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Slope Stability Analysis Based on Safety Factors on Slope CV. Mutiara Timur in Klampok Village, Tongas District, Probolinggo Regency

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Abstract
CV. Mutiara Timur is a company that is applying for a mining business permit for sirtu commodities in Klampok Village, Tongas District, Probolinggo Regency. The planned mining system is open pit mining using the quarry method. From the results of research in the field obtained rock lithology in the form of topsoil, gravel and sand. Where in the slope design later, the topsoil will be peeled off first. The purpose of slope stability analysis is to determine the geometry of the slope by taking into account the safety factor in order to create safe working conditions. Slope stability analysis on CV. Mutiara Timur using the Bishop method using the Slide v6.0 software. Based on the analysis carried out, the recommendation for slope geometry on a single slope is 4 meters high with a slope of 600 so that the no-load safety factor is 1.350 and the safety factor with load is 1.267. In addition, the slope geometry is obtained on the overall slope, which is a total height of 21 meters with a slope of 380 so that the no-load safety factor is 1.243 and the safety factor with the load is 1.239.

1. Introduction

Development in East Java Province, especially infrastructure development is quite rapid. Infrastructure development starts from toll roads, flyovers, bridges, to industrial areas. One of the growing potentials from this infrastructure development is the increasing need and demand for mining commodities, especially industrial minerals [1]. The high demand for mining materials is supported by the large mining potential in East Java Province [2]. One of the industrial minerals that are in great need is sirtu. Sirtu mining materials can be used as the main raw material for the construction of infrastructure and infrastructure. The distribution of sirtu material in Probolinggo Regency is quite abundant, generally found in the northern part and extends from West to East, including in Wonomerto, Lumbang, Tongas, Maron, to Kraksaan Districts. Sirtu is formed from explosive volcanic eruptions which generally form pyroclastic flows and form tuff rocks. These minerals generally have a dark gray to black color. The volcanic material is sourced from volcanic activity in the south of Probolinggo Regency, including: the Bromo-Tengger Mountains Complex, Mount Argopuro, and Mount Lamongan.

CV. Mutiara Timur is a company that is applying for a mining business permit for sirtu commodities in Klampok Village, Tongas District, Probolinggo Regency. The planned mining system is open pit mining using the quarry method. Where open-pit mining activities will not be separated from pit design or slope design. So, it is necessary to analyse the stability of the slope to determine the geometry of the slope by taking into account the safety factor in order to create safe working conditions

2. Methodology

The methodology in this study can be seen in the flow chart as follows:

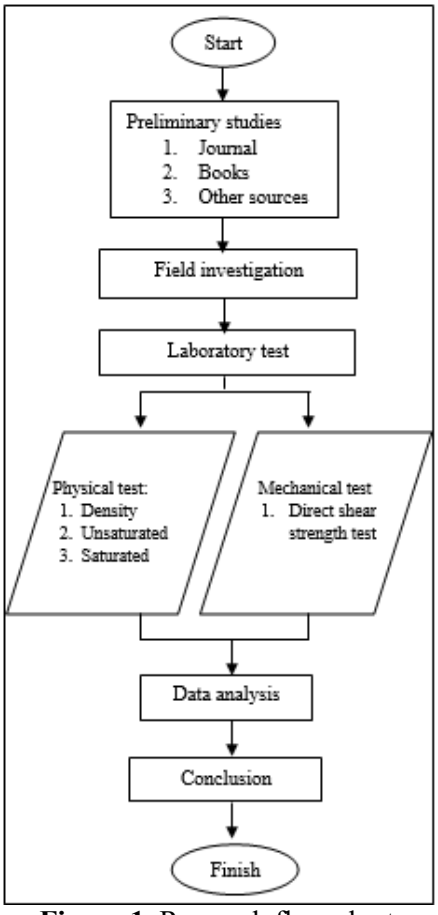

Figure 1. Research flow chart

3. Results

3.1. Pit Geological Conditions CV. Mutiara Timur

The research location is in Klampok Village, Tongas District, Probolinggo Regency, East Java Province. Geological conditions at this location are in the Alluvium (Qa) formation which is composed of claystone, mud, sand, gravel, gravel, boulders and plant remains and is Holocene in age. At the location of this study, there were no features of geological structures in the form of layers, joints or faults.

