GEOTECHNICAL MONITORING OF SLOPE STABILITY IN OPEN-PIT MINING AT PT. SEMEN INDONESIA (PERSERO) TBK TUBAN PLANT

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ABSTRACT

PT. Semen Indonesia (Persero), TBK Tuban Plant is a leading state-owned mining company (BUMN) in Indonesia as a cement producer. The company uses the quarry mining method. One thing to consider in quarry mining method is slope stability. This research discusses on geotechnical monitoring of slope stability in the mine openings at PT. Semen Indonesia (Persero), Tbk Tuban Plant, with the aim of evaluating and understanding the geotechnical behavior of slopes in the cement mining environment and identifying potential stability risks. The research methodology involves monitoring slope deformation, geological analysis, and the application of the latest geotechnical software technology. The results of the research in three tested locations at the open-pit mining of IUP Limestone Temandang, IUP Clay Tlogowaru, and IUP Clay Mliwang obtained SF values of 3.196, 2.037, and 3.317 for single slope, and SF values of 1.982, 1.350, and 1.364 for overall slope. Therefore, it can be concluded that the slope geometry tested in the mine openings can be applied because the slope SF values are still stable for single slope. However, for the overall slopes, there are still some that have critical safety factor values, where the minimum SF for both single and overall slopes is ≥1.5. This research is expected to serve as a crucial reference in the development of mine slope stability policies and provide guidance for the implementation of more effective geotechnical monitoring technologies. The implications of the research can give a positive contribution to safety practices and the sustainable operation of the mine at PT. Semen Indonesia (Persero), Tbk Tuban Plant.

Keyword: Slope stability, quarry method, geotechnical monitoring

Introduction

Mining is an economic sector that has been an integral part of human history since prehistoric times. Over time, the mining industry has undergone significant transformations, influenced by factors such as technology, market demand, and regulatory changes.

PT. Semen Indonesia (Persero), Tbk Tuban Plant is a state-owned enterprise engaged in the mining activities of cement production. The main activity of the company is operating the mining of limestone, clay, and clay for cement production processes. According to Das (1993), every type of slope has the possibility of landslides due to the pushing force surpassing the opposing force originating from the shear strength of the soil along the sliding surface.

The formation of slope geometry with specific dimensions in open-pit mining activities can disrupt equilibrium and lead to landslides. Landslide is the downward movement of a mass of soil that occurs on the surface of a weak area (Braja, 2006)

Because most of the mining locations at PT. Semen Indonesia (Persero), Tbk Tuban Plant use an open-pit mining system (quarry), geotechnical monitoring of slope stability needs to be conducted before carrying out mining operations to determine the Safety Factor (SF).

Therefore, the purpose of this research is to monitor the slopes at the IUP Limestone Temandang, IUP Clay Tlogowaru, and IUP Clay Mliwang to draw conclusions about whether the slopes at these three monitoring locations are stable and do not pose a safety threat.

Methodology

Data

The data used in this research are the results of geotechnical monitoring for the stability of the mine openings obtained from PT. Semen Indonesia (Persero), Tbk Tuban Plant. This data includes geotechnical monitoring of the mine openings at IUP Limestone Temandang, IUP Clay Tlogowaru, and IUP Clay Mliwang in August 2023.

Equipment

The equipment used for data collection includes the Total Station SOKKIA and a rolling meter. For processing, AutoCAD Civil 3D and Slide software were employed.

Research Method

The methods used in this research were survey and mapping. The first stage is a literature review, searching for literature such as journals and articles related to geotechnical slope stability. After the literature review, data collection was carried out and will be processed to obtain the numerical geometry of the single slope and overall slopes of each IUP that has been monitored. After being processed, the values for the SF of the single slope and overall slopes will be determined. The safety factor values in practice (Bowles, 1984) can be expressed as Table 1. The stages of this research can be seen in Figure 1.

