $q_u = 0{,}67.c.N_c' + D_f.\gamma.N_q' + 0{,}5.\gamma.BN_\gamma'$, for the path foundation,
- $q_u = (2/3).c.N_c.(1+0{,}3B/L) + p_o.N_q + 0{,}5.\gamma.BN_\gamma.(1-0{,}2B/L)$, forrectangle foundation.

2.2 DeepFoundation

Deep foundation is criticized by Terzaghi with the formula Df / B >> 1. The load received by the foundation will be transferred to the surrounding soil through the lower end of the foundation and / or through the body along the pile that enters the ground.

In general, the end of the foundation will reach the hard soil layer in order to get a large bearing capacity and avoid any event of land subsidence, but in certain conditions the end of the pile does not reach the hard soil, so the soil layer underneath still allows soil subsidence.

The axial load that occurs at the base of the foundation must be smaller than the allowable axial load and the land settlement that occurs must be smaller than the allowable subsidence. The allowable axial load is found based on the limit axial load which can be obtained from the calculation using many methods.

2.2.1 Axial soil bearing capacity of single pile foundation

In general, it is the sum of 2 components, namely the resistance at the end of the pile and the shear resistance along the pile body:

$$Q_{ult} = Q_{s\ ult} + Q_{p\ ult}$$

Q_{sult} = Layer Shear Resistance ultimate

Q_{pult} = End resistance (ultimate)

$$Q_{all} = \frac{\text{Qult}}{\text{FK}} = \frac{Qult\ end}{FK\ end} + \frac{Qult\ layer}{FK\ layer}$$

Where:

- $FK_{end} = 3$
- FK_{layer}= 3 for piles and 5 for drill/wells piles.

a. Calculation of the pile foundation based on the Sondir test generally uses Schmertmann - Nottingham (1975) recommends calculating the bearing capacity of the end of the pile foundation according to Begemann's method (1963, 1965) based on the average cone stress at a certain height, namely:

$$Q_{ballowable} = \frac{qc1+qc2}{2}.\ A_b/FK$$

Where:

- $Q_{ballowable}$ = pile end bearing capacity [kg]
- q_{c1} = $q_c$average value 0 D - 4 D under foundation end [kg/cm^2]
- q_{c2} = $q_c$average value 0 D - 8 D above foundation end [kg/cm^2]
- A_b = projection area of the pile end of the foundation [cm^2]
- FK_b = pile end safety factor, taken 3 to 5 factors

For Pile Side Bearing Capacity, the friction value can be taken from the value of Total Adhesion Resistance (JHP):

$$Q_{sallowable} = p.JHP/FK_s$$

Where:

- $Q_{s\ allowable}$ = pile side bearing capacity [kg]
- JHP = Total Adhesion Resistance[kg/cm]
- P = foundation pile perimeter [cm]
- FK_s = side security factor, taken = 2 – 3

b. End bearing capacity for soft clay soils, based on laboratory results using the Meyerhoff / Tomlinson Method:

$$Q_{ult\ end}=A_b.c.N_c' = 9.A_b.c.$$

Where: c = soil cohesion using Test U-U, N_c' = 9

The Pole side bearing capacity (friction) formula can be obtained from several known formulas, such as: the α method from Tomlinson, the λ method from Vijayvergiya and Focht, the β method, and other ways.

For Alpha Method, α From Tomlinson can be used for fine-grained soils (cohesion soils), coarse grained soils (deep shear angles), and soils in general (cohesive soil and deep shear angles).

For cohesive soil, the magnitude of the shear permit bearing capacity can be found from the equation:

$Q_{ultpile\ side}= A_s.\sum f = A_s.\sum [\alpha.c_u]$, or

$Q_{ultpile\ side}= p.\int_0^L \alpha.\, cu.dL$

Where:

- F = the shear resistance of the post body and the surrounding soil,
- α = adhesion factor,
- p = circumference of the pole
- ΔL= pole element length

2.2.2 Pile Block Bearing Capacity

In the book Principles of Foundation Engineering written by Braja M. Das and Pile Construction and Construction Practice by MJ Tomlinson stated that in clay soil, the bearing capacity of the pile groups needs to be reviewed based on 2 types of collapse, namely: the collapse of each pile and the collapse of the pile group (block failure).