The morphology in the IUP area is hilly with gentle slopes with a majority slope of <8% leading from South to North. Allotment of land as a moor planted with corn, rice, cassava, peanuts, sengon tree, and teak. The IUP OP location has the lowest elevation of 62 meters above sea level which is located in the north and the highest elevation is 83 meters above sea level which is located in the south of the IUP location, with an elevation difference of 21 meters. The location of the IUP is limited by intermittent rivers located in the east and west with a width of 5-12 meters and has a flow direction from south to north.

3.2. Lithology

Based on the results of observations of outcrops and cliffs of ex-mining openings found at the investigation site and its surroundings, it is known that the study area is composed of volcanic rocks, more precisely pyroclastic rocks covered by topsoil as thick as ± 1 meter. The rocks found at the investigation site are composed of blackish gray volcanic material, compact, have a massive structure, poorly sorted, and open-packed, with a sand-sized matrix, while the fragments are subangular-subrounded with a grain composition of gravel, sand and fine grains. silt-clay). Pyroclastic rocks are rocks formed from explosive volcanic eruptions, generally formed in proximal to medial volcanic facies.

Figure 2. The appearance of rock outcrops at the Mining License location

Figure 3. The appearance of the topsoil that covers the gravel-sand excavation material

3.3. Rock Physical Test Results

Rock physical properties test is carried out to obtain physical properties values in the form of dry volume weight, volume weight or density, porosity, natural water content, void ratio, degree of saturation and specific gravity. The test was carried out in the Soil and Rock Mechanics laboratory of the Department of Civil Engineering, Sepuluh November Institute of Technology. The results of the physical properties test can be seen in table 1.

Table 1. Rock physical test result

No	**Test type**	**Unit**	**Result**
1	Density	gr/cc	1,538
2	Unsaturated density	gr/cc	1.242
3	Natural water content	%	23,711
4	Degree of saturation	%	54,691
5	Porosity	%	53,958
6	Spesific gravity	-	2,699

3.4. Rock Mechanical Test Result

The mechanical properties test carried out is a shear strength test where the test results are in the form of cohesion and internal shear angle. The results of the shear strength test can be seen in table 2.

Table 2. Rock mechanical test result

No test	Normal stress	Shear stress	Cohesion (kg/cm2)	Friction angle (^{0})
1	0,065	0,0690		
2	0,125	0,1000	0,06	34,28
3	0,250	0,1930		

3.5. Safety Factor Analysis

To analyse the stability of a safe slope, it is necessary to model the mine slope design in order to determine the value of the factor of safety (FK) using the Rocscience Slide v6 software. Where in the analysis using the bishop method by entering material define data according to the test results above.

Table 3. Define material

Type of material	Cohesion (kN/m2)	Friction angle (^{0})	Unit weight (kN/m3)
1	5,884	34,28	15,082

Note: 1 gr/cm3 = 9.806 kN/m3; 1 kg/cm2 = 98.0665 kN/m2

The results of the analysis of the calculation of the value of the safety factor (FK) with variations in the value of the slope angle using Rocscience Slide v6.0 software are as follows:

Table 4. The results of a single slope safety factor analysis using Roccsciense Slide v6.0

Height (m)	Slope (^{0})	No-load factor of safety	Safety factor with load	Description
4	50^0	1,604	1,515	Safe
	60^0	1,350	1,267	Safe
	70^0	1,131	1,090	Critical

Table 5. The results of a overall slope safety factor analysis using Roccsciense Slide v6.0

Height (m)	Slope (^{0})	Width (m)	No-load factor of safety	Safety factor with load	Description
21	330	3	1,430	1,424	Safe
	380		1,243	1,239	Safe
	430		1,076	1,071	Critical

