# THE EFFECT OF SURFACE WATER ON THE SLOPE OF "X" HOUSING GUNUNG GEULIS, CIMANGGUNG DISTRICT, SUMEDANG REGENCY

**Revena Denia Putri[1], Raden Irvan Sophian[2], Zufialdi Zakaria[2], and Nur Khoirullah[2]**

[1]Faculty of Geological Engineering, Padjadjaran University
[2]Department of Applied Geology, Padjadjaran University
Corresponding author: revenadeniap@gmail.com

***ABSTRACT***

*Rainfall intensity can affect water infiltration to the ground. The increase in groundwater level will increase pore pressure (μ) that minimizes shear resistance of the slope mass, especially on the ground material (soil). The increase in surface water levels also increases surface water discharge and increases erosion below the surface (piping or subaqueous erosion). As a result of more subtle friction (silt) from the time that washed away soil, the soil will decrease future resilience. This happened in Subdistrict Cimanggung, Sumedang, West Java. This area is composed of weathered soil of volcanic products such as tuff, volcanic breccia, and andesitic lava. The parameters of this research contain basic properties and mechanical properties of soil, slope profile in MH soil, and water surface level. This research aims to determine basic properties and mechanical properties of soil, as well as the effects of groundwater level, that can give recommendations for groundwater level to get a stable condition of the slope. The basic properties and mechanical properties of soil are known based on laboratory tests from a disturbed and undisturbed soil sample were obtained by surface sampling and geotechnical hand drilling. Slopes were analyzed by the Bishop method using Rockscience Slide software. The result is there's an increase in the value of safety factors when the level of surface water level decrease. From the value of the safety factor that varies between slope sections, that slope can be stable if water surface level -7,5 meters beneath the surface.*

**Keyword**: *Cimanggung, Basic Properties of Soil, Mechanical Properties of Soil, Groundwater level, Slope Stability Analysis, Bishop Slice Method*

## INTRODUCTION

Cimanggung District is one of the areas in Sumedang Regency which continues to experience changes in morphology and land function as well as rapid population growth. One of the housing estates in the Cimanggung sub-district is built on a ridge, the presence of hoarding at the top causes additional loads and slopes. At the bottom, housing is built that also peels off the cliff so that there is a fairly steep slope. Not far from the residential area, there is a slope that experiences landslides. This high rainfall is one of the triggers for landslides that cause damage to buildings and high casualties. The geological condition of the Cimanggung District is a tuff deposition area with bedrock in the form of breakthrough volcanic rocks. Residual soil that is above bedrock on hills with moderate to steep slopes will lose the ability to hold freely on it so that it can decay the material.

Indeed, the slope safety factor needs to be considered in regional development because it directly has the potential to pose a risk to the safety of the people who live in the area. The research was conducted by analyzing the depth of surface water with the parameters of physical and mechanical properties of the existing soil. From this research, the value of the safety factor will be acquired which is used as a reference for assessing slope conditions. By reviewing the depth of the surface water and the quality of the slope, the slope stability can be maintained to be more stable. Hopefully, it can lessen the impact and losses that may occur, as well as become a consideration for future regional development.

This research has been done in "X" housing Geulis Mount, Sawahdadap, Cimanggung, Sumedang, West Java. Geographically, the research area is located in 107° 47′ 06′′ E and 107° 49′ 37,2′′ E; -06° 55′ 4,8′′ S till -06° 57′ 32,4′′.


Figure 1 Map of research location.



E-ISSN : 2579 – 3136

## RESEARCH METHOD

The object of this research is the slope of "X" housing Mount Geulis, Cimanggung District, West Java Province. This research was conduct by making observations in the research area, namely by mapping engineering geology based on Dearman (1991, in Zakaria, 2010) to determine the distribution of soil and rock and as a reference in taking undisturbed soil samples (UDS). A sampling of disturbed soil was taken using a hand drill (Hand Auger). The mechanical and physical properties of the soil in the study area were obtained from two undisturbed samples and one surface soil sample obtained from the top of the slope for soil layer 1 with UDS-AKL sample, the foot of the slope for soil layer 2 with UDS-04 sample and soil layer 3 with surface soil samples.

