IOP Conference Series: Earth and Environmental Science

Preface

To cite this article: 2024 *IOP Conf. Ser.: Earth Environ. Sci.* **1339** 011001


6TH
International Conference of Earth Science, Mineral and Energy
ICEMINE
"Accelerating the Advancements in Lower Carbon Energy for A Sustainable Environment"
2023

IOP Conf. Series: Earth and Environmental Science 1339 (2024) 011001 doi:10.1088/1755-1315/1339/1/011001

Preface

Greetings and a warm welcome to the expansive compilation of research and scholarly contributions presented in the Proceedings of the ICEMINE 2023. In the spirit of intellectual exploration and collaboration, this voluminous collection encapsulates the diverse and profound discussions that unfolded during the conference. As we delve into the following pages, readers will encounter a comprehensive exploration of knowledge, innovation, and interdisciplinary collaboration within the overarching theme of ICEMINE 2023.

ICEMINE 2023 is the 6th International Conference hosted by the Faculty of Mineral Technology, Universitas Pembangunan Nasional "Veteran" Yogyakarta, Indonesia. The conference was held at Grand Keisha Hotel, Yogyakarta, Indonesia, on the 9th of November 2023. The theme of this year's program is *"Accelerating the advancements in lower carbon energy for a sustainable environment"*.

We extend our appreciation to our esteemed partner university, whose unwavering dedication and scholarly contributions have significantly enriched the contents of this conference proceedings. In collaboration with our partner universities, Trisakti University and PEM Akamigas, UPN Veteran Yogyakarta creates an academic platform that fosters diverse perspectives, innovative ideas, and interdisciplinary exchange. Their insightful research and collaborative spirit have undeniably elevated the quality of discourse within our academic community, fostering an environment conducive to intellectual growth and innovation.

Furthermore, we would like to express our profound gratitude to our sponsors, whose generous support has been pivotal in bringing this event to success. Their unwavering commitment to advancing research and cultivating intellectual exchange underscores the importance of their role in shaping the trajectory of our academic disciplines.

Reflecting on Sustainability in Indonesia

In recent years, the imperative to decrease carbon emissions and shift towards energy sources with lower carbon footprints has become exceptionally crucial. Emphasizing the importance of transitioning to cleaner energy sources is paramount for preserving our environment and addressing climate change. The significance of advancing lower carbon energy technologies cannot be overstated, as they play a vital role in mitigating the adverse impacts of climate change and ensuring a sustainable environment for future generations. As scholars and researchers, we carry a distinct responsibility to accelerate the development of these technologies, driving innovation, encouraging critical thinking, and offering the expertise and solutions needed to forge a more sustainable future.

The chosen theme for ICEMINE 2023, *Accelerating the advancements in lower carbon energy for a sustainable environment,* resonates with the evolving landscape of academic inquiry and technological advancement. This theme has served as a catalyst for researchers to delve into various aspects, spanning the theoretical frameworks to practical applications. The rich tapestry of this proceedings volume mirrors the comprehensive exploration undertaken by the conference participants, representing a mosaic of perspectives that collectively contribute to the ongoing narrative of Sustainability.

Within this volume lies a plethora of research, articles, case studies, and theoretical explorations carefully curated from the vast pool of submissions and presentations at the conference. These contributions, emanating from a global community of earth science scholars, reflect the breadth and depth of insights shared during ICEMINE 2023. The contributions cover a wide spectrum of earth sciences, which are:

1. Geological Science and Engineering
2. Geophysics, Geomatics and Geochemistry
3. Earth Resources Project Evaluation and Valuation
4. Petroleum and Geothermal Engineering
5. Mining and Metallurgical Engineering
6. Taxation and Policy
7. Conservation, Geoheritage and Geopark
8. Disaster Management
9. Reclamation and Environmental Issues

Navigating the future: a vision for what lies ahead

As we engage with the contents of this proceedings volume, let us not only celebrate the documented achievements but also contemplate the trajectory of our respective fields. The ideas presented here have the potential to seed new research directions, innovative solutions, and transformative advancements. Readers are encouraged to interact critically with the content, fostering discussions and collaborations that transcend traditional academic silos. The interdisciplinary nature of the contributions invites us to explore the intersections of knowledge, where groundbreaking ideas often emerge from the convergence of diverse perspectives. May the knowledge shared within this volume inspire future generations, spark new avenues of inquiry, and contribute to the advancement of our collective understanding.

