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Analysis of Slope Stability Using Geotextile with The Limit Equilibrium Method in Gunung Sari, Batu

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ABSTRACT

Gunung Sari Village, Batu City is a hilly mountainous area. Where the elevation contour of the land is at an altitude of ± 800 meters above sea level. Because of its hilly location, there are many steep slopes around the location. These slopes have the potential to experience landslides, considering that the rainfall in these locations is very high. Potential slopes with such conditions are suspected to have a safety factor (SF) < 1. For this reason, researchers are interested in analyzing the slopes on these slopes using the limit equilibrium method. In this study the method that will be used is to analyze the factor of safety in the existing conditions and the factor of safety after the slope is given geotextile reinforcement which will be modeled with the Geoslope/W 2012 application. The results of the safety factor analysis of existing conditions at cross 1 using the Geo Slope/W 2012 Program, the Bishop method, is 0.851, while for the Morgenstern method it is 0.961. Both methods show a safety factor value of less than 1 (F<1), which means the slope is unstable and has a high potential for landslides. The value of the safety factor with geotextile reinforcement for both methods has increased, making the slope more stable (F>1). The safety factor value for cross 1 of the Bishop method is 1.698 while for the Morgenstern method it is 1.702.

Keywords: *Slope Stability; Geotextile; Limit Equilibrium Method*

INTRODUCTION

A slope is an observation of the surface of nature that has a difference in elevation, and when the difference in the elevation of the two places compared to the vertical straight distance is obtained, the size of the slope (slopes). The slope can be formed by natural processes or by human engineering. Some of the factors affecting the stability of the slopes are human activities and natural activities. Human activities related to land use, such as wild deforestation, the opening of new lands on hillsides, housing development in mountainous areas, etc. As for the activity of nature, it is closely related to the geological conditions of other types of soil, texture (composition), the soil forming slopes, the influences of earthquakes, geomorphology (regional flexibility), and climate, especially high-intensity rainfall.

If a slope is unstable, there is a potential for sliding. Sliding is the time movement of rocks, debris, and soil on a slope that is moved by gravity and is disturbed by the equilibrium force that works between the weight of the soil or rock and its ability to withstand the load [1].

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Therefore, sliding is the motion of the earth or rock from a higher elevation to a lower elevation. In addition to being a soil reinforcement, geotextile also has a function as a filter and separator [2].

Gunung Sari Village, Batu, is a hilly area that is vulnerable to sliding. Researchers are interested in conducting research at the site to identify the potential for a landslide disaster. The potential of this slide can be modeled with the Limit Equilibrium Method so that the safety factor is obtained. (SF). If the value of the stability number is less than 1 (SF<1), then the slope is unstable and potentially exposed to flexibility, so it requires stability improvements [3]. Previous research in slope stability analysis using the SLOPE/W program with the Bishop method obtained a safety factor in existing conditions of 0.4. Then the analysis was done with geotextile reinforcement, and the safety factor increased to 1.3 [4].

Therefore, with the addition of geotextiles as reinforcements, it is expected to increase the safety factor for slope stability. Moreover, the modeling carried out in this study is hoped to be one of the alternatives to disaster prevention.

METHOD

Gunung Sari Village, Batu as the research site, while modeling and calculation analysis was carried out at the Civil Engineering Department, State Polytechnic of Malang.

(a) (b)

Figure 1. Research Location (a), Sumber Ringin River (b)

In this study, several stages are carried out, starting with the preparation of members and tools, determination of survey methods, processing of survey data, modeling of analysis results, and conclusion of research results.

