DESIGN OF ANCHORAGE SHEET PILE USING PLAXIS 2D v-8.6
(Study Case in Piyungan Road-Batas Gunung Kidul, Yogyakarta)

Prepared as a condition of completing Study Program of Bachelor Degree at the Department Of Civil Engineering

By

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Abstract

The history of technological development today continues to grow rapidly. One of its effects is the technological developments on construction. To simplify the planning and calculation of performance efficiency of construction, the software (programs) is urgently needed. In this study, the authors studied how to use the program to analyze slope stability using the Plaxis programs. The analysis is performed with the control stability of Piyungan slope, Yogyakarta to determine the safety factor. After Analyzed the results it showed that the safety factor was less than required, then the alternative solution required. The author planned alternative solution by providing a type of retaining structure that's concrete anchorage sheet pile. There are two calculation methods to find the safety factor, Manually with Fellenius method and computationally with Plaxis program. As for the soil parameters used are: unit weight of soil (γ) 15.186 kN/m^3, specific gravity (SG) 2.66, cohesion (c) 15,984 kN/m^2, friction angle (φ) 30, 44^o, average moisture content 44.82%, for the condition of geological layers in the field it is clayey sand with a height of 16.2 m roommates detained. Calculation results of slopes stability, before the alternatives treatment is used, the safety factor of Fellenius method Obtained was 0.95085 <1.5 (not safe), while Plaxis program was 0.9522 <1.5 (not secure). After the alternative treatment is used, the safety factor by Fellenius method was 1.744 >1.5 (safe), while Plaxis program was 1.7413 >1.5 (safe). So the safety factor is increased by using the anchorage sheet pile treatment.

Keywords: Fellenius, PLAXIS, Anchorage sheet pile, Slope stability

1. INTRODUCTION

The development of civil engineering and planning technology in soil mechanics are experiencing rapid revolution in the 2000 AD to solve many problems of land and many type of soils, as age advance in the field of building construction technology is also experiencing rapid development in the field of geotechnical engineering. Anchorage sheet pile is a type of retaining structure that serves to prevent many geological disasters, stabilizing the soil on the slopes by preventing any land sliding. To design a safety sheet pile, should be able to estimate and calculate the stability of the anchorage sheet pile as well as the stability of the soil.

It is well known that there are many ways to speed up the calculations and reduce errors, it is almost same with manual calculation, but it can give us more specific result, plaxis is one of these methods.

Plaxis is a series of programs designed to solve various geotechnical problems, in addition to analyze and calculate the anchorage sheet pile, also can be used to analyze foundation, excavation, retaining walls, and soil stability.

The Piyungan road at Yogyakarta is a mountainous and dangerous road that leads to many promenade areas, it is a crowded road especially at the weekend days and it must be protected from any land sliding. Anchorage sheet pile is one of the structures that can protect and prevent any land sliding, collapsing, on piyungan road.

In this study, it focused on calculate and design the anchorage sheet pile that need to protect the Piyungan road by analyzing the stability of the pile and the stability of the soil around the road using manual analyzing and plaxis program analyzing with comparing both results of safety factor.

2. RESEARCH METHODS

The soil parameters and data has been known from samples that taken around Piyungan Road-Batas Gunung Kidul, Yogyakarta then it has been carried out at the Soil Mechanics Laboratory of Civil Engineering Department of Universitas Seblas Maret. There are two drilling point DH I and DH II, first with a depth of 8 meters, second with a depth of 10 meters with two different locations.

The planning is consisting tow calculations methods, manually with Fellenius, computationally with Plaxis program.

The equipment used is a computer programs such as *PLAXIS Software v-8.6, AutoCAD 2015 Software, and Microsoft Office 2010 Software.*

Stages of research are divided into nine stages:

Stage I: literature preparation and study

Stage II: Secondary data collection value: γ, Gs, c, φ, *w* that's taken from the test results of *Direct Shear Test (DST)* (Ramadhani fajar 2016).

Stage III: anchorage sheet pile wall analyzing using two methods, namely:

a. Calculation of anchorage sheet pile using fellenuis manual method.

b. Calculation of anchorage sheet pile using *PLAXIS software 2D.v-8.6*

Stage IV: Seeing the execution of safety factor (SF)

a. If SF > 1.5 to stage VII

b. If SF< 1.5 to stage V

Stage V: Slope stability analysis consist tow methods, namely:

a. slope stability analysing after treatment using manual method- Fellenius.

b. slope stability analysing after treatment using Plaxis v-8.6 program.