The undisturbed soil samples were then analyzed in the laboratory to determine the physical and mechanical characteristics of the soil based on American Standard Testing and Material (ASTM) standards, such as soil density test, water content, density, soil consistency limits, grain size analysis, internal shear angle, and soil cohesion.

Slope stability value is obtained from the calculation of the safety factor (FS), which is the ratio between the resisting force and driving force. The resisting force is obtained from the shear strength value from the Mohr-Coulomb failure criterion. Meanwhile, the driving force is obtained from the weight of the rock mass above the slip surface action on the inclined plane. The method of calculating the safety factor (FS) was analyzed by Limit Equilibrium Bishop Method.

### Engineering Geological Condition

Based on Bandung geological regional map scale 1:100.000 (Silitonga, 1973), the research area is form by Undifferentiated Young Volcanic Products, consisting of tuffaceous sand lithology, lapilli, breccia, lava, agglomerates. the material comes from Mount Tangkubanparahu and some from Mount Tampomas.

Based on Bandung engineering geological map scale of 100.000 (Djaja and Hermawan, 1996) research area is form by silty clay and sandy silt soil (R(mc)(cm)). This soil is residual soil which is the result of weathering of tuffaceous sandstones, tuffs, conglomerates, agglomerates, lapilli, and breccias, between 2 – 20 meters thick, in the central and southern parts of this unit it contains a lot of gravel and igneous rocks, reddish-brown with moderate – high plasticity, low permeability, firm to rigid, the allowable bearing capacity of the soil is low – medium.

## RESULT AND DISCUSSION

Soil and rock types in the research were from weathering of volcanic tuff and breccias. Based on geological mapping, sampling of surface soil, rock, and undisturbed soil samples then subjected to laboratory tests to identify the physical and mechanical properties of the soil, the research area composed of high plasticity silt (MH).

This soil has a plasticity index value of 16.50 – 32.78%; soil water content value (w) 29.69 – 56.83%; soil density (Gs) 2.3891 – 2.5920 gr/cc; unit weight of soil 1.354 – 2.017 gr/cm$^3$, void ratio 1.308 – 1.896; degree of saturation 50.13 – 72.93%; porosity 57.68 – 65.47%; percentage of gravel 0.20 – 6.36%, percentage of sand 6.68 – 40.40%, percentage of silt 33.02 – 82.5%, and percentage of clay 0.98 – 41.25%. By using the Direct Shear test, this soil unit has an friction of angle of 20.04 – 48.070$^o$ and a cohesion value of 0.1034 – 0.5174 kg/cm$^2$.


Figure 2 High Plasticity Silt Units (MH).

### Laboratory Test Result

From the laboratory test, the cohesion, friction angle, and unit weight are determined and can be seen in table 1.

In the third layer with SW soil type (Well graded sandy soil) taken from surface soil samples, the parameters of physical and mechanical properties in the form of an internal shear angle, cohesion, and soil density were obtained from the author's assumptions based on the typical characteristic of unit weight and cohesion of soil (Lindeburg, 2001) and specific values angle of friction of soil (Obrzud and Truty, 2018) and compared with the results of the physical and mechanical properties of the previous layer. This cause due to the limited data obtained.



E-ISSN : 2579 – 3136


Figure 3 Conditions of the weathering level of the slopes in the study area.

Table 1 Physical and mechanical properties of soil in research area

| No | Sample Code | Angle of Friction (°) | Cohesion (kN/m²) | $\gamma$ (kN/m²) | $\gamma s$ (kN/m²) | Type of Soil (USCS) | Weathering Level of Soil |
|---|---|---|---|---|---|---|---|
| **1** | UDS-AKL | 28.26 | 3.102 | 13.39 | 16.11 | MH 1 | CWZ |
| **2** | UDS-04 | 34.65 | 1.034 | 13.8 | 16.31 | MH 2 | HWZ |
| **3** | ST 58 | 38 | 0 | 14.3 | 17.01 | SW | MWZ |