This research is carried out in a clear and systematic manner in order to obtain satisfactory and accountable results. Therefore, the implementation of the research is divided into several stages, namely:

1. Preparation phase: in this phase, the preparation of members to carry out topographic measurements and the determination of CPT test points. In the preparations of members, a briefing is carried out for the execution of the survey to ensure the date of the survey as well as the readiness of members and equipment. The methods of execution are also submitted at the initial briefing so that the implementation of the survey can be performed effectively and efficiently.
2. Implementation stage of the survey: at this stage, the team is working to obtain the required data, such as topographic maps and soil parameter data. In the survey of topographic

measurement, it is carried out using theodolithic tools to measure and map the shape of the soil surface at the research site so that the model of the soil surface can be used in the Sketchup application for design purposes. In the CPT test, the test is carried out as deep as hard ground, or the conic end holding value is greater than 250 kg/cm2 (qc > 250 kg/cm).

3. Data processing phase: at this stage, data is collected and processed into surface contour data using a number of some software programs, such as Microsoft Excel, sketch-up.
4. Data processing modeling phase: This phase is the modeling or design of slopes that will be modeled using the Limit Equilibrium Method by entering the soil parameters of each layer. If the safety factor number is less than 1 (SF<1), then it is necessary to perform the method of soil inforcement of a geotextile.
5. Conclusion stage: this stage will lead to one conclusion, namely whether the slope is potentially resistant to landslide and needs to use geotextile reinforcement to prevent land.

To be able to clarify the picture of the final result that will be obtained, the following is an example of the simulation picture that is to be done on this study, namely the design of slopes that use geotextile reinforcement.

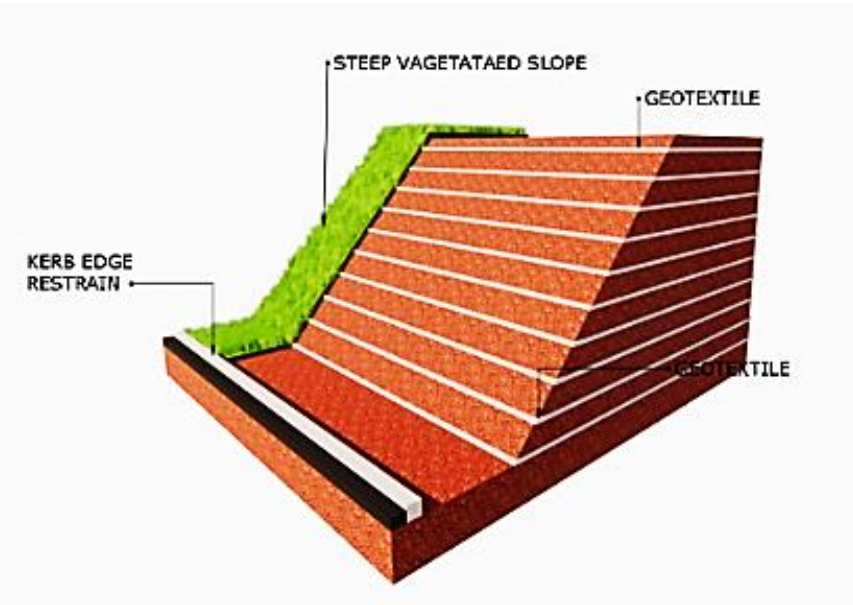

Figure 2. Design Using Geotextile Reinforcement

RESULTS AND DISCUSSION

Data Analysis

Based on the results of the Cone Penetration Test (CPT) at 2 points. Then the data is obtained as follows. The results of the CPT test SD-01 presented in Table 1 and the SD-02 results presented at Table 2.