Cordially yours,

Dr. Widyawanto Prastistho

Chairperson ICEMINE 2023

Steering Committee

Dr. Ir. Sutarto, M.T.
Geological Engineering, Universitas Pembangunan Nasional Veteran Yogyakarta

Dr. Ir. Barlian Dwinagara, M.T.
Mining Engineering, Universitas Pembangunan Nasional Veteran Yogyakarta

Dr. Ir. Basuki Rahmat, M.T.
Geological Engineering, Universitas Pembangunan Nasional Veteran Yogyakarta

Ir. Bambang Bintarto, M.T.
Petroleum Engineering,Universitas Pembangunan Nasional Veteran Yogyakarta

Organizing Committee

Chairperson
Dr. Widyawanto Prastistho
Environmental Engineering, Universitas Pembangunan Nasional Veteran Yogyakarta

Vice Chair
Yohana Noradika Maharani, PhD
Disaster Management, Universitas Pembangunan Nasional Veteran Yogyakarta

Secretary
Lysa Dora Ayu Nugraini, S.T., M.T.
Geomatics Engineering, Universitas Pembangunan Nasional Veteran Yogyakarta

Husna Muizzati Shabrina, S.T., M.T.
Environmental Engineering, Universitas Pembangunan Nasional Veteran Yogyakarta

Finance
Intan Paramita Haty, S.T., M.T.
Geological Engineering, Universitas Pembangunan Nasional Veteran Yogyakarta

Dian Rahma Yoni, S.T., M.Eng.
Geological Engineering, Universitas Pembangunan Nasional Veteran Yogyakarta

Sponsorship
Dr. Kharisma Idea, S.T., M.T.
Petroleum Engineering, Universitas Pembangunan Nasional Veteran Yogyakarta

Editorial and Article Management
Moch Prahastomi Muttahari S, S.T., M.Sc
Geological Engineering, Universitas Pembangunan Nasional Veteran Yogyakarta

M Firdaus Al Hakim, ST, M.Eng
Geophysical Engineering, Universitas Pembangunan Nasional Veteran Yogyakarta

Publication and Program
Nuha Amiratul Afifah, S.T., M.Eng
Environmental Engineering, Universitas Pembangunan Nasional Veteran Yogyakarta

Peter Pratistha Utama, S.T., M.Eng
Geological Engineering, Universitas Pembangunan Nasional Veteran Yogyakarta

Riska Aprilia Triyadi, S.T., M.Eng
Enivornmental Engineering, Universitas Pembangunan Nasional Veteran Yogyakarta

IOP Conf. Series: Earth and Environmental Science 1339 (2024) 011001 doi:10.1088/1755-1315/1339/1/011001

Scientific Committee

Head of Scientific Committee

Moch Prahastomi Muttahari S., S.T., M.Sc.
Geological Engineering, UPN Veteran Yogyakarta

Editorial Board

Indriati Retno Palupi, S.Si., M.Si
Geophysical Engineering, UPN Veteran Yogyakarta

Dr. Widyawanto Prastistho, ST., M.Eng
Environmental Engineering, UPN Veteran Yogyakarta

Yohana Noradika Maharani, S.T., M.Eng., Ph.D.
Disaster Management, UPN Veteran Yogyakarta

Steven Chandra, S.T., M.T.
Petroleum Engineering, ITB

Muhamad Firdaus Al Hakim, S.T., M.T.
Geophysical Engineering, UPN Veteran Yogyakarta

Lysa Dora Ayu Nugraini, S.T. M.T.
Geomatics Engineering, UPN Veteran Yogyakarta

Wahyu Hidayat, S.T., M.T.
Geophysics Engineering, UPN Veteran Yogyakarta

Naufal Setiawan, S.T., M.Sc.
Geomatics Engineering, UPN Veteran Yogyakarta

Hasan, Tri Atmojo, S.T., M.T.
Geological Engineering, UPN Veteran Yogyakarta

Setia Pambudi, S.T., M.Sc. RWTH
Geological Engineering, UPN Veteran Yogyakarta

Dian Rahma Yony, S.T., M.T.
Geological Engineering, UPN Veteran Yogyakarta

Dr. Kharisma Idea, S.T., M.T.
Petroleum Engineering, UPN Veteran Yogyakarta

RR. Desi Kumala Isnani, S.T., M.Eng
Geological Engineering, UPN Veteran Yogyakarta

Nuha Amiratul Afifah, S.T., M.T
Environmental Engineering, UPN Veteran Yogyakarta

Husna Muizzati Shabrina, S.T., M.T.
Environmental Engineering, UPN Veteran Yogyakarta

Peter Pratistha Utama, S.T.., M.Eng
Geological Engineering, UPN Veteran Yogyakarta

Dr Shindy Rosalia, S.T., M.T.
Geophysical Engineering, ITB

Septyo Uji Pratomo, S.T., M.T.
Geological Engineering, UPN Veteran Yogyakarta

Ristiyan Ragil Putradianto, S.T., M.T.
Petroleum Engineering, UPN Veteran Yogyakarta