Table 1. Table of Safety Factor Values

SF	Description
>1.5	Stable
1.07<SF<1.5	Critical
<1.07	Unstable

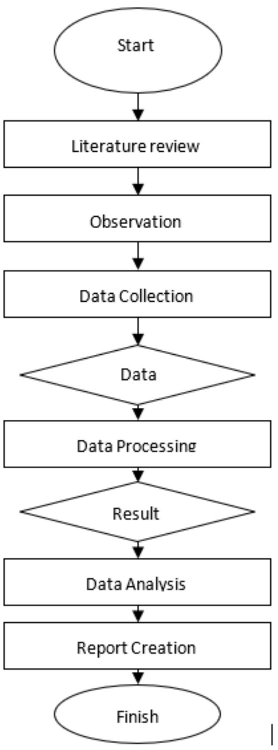

Figure 1. Research Flowchart

Result and Discussion

After monitoring and processing the slope stability in three mine openings, geotechnical monitoring data was obtained for the IUP Limestone Temandang, IUP Clay Tlogowaru, and IUP Clay Mliwang in August 2023.

Table 2. Slope Stability of IUP Limestone Temandang

Slope characteristics	Units
Single slope height	6 meter
Overall slope height	34 meter
Single slope inclination	78°
Overall slope inclination	50°
Single bench width	5 meter
Buffer zone	50 meter

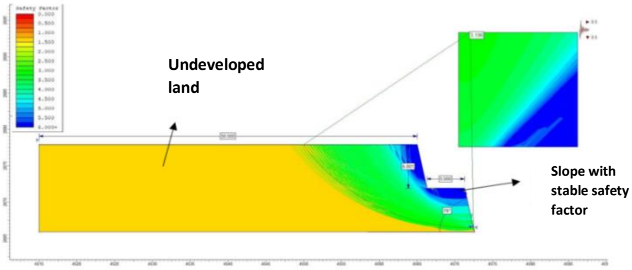

Figure 2. Numerical Modeling of Single Slope (SF = 3.196)

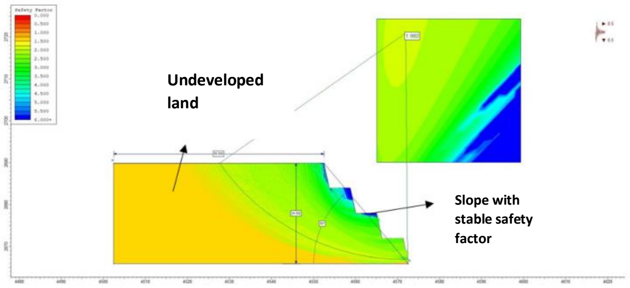

Figure 3. Numerical Modeling of Overall Slopes (SF = 1,982)

At the IUP Limestone location, the required standard slope geometry is a single height of 6 meters, a bench width of 4 meters, and a single slope inclination of 80° with a minimum Safety Factor (SF) for both the single slope and overall slope is ≥1.5.

In addition to using single height, bench width, and slope inclination, there are several factors that influence slope stability, namely density, cohesion, and internal angle. From the processing results, the density obtained is 2.040 g/cm³ and 19.922 kN/m³. The cohesion value obtained is 2.610 kg/cm² and 256.041 kN/m². The internal angle obtained is 26.570 degrees.

Based on the monitoring results and calculations, a Single Slope SF of 3.196 and an Overall Slope SF of 1.982 were obtained.

From this data, it can be concluded that the slope at the testing location is stable.

Table 3. Slope Stability of IUP Clay Tlogowaru

Slope characteristics	**Units**
Single slope height	2 meter
Overall slope height	8 meter
Single slope inclination	45°
Overall slope inclination	25°
Single bench width	3 meter
Buffer zone	50 meter

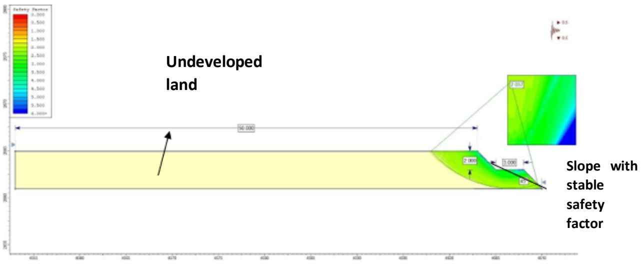

Figure 4. Numerical Modeling of Single Slope (SF = 2,037)