Table 1. The results of the CPT test SD-01

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Depth (m)	Average qc	Clasification of Soil	Thicknes of Layer (m)	Average FR
0.0 - 0.8	8.5	silty clays	0.0	3.3
0.8 - 1.8	11.6	organic clays n mixed soils	0.8	6.4
1.8 - 2.4	9.0	medium clay	1.0	5.6
2.4 - 2.8	10.0	organic clays n mixed soils	0.6	7.0
2.8 - 4.0	8.5	medium clay	0.4	4.5
4.0 - 8.2	12.3	organic clays n mixed soils	1.2	8.3
8.2 - 8.8	18.7	organic clays n mixed soils	4.2	7.2
8.8 - 9.8	27.6	organic clays n mixed soils	0.6	7.8
9.8 - 10.4	65.0	clayey silts	1.0	3.4
10.4 - 12.0	42.9	silty clays	0.6	4.5
12.0 - 12.8	75.8	clayey silts	1.6	3.3
12.8 - 13.8	36.8	silty clays	0.8	3.5
13.8 - 15.0	34.0	organic clays n mixed soils	1.0	7.5
15.0 - 15.4	58.0	silty clays	1.2	4.9
15.4 - 16.0	150.7	silty sand	0.4	2.3
16.0 - 16.4	246.0	dense or cemented sands	0.6	1.4

In Table 1 it is seen that there is a dominant soil in the form of organic clays and mixed soils, besides this soil has a mixture of silty clays (clayey silts).

Table 2. The results of the CPT test SD-02

Depth (m)	Average qc	Clasification of Soil	Thicknes of Layer (m)	Average FR
0.0 - 2.4	8.7	medium clay	2.4	4.1
2.4 - 9.8	17.9	organic clays n mixed soils	7.4	8.5
9.8 - 10.8	66.4	silty clays	1.0	3.8
10.8 - 11.4	45.3	silty clays	0.6	4.4
11.4 - 11.8	36.0	very stiff clay	0.4	6.9
11.8 - 12.6	82.3	silty clays	0.8	3.6
12.6 - 13.4	37.0	silty clays	0.8	4.0
13.4 - 15.0	51.5	silty clays	1.6	5.6
15.0 - 15.8	32.5	organic clays n mixed soils	0.8	8.2
15.8 - 16.4	42.3	very stiff clay	0.6	6.7
16.4 - 17.4	65.2	silty clays	1.0	5.6
17.4 - 17.8	148.5	sandy silt	0.4	2.8
17.8 - 18.2	243.5	dense or cemented sands	0.4	1.5

In Table 2 we can see that there is dominant soil in the form of organic clays and mixed soils, besides this soil has a mixture of silty and medium clays. (medium clay).

Here's a picture of the cross 1 slope at the research site before and after using 20 layer geotextile reinforcements with each layer 30 cm thick modeled on the GeoSlope/W 2012 program. The soil reinforcement using this geotextile is expected to have an impact on the stability of the slope as proven by the increased value of the safety factor. (F).

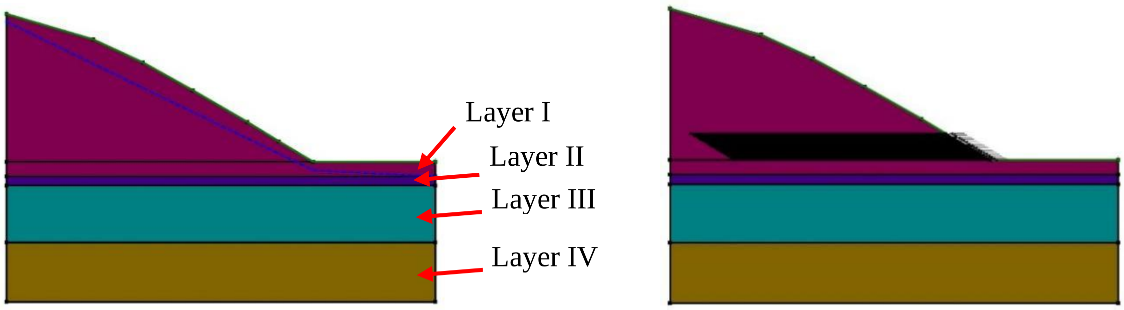

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Figure 3. Condition of Slope Existing

Figure 3 shows that the slope has 4 layers consisting of:
a. Layer I has a thickness of 2.40 meters.
b. Layer II has a thickness of 1.60 meters.
c. Layer III has a thickness of 9.60 meters.
d. Layer IV has a thickness of 16.40 meters.