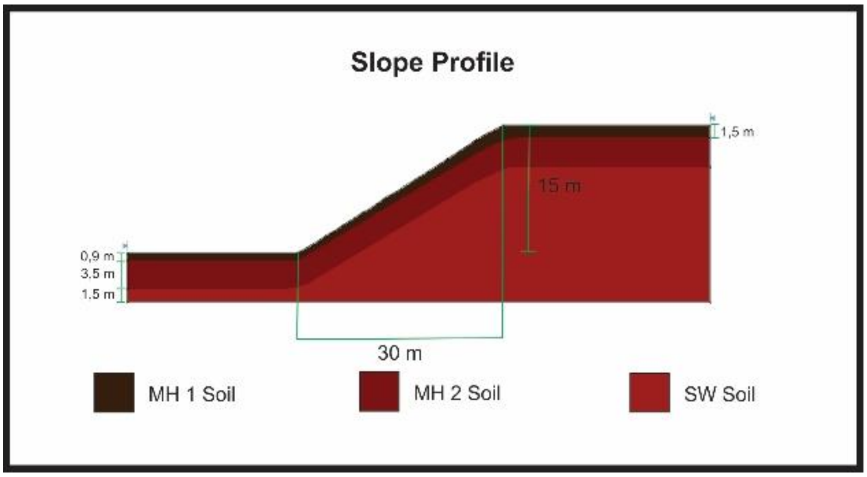



Figure 4 Slope profile in research area.

**Modeled of Slope**

Based on the results of hand drilling and engineering geological mapping, the soil at the study site is composed of three types of soil layers. The constituent material on the body of this slope is high plasticity (MH) silt soil. The thickness of the first soil layer on the results of hand drilling is 1.5 meters thick at the top of the slope and 0.9 meters at the foot of the slope.



E-ISSN : 2579 – 3136

Table 2 Geometry slope profile in research area

| Slope Profile | | |
|---|---|---|
| Height of slope (m) | Overall Slope (°) | Width of Slope (m) |
| 15 | 32 | 30 |

The thickness of the second layer is obtained from the results of the engineering geological mapping in the form of cut of the slopes resulting from land clearing for housing development, which is 3.5 meters. The thickness of the third layer is also obtained from the geological mapping of the research area in the form of cut of the slopes resulting from land clearing for housing construction, which is 1.5 meters. The thickness of the soil is assumed till the bottom of the slope considering the limitations of the data obtained with the consideration that the slope is in the most pessimistic condition. The height of the overall slope is assumed to be 15 meters, according to the thickness of the soil based on the regional engineering geology of the study area (Djaja and Hermawan, 1996).

## SLOPE STABILITY ANALYSIS

Based on the results of the calculations in table 3, shows the FS value obtained from the simulation results in the software after being given variations in the depth of surface water becomes smaller than its normal condition.

Table 3 The results of the calculation of the value of the safety factor with variations in the depth of surface water.

| **No** | **Water Surface Level (m)** | **FS** | **Bowles Classification (1989)** |
|---|---|---|---|
| 1 | *Full Saturated* | 0.317 | Unstable |
| 2 | -1.875 | 0.813 | Unstable |
| 3 | -3.75 | 1.281 | Stable |
| 4 | -7.5 | 1.281 | Stable |
| 5 | *Unsaturated* | 1.281 | Stable |

According to these results, the effect of surface water decreased on the value of the safety factor on the slopes can be connected with a graph (Figure 5).

From the graph, the trend chart is decrease at a depth of 0 (full saturated) to 7,5 meters. The value of the correlation coefficient is r = 0.828 (this obtained from the root of the value of R squared). There's also the formula for the function of surface water depth to the safety factor. The relationship between the value of the safety factor and the depth of the surface water on the slope has a correlation value of 0.828, with a function value of y = 0.0859x + 0.5972. According to Sugiyono (2017), this value is close to accurate because the correlation value is strong.

