SIMULATION OF DISPOSAL SLOPE DESIGN USING THE SPENCER METHOD IN THE SOFT MATERIAL AREA OF PT XYZ, BERAU, EAST KALIMANTAN

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ABSTRACT

PT XYZ is a coal mining company utilizing an open-pit mining system, currently serving as the subject of this research. Every mining activity requires a disposal area to place the residual materials covering the mineral deposits. *This study aims to analyze the disposal slope's stability in accordance with KEPMEN ESDM No.1827 Tahun 2018. The slope design simulations were conducted using limiting variables, like the bench angle of 35°, bench heights of 5 meters and 10 meters, and bench widths of 10 meters, 20 meters, and 30 meters. Input data comprised material properties such as unit weight, cohesion, and internal friction angle for materials including soft clay, dense clay, bund wall, and waste. The data was obtained by tests on basic physical properties and triaxial compression tests. The conditions assumed the slope was saturated groundwater level while considering the earthquake coefficient. This research employed the Spencer method for slope stability analysis, resulting in a safe and volumetrically efficient slope design with bench angle angle of 35°, bench heights of 5 meters, and bench widths of 30 meters with the safety factor 1,11.*

Keyword: Disposal Area, Slope Stability Analysis, Limit Equilibrium Method, Spencer Method

INTRODUCTION

Kalimantan Island holds the most significant potential coal resource reserves in Indonesia. PT XYZ is a company involved in coal mining on Kalimantan Island, utilizing an open-pit mining system. This open-pit mining method has advantages such as shorter operational time, higher production targets, and improved work safety assurances (Arief, 2016).

Every mining activity requires a disposal area to place the residual materials covering the mineral deposits. The eastern disposal area (OPD East) at PT XYZ is the subject of the upcoming research. Geotechnical studies, specifically slope stability analysis, are essential to determine a safe disposal slope design. This research is conducted to prevent potential losses, such as landslides, which could impact the company and its human resources."

LITERATURE REVIEW

Slope Stability

The condition of a slope being in a safe position and not experiencing significant movement or deformation is known as slope stability. The slope is influenced by resisting forces and driving forces. These forces act on a slope, so maintaining slope stability requires careful management of both forces.

Limit Equilibrium Method

The Limit Equilibrium method computes the ratio between the resisting force and the driving force. The resisting force works to prevent slope movement while the driving force causes movement or deformation. This method involves dividing the material along the sliding surface into several slices for calculation.

Spencer Method

The Spencer method is one of the slope stability analysis techniques using the limit equilibrium method. This method divides the slope into small segments, and the forces acting on each segment are identified and analyzed.

$$\frac{X}{E} = \tan \theta = \lambda$$

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Description:
X = Vertical force
E = Horizontal force
λ = Scale of the angle formed by the normal force and the friction force on the slice side
θ = Inclination angle of the resultant force between slice

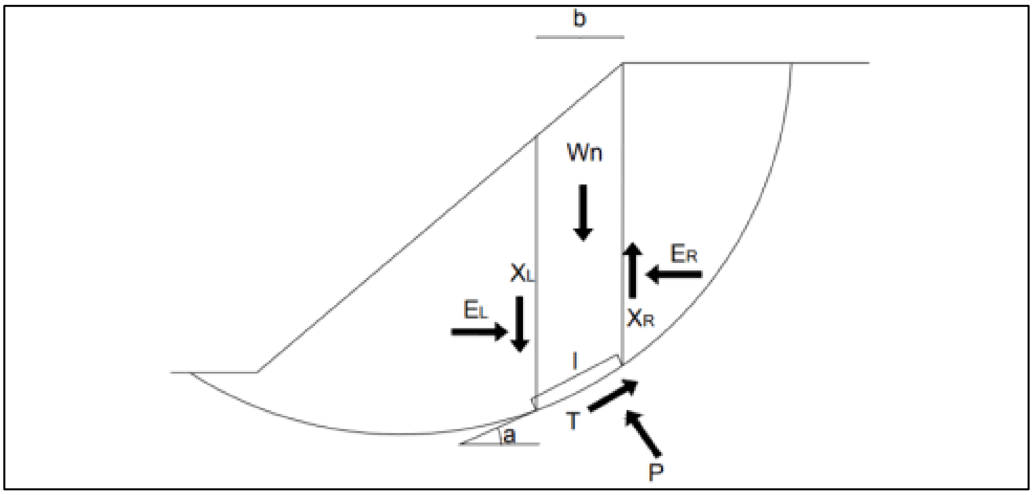

Figure 1 Forces acting on the slip-surface slice using the Spencer Method

Criteria for Safe Slope Engineering.