The modeling of existing slopes only holds the load from the slope itself because there are no external loads such as the traffic load or the load on the sloping that works on the current slope.

The existing slope geometry modeling begins with the determination of the slope slope and the insertion of each of the soil parameter data into the soil layer on that slope. Analysis of the stability of the current slope using the Geo Slope/W 2012 program with a comparison of two methods, namely using the Bishop Method and the Morgenstern Method.

A. Bishop Method

The following is the result of the analysis of the calculation of the cross-slope 1 using the Bishop method with existing conditions or without using reinforcements. From this analysis, it can be concluded that there are several possible slide fields with the smallest safety factor value of 0.851, which means less than the required safety factor of 1 (0.851). In other words, the slopes are potentially exposed to (unsafe) slippage in the slope.

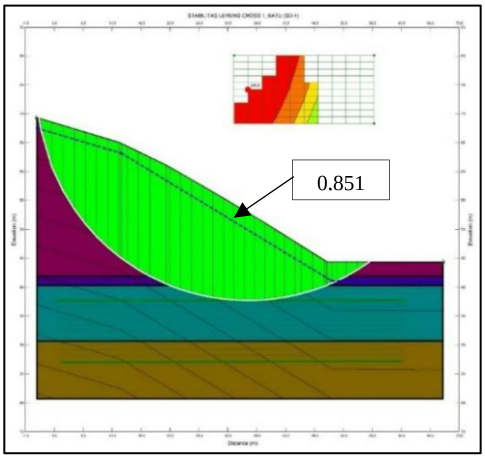

Figure 4. Conditions of existence with the Bishop Method

B. Morgenstren Method

The following is the result of the analysis of the calculation of the cross slope 1 using the Morgenstern method of conditions existing or without using reinforcements. From this analysis, it can be concluded that there are several possible slide fields with the smallest safety factor value of 0.961, which means less than the required safety factor of 1 (0.961). In other words, the slopes are potentially exposed to (unsafe) slippage in the slope.

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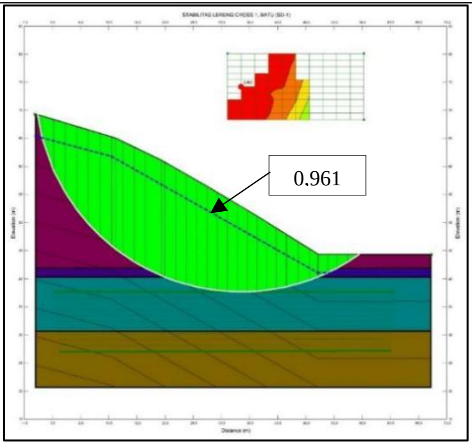

Figure 5. Conditions of existence with the Morgenstern Method

1. Alternative Handling Using Geotextile

In the analysis of the security factor value of the existing condition, both methods obtained a safety factor value of 1, which is the background for the researchers to add reinforcements so that the value of the safety factor becomes increased. Several methods of soil repair may be the solution in this case, but these curtains choose alternatives of geotextile reinforcement to increase the values of the slope safety factor.

Analysis of slope stability with geotextile reinforcement is done using two methods, namely the Bishop method and the Morgenstern method.

A. Bishop Method

The following are the results of an analysis that has already shown a stable condition due to the geotextile reinforcement of 20 layers so that the minimum safety factor value increased to 1,698, which means exceeding the required safety factor value of 1.5 (1,698 > 1,5). This means that the slopes have a small potential for a safe slip.