The formula for bearing capacity of pile groups is used for conditions:

- Single Pile Collapse, for s > 2D:

$$Q_{u\ single} = E.\ n.Q_b$$

The magnitude of the pile group efficiency factor (E) can be calculated based on the formulation of the "uniform Building Code" according to AASHO:

$$E = 1 - (\frac{\theta}{90^0}) \left[\frac{[(m-1)n+(n-1)m]}{m.n}\right],$$

where: θ = arc tan ($\frac{d}{s}$), m = number or row, n = the number of pile collection columns

- Pile Group Block Collapse:

$$Q_{u\ group} = 2D_p.(B + L).c_{av} + 1{,}3\ c.N_c.B.L$$

Where:

D_p = embedded pile length,
B, L = width, length of pile group,
c_{av} = average cohesion over the pile ends
c = average cohesion below the pile ends
N_c = bearing capacity factor

The amount of the bearing capacity of the pile group boundary is taken from the smallest value of the 2 reviews.

2.3 Land Subsidence

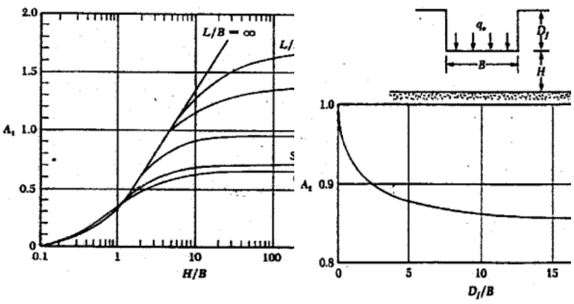
Land subsidence is calculated based on the sum of the amount of immediate land subsidence (elastic) and subsidence due to consolidation.

2.3.1 Immediate Land Subsidence (Elastics) onSaturated Clay.

Janbu,Bjerrum &Kjaerum (1956) propose the equation for the decrease in the average elastic with the formula:

$$S_e = A_1.A_2.(q_o.\text{B}/E_s)$$

Where: A_1function H/B & L/B &A_2functionD_f/B which is modified by Christian & Carrier (1978), as seen in Figure 1.



1. A1 2. A2

Fig.1. A_1&A_2Value for Elastic Calculations

2.3.2 Consolidation Decline in Pile Group

The amount of land subsidence under the pile group foundation can be found from the provisions using the 2:1 Method or using a graphic such as the Shallow foundation. Pile length L and total vertical load acting on pile group V.

This V load is considered to be evenly distributed into the ground starting at a depth of 1L/3 from the head of the pile group (bottom of the pile cap). The z distance is measured downwards starting at the 2L/3 depth to obtain additional stress due to external loads (Δp) = I.qo. (I = influence factor).

III. RESEARCH METHODOLOGY

3.1 Soil Data

Soil data is taken from the soil investigation report of the State Polytechnic and Transportation Laboratory of Banjarmasin State Polytechnic at a depth of 3.20 m as in Table 1, while based on the results of2 pointsSondir test, the soil layer in the location gets a soil description as in Table 2.

Table 1. Conclusion of Undisturb Soil Test Results in Laboratory

Jenis Pemeriksaan	B1 / 3.00 m - 3.40 m	Jenis Pemeriksaan	B1 / 3.00 m - 3.40 m
Wn (%)	86.17	qu (kg/cm2)	0.090
γn (g/cm3)	1.321	qr (kg/cm2)	0.048
Gs	2.329	St	1.875
LL	57.25	Cc	0.815
PL (%)	37.62	Cs	0.197
PI (%)	19.63	Cv (cm2/det)	0.0000768
C' (kg/cm2)	0.350	k (cm/det)	1.12426E-08
ø' (°)	0	e₀	1.9090
Cu (kg/cm2)	0.045	e'	0.9623

Source: Geotechnical and Transportation Laboratory of Banjarmasin State Polytechnic

Table 2. Soil Description

Tabel 1. Deskripsi Tanah Hasil Uji Sondir Titik S.1

Kedalaman	Deskripsi	Klasifikasi
00.40 - 00.60	Lempung	Sedang
00.60 - 25.60	Lempung	Sangat Lunak
25.60 - 27.60	Lempung	Lunak
27.60 - 30.60	Lempung	Sedang
30.60 - 31.40	Lempung	Kaku
31.40 -35.60	Lempung	Sangat Kaku
35.60 - 36.00	Pasir	Padat
36.00 - 36.40	Pasir	Sangat Padat

Tabel 2. Deskripsi Tanah Hasil Uji Sondir Titik S.2

Kedalaman	Deskripsi	Klasifikasi
00.40 - 24.60	Lempung	Lunak
24.60 - 29.60	Lempung	Sedang
29.60 - 30.80	Lempung	Kaku
30.80 - 35.80	Lempung	Sangat Kaku
35.80 - 36.40	Pasir	Padat
36.40 - 36.80	Pasir	Sangat Padat

Source: Geotechnical and Transportation Laboratory of Banjarmasin State Polytechnic

3.2 Implementation of Shallow Foundation Width Scenarios

In order to get the magnitude of the increase in the allowable pressure using the *dolken* pile, a scenario to calculate the increase in the allowable pressure is carried out. In this case it is assumed to use a rectangular shape, the depth of the shallow foundation is 1.50 m from the ground.