The safety factor value obtained after performing the slope stability analysis requires a reference to determine whether a slope can be considered safe. In this study, the reference for the safety factor value is based on the Minister of Energy and Mineral Resources Decree No. 1827 of 2018

Table 1 The value of the safety factor and the probability of mining slope failure

Jenis Lereng	Keparahan Longsor (*Consequences of Failure/ CoF*)	Kriteria dapat diterima (*Acceptance Criteria*)		
		Faktor Keamanan (FK) Statis (Min)	Faktor Keamanan (FK) Dinamis (Min)	Probabilitas Longsor (*Probability of Failure*) (maks) *PoF* (FK≤1)
Lereng Tunggal	Rendah s.d. Tinggi	1,1	Tidak ada	25-50%
Inter-ramp	Rendah	1,15-1,2	1,0	25%
	Menengah	1,2-1,3	1,0	20%
	Tinggi	1,2-1,3	1,1	10%
Lereng keseluruhan	Rendah	1,2-1,3	1,0	15-20%
	Menengah	1,3	1,05	10%
	Tinggi	1,3-1,5	1,1	5%

Factors influence the slope stability.

Several factors influence the stability of a safe slope, such as groundwater conditions and the earthquake coefficient. When a slope is saturated, it becomes inundated, accelerating the erosion process and eroding soil material, which decreases the slope's stability. The earthquake coefficient reflects a slope's response to seismic forces generated by an earthquake. These seismic forces result from soil displacement, leading to landslides. The earthquake coefficient value for a particular area is obtained using the Indonesian Earthquake Zoning Map as follows:

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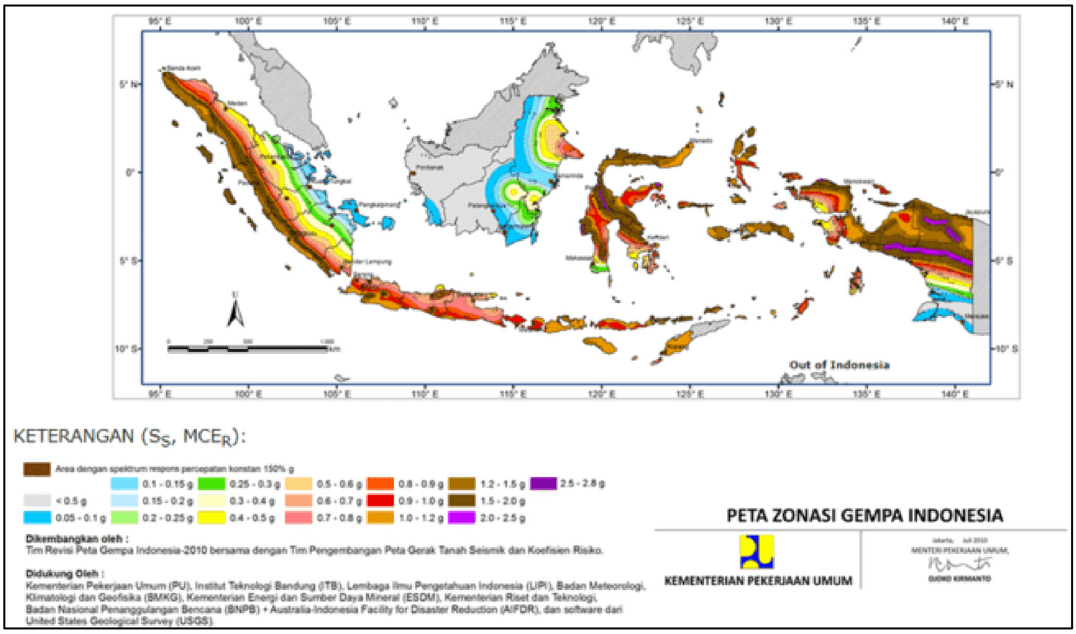

Figure 2 Indonesia's earthquake zoning map according to the Ministry of Public Works

RESEARCH METHOD

The research objects examined in this study include the actual slope geometry, material properties, earthquake coefficient, slope groundwater level, and safety factor criteria based on the reference of Ministerial Decree of Energy and Mineral Resources, KEPMEN ESDM No. 1827 K/30/MEM/2018. This research used literature study, field research, data processing, and analysis. A literature review was conducted on the study area and its regional geological conditions.

In this field research stage, Direct observation of the research area, specifically the Outpit Dump East, was conducted in this field research stage. This stage was carried out periodically to monitor the melting process of the dump material in that area.