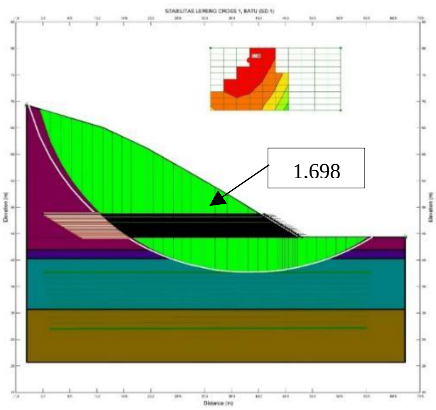

Figure 6. Conditions with the addition of geotextile (Bishop Method)

B. Morgenstern Method

The following are the results of an analysis that has already shown a stable condition due to the geotextile reinforcement of 20 layers so that the minimum security factor value increases to 1,702, which means exceeding the required safety factor value of 1.5 (1,702 > 1.5). This means that the slopes have a small potential for a safe slip.

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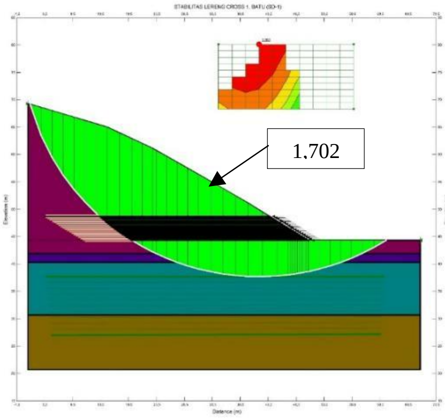

Figure 7. Conditions with the addition of geotextile (Morgenstern Method)

The results of this study are presented in Table 3 and Table 4 which explain that the conditions prior to geotextile reinforcement of slopes have a safety factor value less than 1 (F < 1) which means the slope condition is unstable and allows for slope. Later, it was also explained that the slope condition after given geotextile reinforcements of 10 layers, 15 layers, and 20 layers experienced an increase in the safety factor value of more than 1.5 (F > 1.5), which means that slope conditions are stable and potentially very little undergoing loosening.

Table 3. Results of analysis at SD-01

SD-1			GEOTEXTILE (10 Lapis)		GEOTEXTILE (15 Lapis)		GEOTEXTILE (20 Lapis)	
CROSS	BISHOP	MP	BISHOP	MP	BISHOP	MP	BISHOP	MP
1	0.815	0.961	1.669	1.681	1.678	1.693	1.698	1.702
2	0.92	0.929	1.621	1.614	1.64	1.636	1.657	1.66
3	1.072	1.105	1.821	1.843	1.844	1.866	1.868	1.89
4	1.22	1.286	2.354	2.371	2.37	2.387	2.377	2.394
5	1.165	1.189	1.833	1.839	1.864	1.872	1.895	1.904

Table 4. Results of analysis at SD-02

SD-2			GEOTEXTILE (10 Lapis)		GEOTEXTILE (15 Lapis)		GEOTEXTILE (20 Lapis)	
CROSS	BISHOP	MP	BISHOP	MP	BISHOP	MP	BISHOP	MP
1	0.922	0.981	1.781	1.812	1.794	1.823	1.803	1.832
2	0.96	0.996	1.776	1.798	1.797	1.817	1.814	1.84
3	1.026	1.069	1.964	1.992	1.988	2.015	2.012	2.039
4	1.31	1.341	2.55	2.569	2.566	2.585	2.573	2.591
5	1.191	1.212	1.964	1.967	1.995	2.001	2.025	2.027

CONCLUSION

In the implementation of this study, the conclusion was as follows:

1. The safety factor analysis of existing conditions using the Geo Slope/W 2012 Program is divided into 2 methods, namely the Bishop method and the Morgenstern method. The safetyfactor value of the existing condition for the Bishop method is 0.851, whereas the Morgentern method was 0.961.
2. The geotextile reinforcement method is used with variations in the number of layers of geotextile: 10 layers, 15 layers, and 20 layers each with a thickness of 30 cm.

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3. Safety factor analysis with geotextile reinforcement using the Geo Slope/W 2012 Program is divided into two methods, namely the Bishop method and the Morgenstern method. The safety factor value with the geotextil reinforcements for both methods is increased and makes the slope more stable (F>1). The safety factor value on the cross-1 method is 1,698, whereas with the Morgestern method it is 1,702.

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