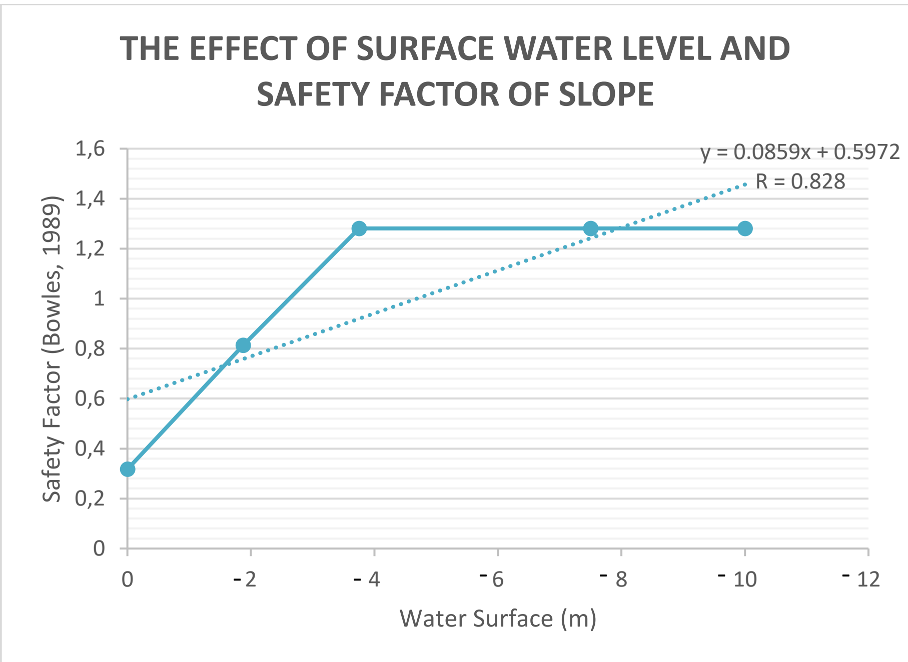



Figure 5 Graph of the relationship between the Value of the Safety Factor and the Depth of Surface Water.



E-ISSN : 2579 – 3136

Table 4 Relationship between Fs (Bishop) value, landslide intensity, and surface water depth (Bowles Modification, 1989).

| **Factor of Safety Values** | **Landslide Intensity** | **Water surface level** |
|---|---|---|
| Fs ≤ 1,07 | Landslides frequently happened | Water surface ≤ 5,5 |
| 1,07 < Fs ≤ 1,25 | Landslide have occurred | 5,5 < Water surface ≤ 7,5 |
| Fs > 1,25 | Landslide rare occurred | Fs > 7,5 |

Based on this equation, the boundary values in the Fs value in the Bowles classification can be modified. For the Fs value of 1.07, the depth of the surface water is 5.5 meters and for the Fs value of 1.25, the depth of the surface water is 7.5 meters. Then the table of relationship values Fs Bowles (1989)can be modified as in the following table

From the simulation results, it can be seen that by using the Bishop method, surface water with a depth of below 7.5 meters can make the slopes in a stable condition. Reduction of surface water on the body of the slope can be done in several ways, depending on the efficiency and economic value. The dewatering process can be done by installing water linning on the wall of the slope or by using a water pump on the slope surface with a certain distance or at a certain location so that surface water on the slope body can be controlled until the slope becomes stable.

## CONCLUSION

Based on the result we get that the slope is stable when the surface water depth is below -7.5 meters. And the slope is in an unstable condition if the depth of the surface water is above -5.5, meters. The decrease in surface water on the slope will increase the value of the safety factor. Further analysis such as groundwater condition, seismic load condition is needed for advance slope stablity analysis on this area.

## ACKNOWLEDGEMENT

The author would like to thank Fajar Abdullah, Nisa Shafira, Muslim Taufiq, Rifqi Dwi and Ghoffar Cahya for assisting the field and processing data.

## REFERENCES

Djaja, Hermawan, 1996. Peta Geologi Teknik Regional Lembar Bandung Skala 100.000.

Lindeburg, M.R., 2001. Civil engineering reference manual for the PE exam, 8th ed. Belmont, CA: Professional Publications.