Stage VI: Seeing the execution of safety factor (SF)

a. If SF > 1.5 to stage VII.

b. If SF< 1.5 to stage V.

Stage VII: Discussion.

Stage VIII: Conclusion and recommendations.

Stage IX: Completed.

3. Slope stability analysis before the treatment

3.1 Manual calculation with Fellenius

The following soil data and model that needed for Fellenius method applying on the slope.

Table 1. Soil parameters in *the Drill Hole* I

Table of *Soil Properties*				
No.	Properties	Symbol	silty sand	Unit
	Depth		from 2.50 to 3.00	m
1.	Material Model	*model*	*Morh-Coulomb*	-
2.	Material *behavior*	*Type*	*Drained*	-
3.	Unit weight of dry soil	γ_d	10.486	kN / m^3
4.	Unit weight of wet soil	γ_{wet}	15.186	kN / m^3
5.	Permeability horizontal direction	K_x	0	m / day
6.	Permeability vertical direction	K_y	0	m / day
7.	The elastic modulus	E_{ref}	15000	kN / m^2
8.	Poisson's ratio	ν	0.30	-
9.	Cohesion	c	15.984	kN / m^2
10.	friction angle	φ	30.44	^{o}
11.	angle of dilation	ψ	0.44	^{o}

Based on data above, Fellenius has been applied and by Trial and Error with R = 27.090, the safety factor was equal to 0.95085 and still less than < 1.5

3.2 Calculation of *PLAXIS* program *v–8.6*

Due to slope stability analysis using Plaxis, the result of safety factor with Plaxis output was equal to 0.9522 and the displacement is 6.658 cm, so the safety factor is still less than the minimum safety factor 1.5, the slope will totally get failure due to its own weight, following figures shows the deformation of the slope by Plaxis as well as the safety factor result.