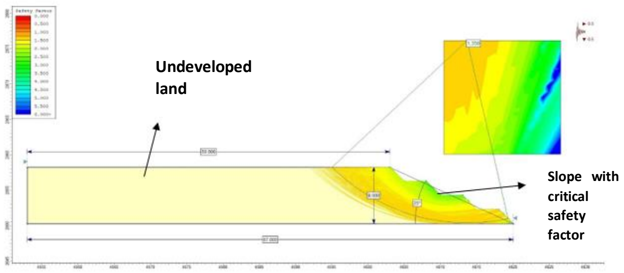

Figure 5. Numerical Modeling of Overall Slopes (SF = 1,350)

At the IUP Clay Tlogowaru, the required standard slope geometry is a single height of 2 meters, a bench width of 2 meters, and a single slope inclination of 45° with a minimum Safety Factor (SF) for both the single slope and overall slope is ≥1.5.

In addition to using single height, bench width, and slope inclination, there are several factors that influence slope stability, namely density, cohesion, and internal angle. From the processing results, the density obtained is 2.510 g/cm³ and 24.598 kN/m³. The cohesion value obtained is 0.520 kg/cm² and 51.012 kN/m². The internal angle obtained is 19.260 degrees.

Based on the monitoring results and calculations, a Single Slope SF of 2.037 and an Overall Slope SF of 1.350 were obtained. From this data, it can be concluded that the single slope at the testing location is stable, but the overall slope is still considered critical

Table 4. Slope Stability of IUP Clay Mliwang

Slope characteristics	**Units**
Single slope height	2 meter
Overall slope height	20 meter
Single slope inclination	35°
Overall slope inclination	23°
Single bench width	2 meter
Buffer zone	50 meter

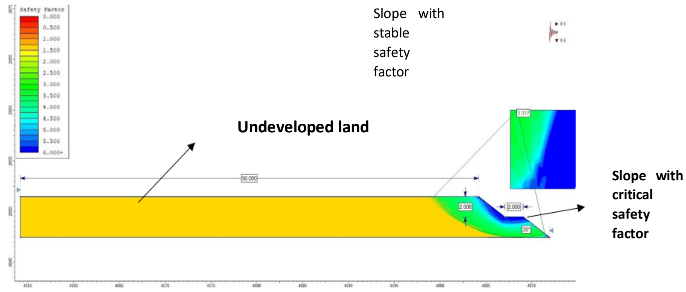

Figure 6. Numerical Modeling of Single Slope (SF = 3,317)

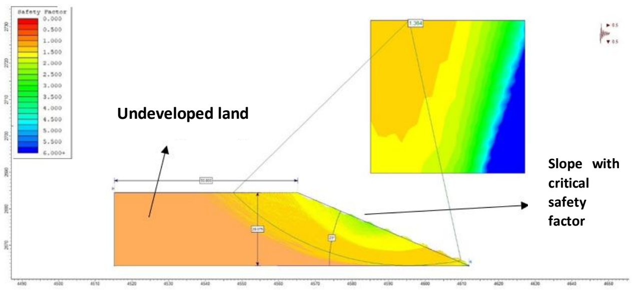

Figure 7. Numerical Modeling of Overall Slopes (SF= 1,364)

At the Clay Mliwang Quarry location, the required standard slope geometry includes a single slope height of 2 meters, a bench width of 2 meters, and a single slope inclination of 45°, with a minimum Single Slope and Overall SF of ≥1.5.

In addition to using single height, bench width, and slope inclination, there are several factors that influence slope stability, namely density, cohesion, and internal angle. From the processing results, the density obtained is 2.330 g/cm³ and 22.834 kN/m³. The cohesion value obtained is 0.820 kg/cm² and 80.442 kN/m². The internal angle obtained is 27.520 degrees.