The data processing stage utilizes data provided by the company in the form of material properties values obtained through laboratory testing. These include basic physical properties testing and triaxial compression test for mechanical properties. Material properties also has gone through several adjustments through back analysis method. Therefore, it is expected that material properties reflect actual area conditions.

In the studio work stage, slope stability data processing is conducted using geostudio Slope/W software. The process involves simulating slope stability using limiting variables, a 35° bench angle, bench heights of 5 m and 10 m, and bench widths of 10 m, 20 m, and 30 m. The simulations are conducted under saturated slope conditions and with seismic vibration values.

RESULTS AND DISCUSSION

Material in disposal area

The predominant material in the research area consists of claystone with varying densities, namely dense clay and soft clay. Dense claystone has an ash-yellowish color, while soft claystone has an ash-brownish color. This data was obtained based on core data from Pit A at PT XYZ.

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Figure 3 Core results of In-situ Material Drilling from Pit A of PT XYZ

Material Properties Values

The material properties values are obtained through laboratory testing. The unit weight values are obtained through basic physical properties testing, which includes physical property testing. The cohesion and internal friction angle values are obtained through triaxial compression testing. Triaxial compression testing is a destructive test which falls under mechanical property testing.

Table 2 The material property values used in the engineering simulation of disposal slope design

Material	Properties		
	Bobot isi (kN/m^3)	Kohesi (kPa)	Sudut Gesek Dalam (°)
Soft Clay	16,28	12	9
Dense Clay	16,3	110	26,26
Waste	16,28	18	15
Bundwall	16,28	18	15

Soft clay and dense clay are naturally formed in-situ materials at Pit A. Both of these materials are claystone materials with different densities. In addition to the in-situ materials, there are also ex-situ materials, namely waste material and bund wall material, which are essentially the same materials distinguished by their use. These ex-situ materials are a combination of several materials found at Pit A.

Slope Stability Analysis

This simulation is conducted on slope cut A, which is still an actual slope before the formation of a slope. The simulation is carried out using a bench angle of 35°, slope heights of 5 m and 10 m, and bench widths of 10 m, 20 m, and 30 m. The simulation is conducted under saturated slope conditions and considers the seismic coefficient value. The simulation results are considered safe if the safety factor value (FK) is ≥ 1.1 according to the reference of Ministerial Decree of Energy and Mineral Resources KEPMEN ESDM No. 1827 K/30/MEM/2018

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Table 3 Safety factor values from the slope design simulation for section A

Section:	Section A							
Ketinggian Bench	Lebar Bench	Sudut Bench		Banyak Bench				
				1	2	3	4	5
5 m	10 m	35	Nilai Faktor Keamanan	3,64	1,5	1,12	0,97	0,83
	20 m	35		2,95	1,59	1,29	1,1	0,98
	30 m	35		2,27	1,56	1,3	1,19	1,11
10 m	10 m	35		1,43	0,78	0,68	0,6	0,52
	20 m	35		1,22	0,89	0,74	0,67	0,62
	30 m	35		1,24	0,97	0,84	0,77	0,71