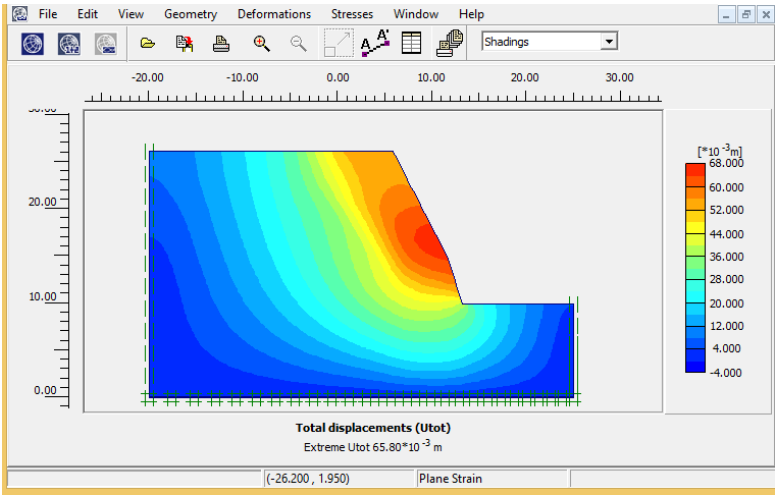

Figure 1. Deformations and soil movement direction due to *Gravity Loading*

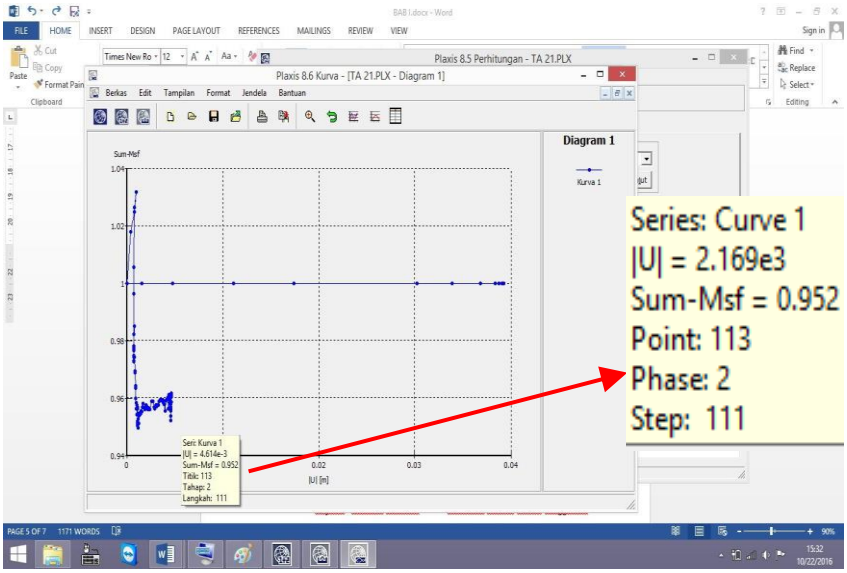

Figure 2. Safety factor result due to *Gravity Loading* and *Vertical Loading*

4. Slope stability analysis with the Treatment

Through the previous manual and computational analysis result, the safety factor was less than the minimum safety factor 1.5, so the slope can get failure and the land sliding can be occurred, the alternative treatment must be added, the author has studied about providing an Anchorage sheet pile to prevent the sliding of the slope at Piyungan-Yogyakarta.

4.1 Modeling of Materials

Table 2. Design parameters of anchorage sheet pile on Plaxis input

No.	Properties	Symbol	Value	Unit
1.	material model	*model*	*Linear Elastic*	-
2.	Material *behavior*	*Type*	*Non Porous*	kN / m
3.	Unit weight of dry soil	γ_d	25	kN / m^3
4.	Modulus of Elasticity	E_{ref}	2.574 x 10^7	kN / m^2
5.	*Poisson's ratio*	*v*	0.15	-

4.2 Fellenius method calculations with Treatment

Due to the slope stability analyzing with the provided anchorage sheet pile treatment the result of safety factor is more than > 1.5 (safe), and it can be seen in the following table.

Table 3. Results of safety factor with the treatment of anchorage sheet pile

No	analysis stage	The radius of Fellenius slip circle (R)	Safety factor (SF)	Note
1.	Due to its own weight	R = 23.559 m	SF = 1.77326	Safe

Based on the analysis that has been done with Fellenius the safety factor against sliding can be increased from 0.95085 to 1.77326.

4.3 Plaxis calculations with Treatment

Through Plaxis calculations with the provided anchorage sheet pile, the safety factor value that got from Plaxis output was equal to 1.7750 and the displacement is 4.432 cm, it is more than the minimum safety factor >1.5 so the treatment with anchorage sheet pile is adequate against the sliding, it can keep the slope safe and stable, next figures shows the calculations process and deformations of soil movement.