Obrzud, R.F., Truty, A., 2018. The hardening soil model - a practical guidebook. Zace Serv. Ltd, Softw. Eng. 05, 205.

Silitonga, P.H., 1973. Peta Geologi Lembar Bandung Skala 100.000.

Sugiyono, 2017. Metode Penelitian Kuantitatif, Kualitatif, dan R&D. Bandung : Alfabeta, CV.

Zakaria, Z., 2010. Praktikum Geologi Teknik. Laboratorium Geologi Teknik, Fakultas Teknik Geologi, Universitas Padjadjaran.

Zakaria, Z., 2011. Analisis Kestabilan Lereng. Laboratory of Engineering Geology, Faculty of Geological Engineering, Padjadjaran University.



E-ISSN : 2579 – 3136

Figure 6 Geological Engineering Map Jatinangor and Cimanggung Sub-DIstrict.

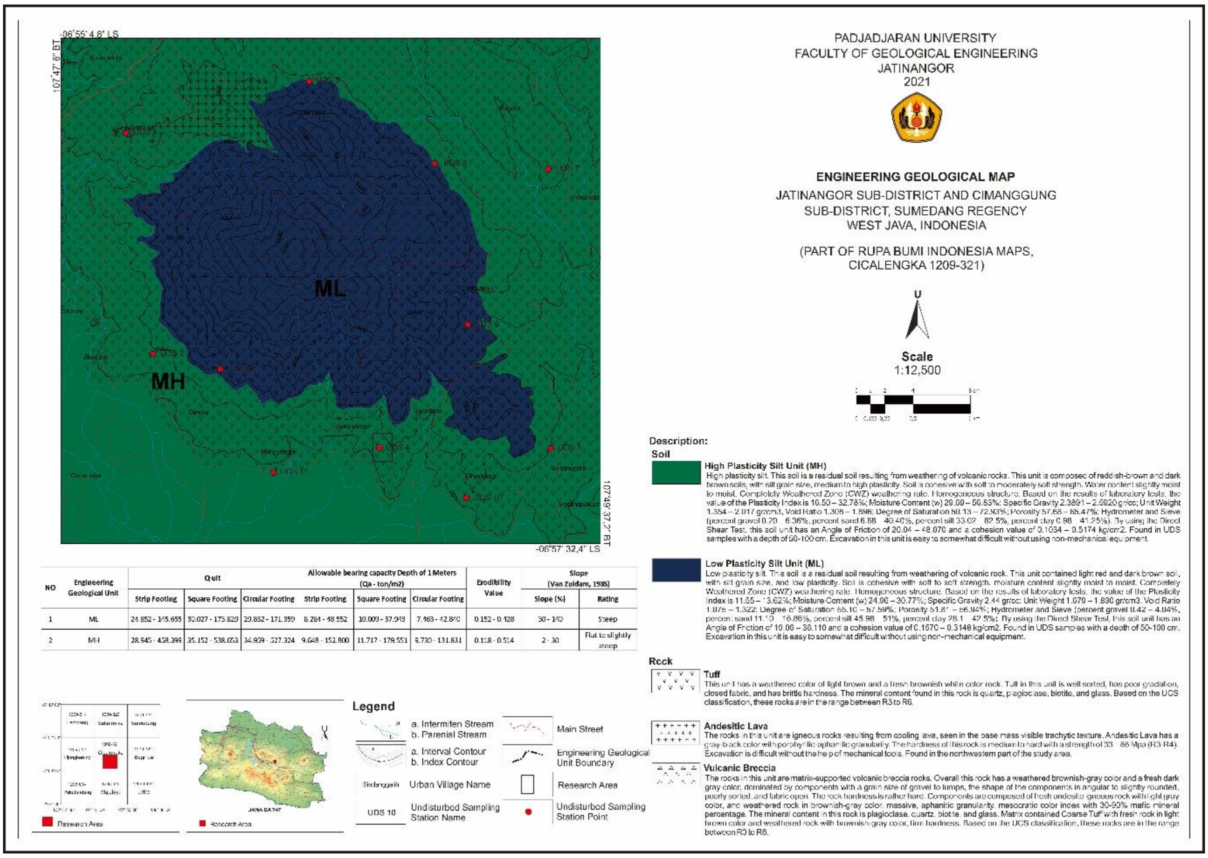
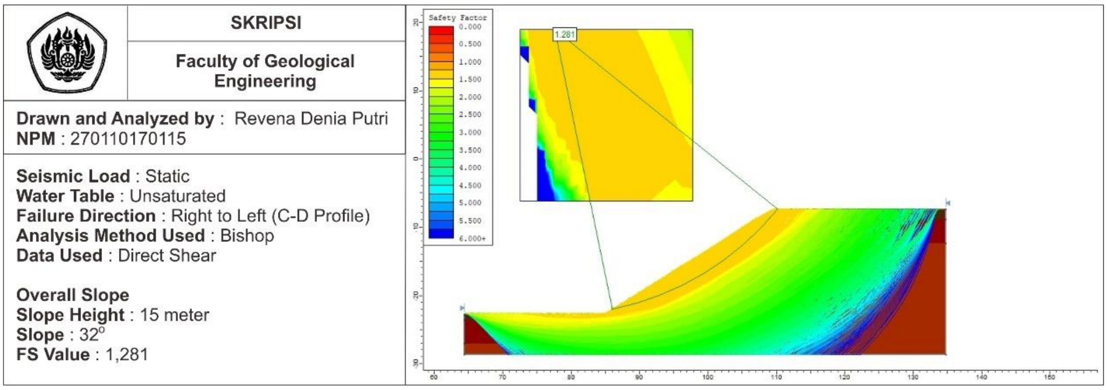