In this case, a scenario of foundation length (L): 3.5 m is used; 5.3 m and 5.5 m varied with the width

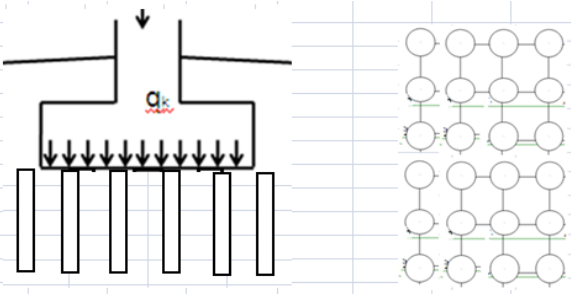


Fig. 3. An example of a dolken pile mounting formation scenario

3.3 Dolken Wood Length and Diameter

The length of *dolken* wood used is 7.5 m - 9.0 m long. while the diameter of *dolken* wood used is 10 cm. The distance between the *dolken* wood axles is taken as 3D, which is 30 cm.

IV. FINDINGS AND DISCUSSION

The results of the calculation of the bearing capacity of the land permit use the formulas in the Literature Review by performing several square foundation size scenarios. Furthermore, the results are summarized in Table 3 below.

Table 3. Recapitulation of Results of the Allowable Bearing Capacity of Shallow Foundation Soil

Shallow Foundation	Allowable Soil Pressure (kg/cm^2)		
Size (m x m)	Shallow Foundation	Dolken Pile Group	Total
1,50 x 5,35	0,084	0,43	0,514
1,20 x 5,50	0,083	0,425	0,508
1,20 x 3,50	0,085	0,449	0,534
1,5 x 5,50	0,084	0,418	0,502

Based on the results of the calculation of the amount of land subsidence, the total size of the foundation is 1.5 x 5 m2 and 2.0 x 5 m2 with an external load of 3.5 t/m2 and 2.5 t/m2, the amount of total settlement is obtained as in Table 4.

The calculation of this reduction uses the assumption that the load works at once, while in reality development takes time, the external load and the weight itself work slowly, so the actual decrease is smaller than the theoretical decrease, meaning that the result of the reduction can be reduced by 50%.

Table 4. Recapitulation of the Calculation of Land Subsidence Amount(cm)

Land Subsidence	Square Foundation Width, B			
	1,50 m		2,0 m	
	q_o = 3,5 t/m^2	q_o = 2,5 t/m^2	q_o = 3,5 t/m^2	q_o = 2,5 t/m^2
S.Elastic, S_e	49,70	35,50	60,66	43,33
S.Consolidation, S_c,cm	21,49	15,49	21,49	15,49
S.total (theoretical),cm	71,19	50,99	82,15	58,82
S. total actual, cm	35,59	25,49	41,07	29,41

V. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

1. Allowable SoilPressure, (σ_t) Shallow foundation of existing soft clay soil at a depth of 1.5 m from the ground level is only **0.084 kg**/cm^2
2. To increase the bearing capacity of the soil (σ_t), it is necessary to have soil repair work using a pole niche, in this case using *dolken* wood with a diameter of 10cm which is often found in locations, in this case the calculation results obtained an additional **0.42** kg/cm^2,
3. The amount of allowable soil pressure (σ_t) due to the combination of shallow foundations and the use of *dolken* piles can be taken as **0.51** kg/cm^2, and
4. Based on the calculation of the amount of land subsidence due to immediate subsidence and consolidation with an external load of 3.5 t/m^2 of 71 cm for the load at once or 36 cm for the assumption of working load gradually.

5.2 Recommendation

1. In determining the size of the shallow foundation dimensions with the addition of *dolken* wood poles, it is necessary to take into account the amount of load that is borne, land subsidence due to soft soil elasticity and decrease due to consolidation of soft soil,
2. For foundations that receive a fairly large load, due to the magnitude of land subsidence due to soil elasticity and consolidation events, the amount of allowable pressure (σ_t) due to the use of *dolken* piles can be reduced to **0.25 - 0.30** kg/cm^2, and
3. In connection with the suggestions above, it is

proposed to use a shallow foundation/direct rigid path.

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AUTHORS

Ir. Hikmad Lukman, M.T., Lecturer of Civil Engineering Study Program, Faculty of Engineering, Universitas Pakuan, Bogor, Indonesia.

Dr. Ir. Titik Penta Artiningsih, M.T.,Lecturer of Civil Engineering Study Program, Faculty of Engineering, Universitas Pakuan, Bogor, Indonesia.