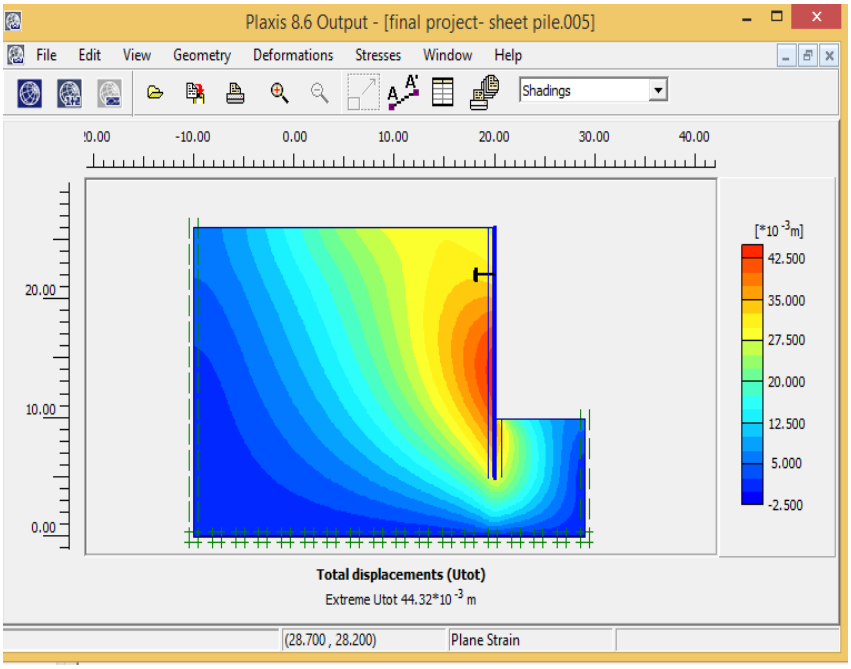

Figure 3. Soil movement directions due to gravity loading

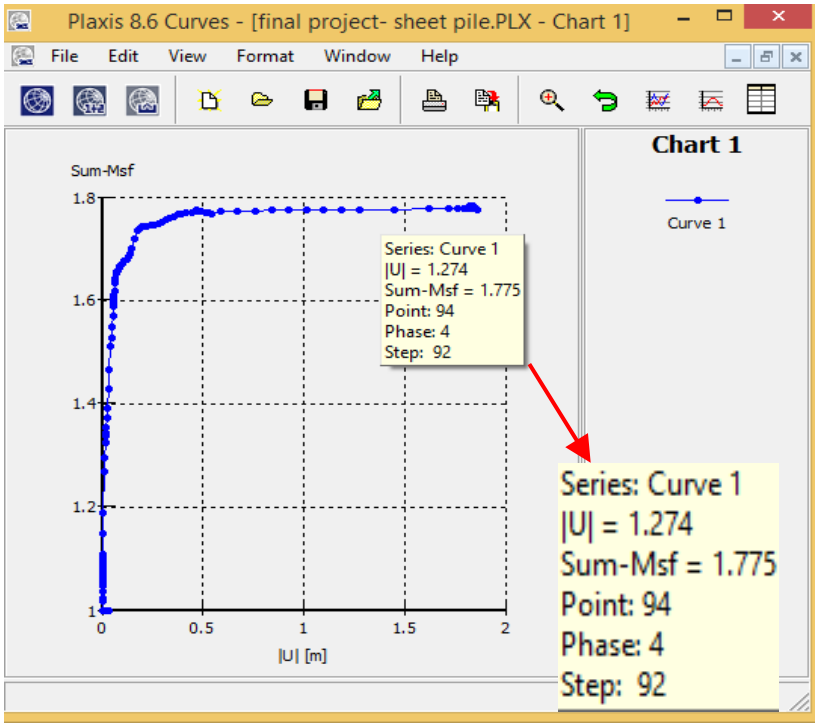

Figure.4. Safety factor result due to *Gravity Loading* and *Vertical Loading*

5. The Comparison Between The Results Before And After The Treatment

Table 4. Safety factor results comparison

Calculation Methods	Before treatment	After treatment
Manual (Fellenius)	0.95085	1.77326
Plaxis	0.9522	1.7750

Before the treatment the Fellenius manual calculations got a safety factor of 0.95085 and it has been increased to 1.77326 because the provided anchorage sheet pile, as well as for Plaxis calculations before the treatment, the safety factor was 0.9522 and increased to be equal to 1.7750, both results was not safe because of the safety factor against sliding was less < 1.5, but after the anchorage sheet pile provided the increasing of safety factor shown clearly and its more than > 1.5, the slope became safe and stable against any land sliding.

6. CONCLUSIONS AND SUGESTIONS

Through data analysis of slope stability that occurring in Piyungan, Yogyakarta with the manual method (Fellenius) and *Plaxis* program v-8.6, the conclusions can be summed up as follows:

1. The anchorage sheet pile can keep the slope stable and prevent the land sliding; it can be proved by the safety factor (SF) that equal to 1.7750 according to analysis result of Plaxis program.
2. The safety factor (SF) result that obtained manually by Fellenius method on the slope is equal to 0.95085, while using Plaxis program to get safety factor (SF) of 0.9522. The safety factor of these two calculation methods demonstrate the value that <1.5 so that's the slope is unstable and need an alternative treatment. After the treatment with Anchorage Sheet Pile and calculated using manual method and *Plaxis* program, the safety factor increased to get those values, manually equal to 1.77326 and *Plaxis* program equal to 1.7750. Thus the addition of an anchorage sheet pile is enough to increase the safety factor against the sliding of slope.

Suggestions:

1. Conducting of soil *sampling* is needed to get an overview of the characteristics of the soil layers to help the plaxis program calculation and modeling accuracy.
2. Additional soil data is needed such as UCT (unconfined compression test) lab test to determine the parameter of land in fill, so that the input parameter of plaxis can be more accurate.
3. The safety factor of external load need to be calculated to be increased, as well as to be accordance with the site's ground conditions.

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