Figure 7 Slope Simulation Results on Unsaturated Surface Water Depth Conditions.






E-ISSN : 2579 – 3136

Figure 8 Slope Simulation Results on Full Saturated Surface Water Depth Conditions.

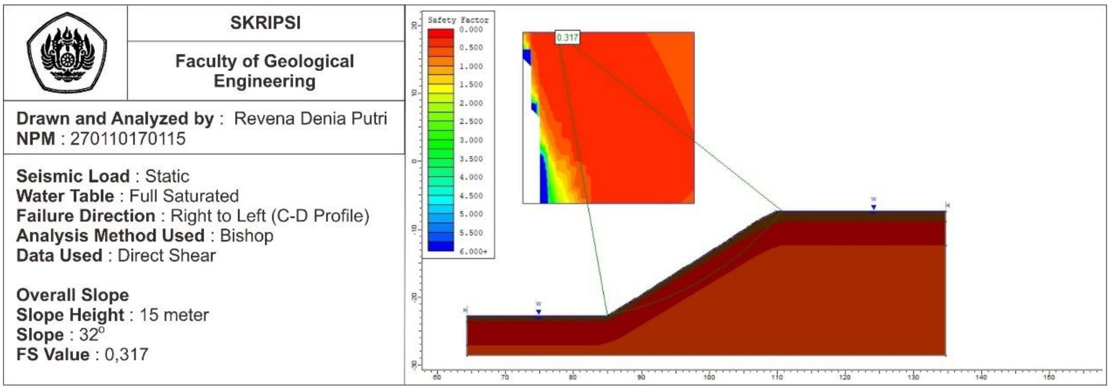
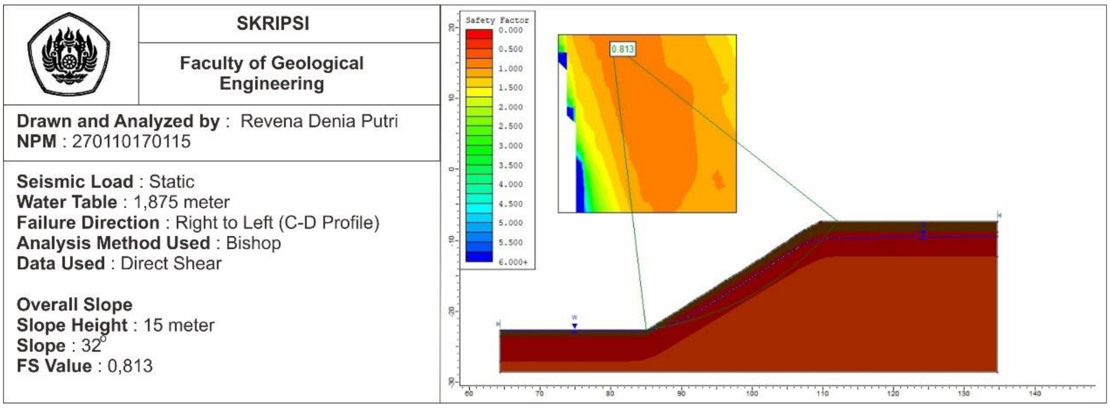