Description: Based on the Kobelco handbook, the heavy equipment load of the Kobelco SK200 excavator is 20,700 kg with dimensions as in table IV.5, so that the excavator load is 770.08 kg/m2 or 7.70 kN/m2

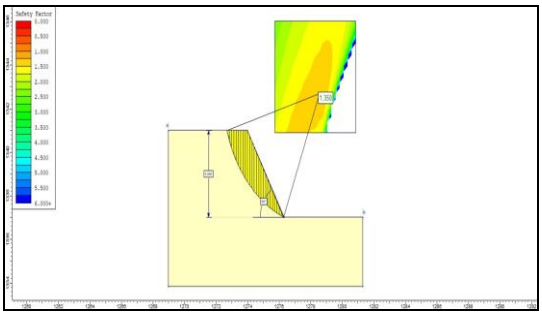

Figure 4. The results of SF analysis on a single slope of 4 m high, a slope of 60^0 without load

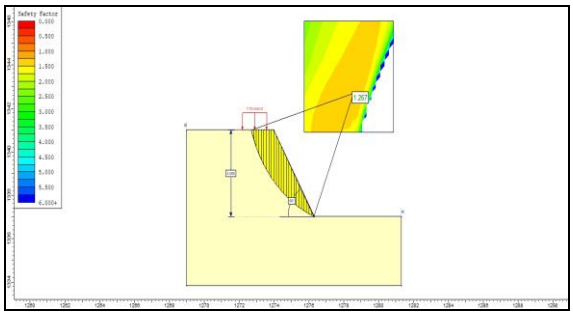

Figure 5. The results of SF analysis on a single slope of 4 m high, a slope of 600 with a load

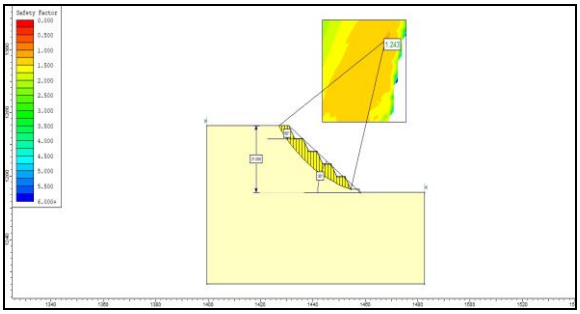

Figure 6. The results of SF analysis on an overall slope of 21 m high, a slope of 28^0 without load

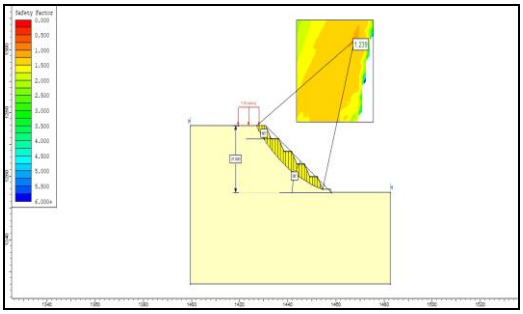

Figure 7. The results of SF analysis on an overall slope of 21 m high, a slope of 28^0 with a load

From the results of the research above, it can be seen that there are two slope geometries that are safe for slope geometry recommendations for IUP CV. Mutiara Timur is a slope geometry with a height of 4 meters with a slope of 500 and 600 for a single slope. As for the overall slope, which is 21 meters high with a slope of 330 and 380 and a slope width of 3 meters. Determination of slope geometry recommendations is not only based on the safety factor but also based on the economics of the slope for mining. So, the recommended slope geometry is one that has a large slope and a safety factor value of more than 1.1.

4. Conclusion

Based on the results and discussion above, it can be concluded that the slope geometry recommendations at the IUP CV. Mutiara Timur in Klampok Village, Tongas Subdistrict, Pasuruan Regency, East Java Province for a single slope is 4 meters high with a slope of 600 obtained FK of 1.267-1.350. While the recommendation for slope geometry for the overall slope is a slope height of 21 m, a slope width of 3 m, an overall slope of 380 so that the FK is 1.239-1,243.

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