Based on the monitoring results and calculations, a Single Slope SF of 3.317 and an Overall Slope SF of 1.364 were obtained. From this data, it can be concluded that the single slope at the testing location is stable, but the overall slope is still considered critical.

Conclusion

Monitoring of slope progress is conducted monthly, in accordance with the open-pit mining or the IUPs managed by the company. To determine the slope stability level of each IUP, data is collected for single slope height, overall slope height, single slope inclination angle, overall slope inclination angle, single bench width, and buffer zone.

The processing is carried out using the simplified bishop method. Several factors affecting stability include bench geometry, bulk density, cohesion, and internal friction angle.

In this study, slope geometry testing was conducted on the open-pit mining of IUP Limestone Temandang, IUP Clay Tlogowaru, and IUP Clay Mliwang in August 2023. The results obtained from observation and data processing are as follows:

- At the IUP Limestone Temandang the minimum Safety Factor (SF) for the single slope and overall slope is ≥1.5, a Single Slope SF of 3.196 and an Overall Slope SF of 1.982 were obtained. From this data, it can be concluded that the slope at the testing location is stable.
- At the IUP Clay Tlogowaru the minimum Safety Factor (SF) for the single slope and overall slope is ≥1.5, a Single Slope SF of 2.037 and an Overall Slope SF of 1.350 were obtained. From this data, it can be concluded that the single slope at the testing location is stable, but the overall slope is still considered critical.
- At the IUP Clay Mliwang the minimum Safety Factor (SF) for the single slope and overall slope is ≥1.5, a Single Slope SF of 3.317 and an Overall Slope SF of 1.364 were obtained. From this data, it can be concluded that the single slope at the testing location is stable, but the overall slope is still considered critical

References

[1] I.Y.N. Afani, B.D. Yuwono, & N. Bashit, Optimalisasi pembuatan peta kontur skala besar menggunakan kombinasi data pengukuran terestris dan foto udara format kecil, *Jurnal Geodesi UNDIP.* ***8***(1) (2019) 180-189.

[2] S. Ahdan, & S. Setiawansyah, Pengembangan sistem informasi geografis untuk pendonor darah tetap di bandar lampung dengan algoritma dijkstra berbasis android, *Jurnal Sains Dan Informatika*: *Research of Science and Informatic*. 6(2) (2020) 67–77.

[3] M. Ariandi, & P. Eka. Data spasial dan non spasial penyebaran penduduk di Kecamatan Rambutan, *Proceeding Seminar Nasional APTIKOM (SEMNASTIKOM).* (2016) 292-297. ISSN 978 - 602 - 17488 - 1 – 7.

[4] A.W. Bishop, The use of slip circle in the stability of analysis of slopes, *Geotechnique*. **5** (1955) 7.

[5] J.E. Bowles, Physical and Geotechnical Properties of Soils, McGrawHill,Inc., USA, 1984.

[6] B.M.E. Noor, M.B. Indrasurya, Mekanika Tanah (Prinsip-prinsip Rekayasa Geoteknik), Surabaya: Erlangga, 2006.

[7] B.M.E. Noor, M.B. Indrasurya, Mekanika Tanah (Prinsip-prinsip Rekayasa Geoteknik), Surabaya: Erlangga, 1993.

[8] Gistut, Sistem Informasi Geografis. Gramedia Pustaka Utama, 1994.

[9] I. Edy, Sistem Informasi Geografis : Prinsip Dasar dan Pengembangan Sistem, Yogyakarta: Digibooks, 2013.

[10] IW Nuarsa, Belajar Sendiri Menganalisis Data Spasial Dengan Software ARCVIEW GIS 3.3 untuk Pemula, Jakarta: PT Alex Media Computindo, 2005

[11] Y. Rahmanto, S. Hotijah, & Damayanti, Perancangan sistem informasi geografis kebudayaan lampung berbasis mobile, *JDMSI*. **1**(3) (2020) 19–25.

[12] S. Rostianingsih, G. Kartika, & H. Ivan, 2004. Pemodelan peta topografi ke objek tiga dimensi, *Jurnal Informatika.* **5**(1) (2004) 14 – 21.