Figure 9 Slope Simulation Results if the depth of the surface water is -1,875 meters below the surface.






E-ISSN : 2579 – 3136

Figure 10 Slope Simulation Results on Conditions if the depth of surface water is -3,75 meters below the surface.

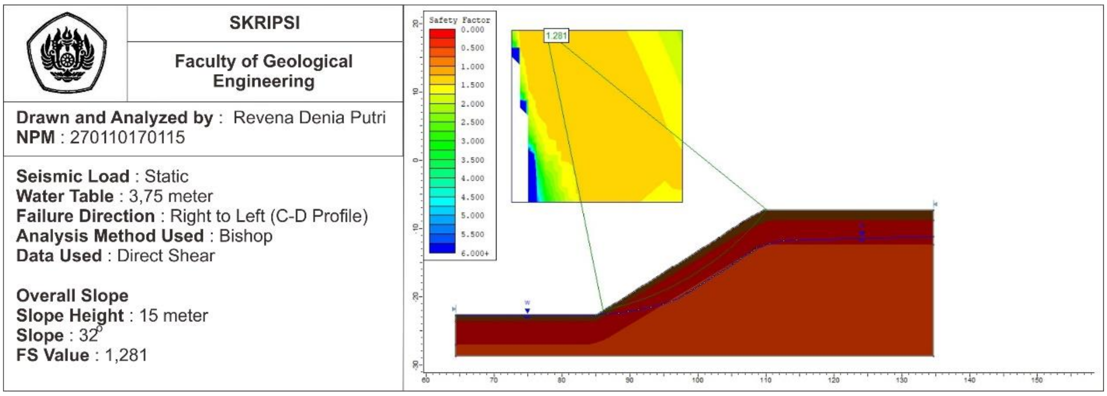
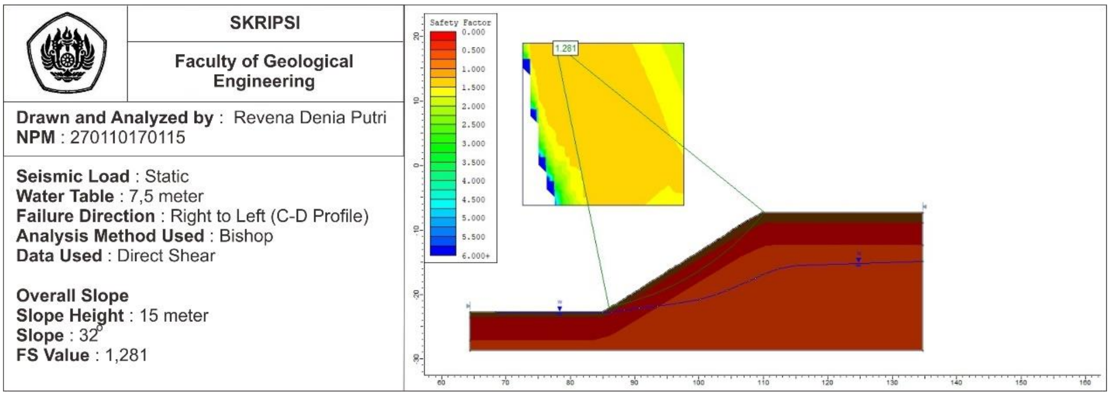



Figure 11 Slope Simulation Results if depth of the surface water is -7,5 meters below the surface.






E-ISSN : 2579 – 3136