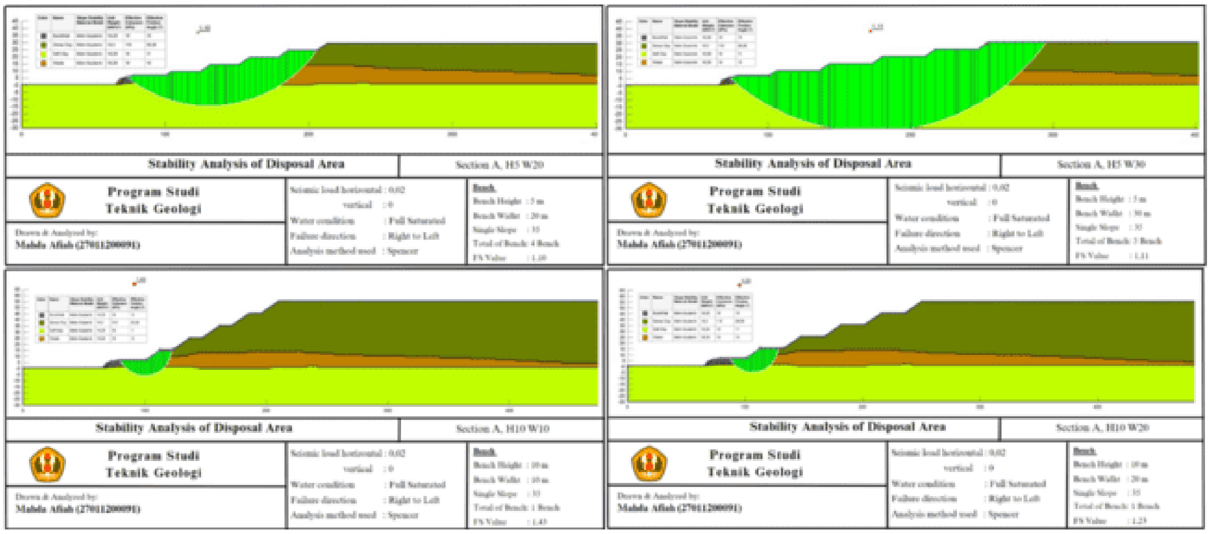

Figure 4 Example the Simulation of the Slope Design

Final design of disposal slope

After several simulations, two safe disposal slope designs with high volume capacity were obtained. These two slope designs were compared to determine which could accommodate the highest volume. This comparison was made by estimating the volume and the result was the final disposal slope design with a bench angle of 35 degrees, bench height of 5 m, and bench width of 30 m with a total of five benches. This slope design was analyzed by considering saturated slope conditions and the seismic coefficient value. The following is the recommended final slope design with a safety factor value of 1.11:

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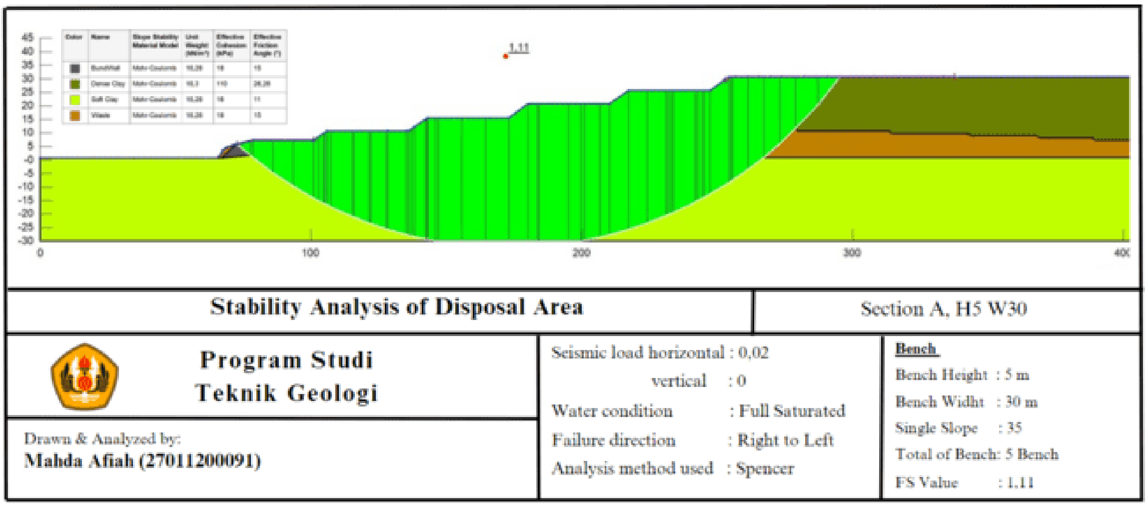

Figure 5 The final recommended slope design for the disposal area section A

CONCLUSION

Based on the core data, the material conditions in the research area are filled with claystone categorized by density, namely dense clay and soft clay. These materials are in-situ materials formed in the research area. There are also ex-situ materials such as waste material and bund wall material. Soft clay has a bulk density value of 16.28 kN/m3, cohesion of 12 kPa, and internal friction angle of 9°. Dense clay has a bulk density value of 16.3 kN/m3, cohesion of 110 kPa, and internal friction angle of 26.26°. Waste material and bund wall material have a bulk density value of 16.28 kN/m3, cohesion of 18 kPa, and internal friction angle of 15°. A safe slope design with the highest values of safety factor and volume capacity was obtained after conducting several slope stability simulations with variables such as a 35° bench angle, slope heights of 5 m and 10 m, and bench widths of 10 m, 20 m, and 30 m. Meeting these requirements resulted in a safety factor value of 1.11, which, according to the reference of Ministerial Decree of Energy and Mineral Resources 1827 K/30/MEM/2018, can be considered safe under saturated slope conditions and considering the seismic coefficient value. From these simulations, it can be concluded that lower bench angles lead to higher safety factor values, wider bench widths lead to higher safety factor values, and fewer benches formed result in higher safety factor values.

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