Allen Haryanto Lukmana, S.T., M.T.
Petroleum Engineering, UPN Veteran Yogyakarta

Dr. Shofa Rijalul Haq, S.T., M.Eng
Mining Engineering, UPN Veteran Yogyakarta

6TH International Conference of Earth Science, Mineral and Energy ICEMINE "Accelerating the Advancements in Lower Carbon Energy for A Sustainable Environment" 2023

KEYNOTE SPEAKERS

BEST PRESENTERS

Naufal Setiawan	The Prospect of Typhoon Landfall Observation Utilizing L-band InSAR	Geomatics Engineering UPNVY
Andra Y Ginting	The Effectiveness of Soil Washing as a Remediation Method on Oil Spill Contaminated Soil (Case Study: Wonocolo Traditional Oil Mine)	Environmental Engineering UPNVY
Muhammad Irvingia Al Farizzi	Telomoyo Volcano Complex Geotourism: An In-Depth Analysis and Future Development	Geological Engineering UPNVY
David Michael	Optimizing the Impact of Rheological Properties on Bentonite Prehydrated- Based Drilling Mud Through the Utilization of Prehydration	Trisakti University
Muhammad Naufal Hisya Himendra	Comparative Analysis of The Use Emulsion and Watergel Explosive on Fragmentation at PT Dahana Site Kaltim Jaya Bara, East Kalimantan	Mining Engineering, Trisakti University
Nungky N. Wijayanti	Determination of Perforation to Obtain the Optimum Rate in "NKY" Well Of "MWA" Field	Petroleum Engineering, UPNVY
Kyeong Park	Geoparks and Sustainability - Korean Case	Sungshin Women's University, South Korea

Table of contents

Volume 1339

2024

← Previous issue Next issue →

The 6th International Conference on Earth, Science, Mineral, and Energy 09/11/2023 - 09/11/2023 Yogyakarta, Indonesia

Accepted papers received: 12 April 2024

Published online: 13 May 2024

Open all abstracts

Preface

Geological Science and Engineering

Geophysics, Geomatics and Geochemistry

Petroleum and Geothermal Engineering

Mining and Metallurgical Engineering

Conservation, Geoheritage and Geopark

Disaster Management

Reclamation and Environmental Issues

JOURNAL LINKS

IOP Conference Series: Earth and Environmental Science

PAPER • OPEN ACCESS

Analysis of the Influence of Groundwater Level on Slope Stability at Highwall PT. X, South Kalimantan

To cite this article: Abi Setyananda *et al* 2024 *IOP Conf. Ser.: Earth Environ. Sci.* **1339** 012029

Analysis of the Influence of Groundwater Level on Slope Stability at Highwall PT. X, South Kalimantan

Abi Setyananda[1)], Pantjanita Novi Hartami[1*)], Yuga Maulana[1)], Edy Jamal Tuheteru[1)], Mixsindo Korra Herdyanti[1)], Danu Putra[1)]

[1]Departement of Mining Engineering, Faculty of Earth Technology and Energy, Universitas Trisakti.

*Corresponding author: nita2389@trisakti.ac.id

Abstract. Mine slope design is an important part of mining operations because it is used to determine the balance between mine economy and operational safety. In the mine slope design there will also be a groundwater level design, the groundwater level is one of the triggers for a slide to occur. Therefore, this study aims to determine the effect of the groundwater level on the stability of the highwall slope cross section A-A' as well as to determine the factor of safety value and probability of slope failure under various conditions of high groundwater levels. This research method uses quantitative methods because there are numerical data that will be used to calculate the value of slope stability. Slope stability analysis uses the “morgenstern-price” boundary equilibrium and the “monte-carlo” landslide probability. From the research results it is known that the higher the groundwater level, the lower the safety factor value because the presence of groundwater can reduce slope stability causing a decrease in soil shear strength due to increased pore water pressure. In addition, the weight of the material will increase due to the presence of groundwater, which causes the driving force on the slope to also increase. In addition, the movement of air in the soil can cause seepage forces which can affect slope stability. The lowest safety factor value is at the groundwater level 100% of the overall slope height, in conditions of 100% of the overall slope height, the deterministic safety factor value is 1.337, the mean safety factor is 1.358, and 0% hazard susceptibility.

Keywords: groundwater level, safety factor, limit equilibrium, probability of failure

1. Introduction

Slopes are inclined surfaces that connect two areas at different elevations. They can form naturally or be constructed by humans. Designing mine slopes is a crucial part of mining operations because it's used to determine the balance between mining cost-effectiveness and operational safety [1]. In designing mine slopes, the design of the groundwater level height is essential, as it's one of the triggers for slope failure due to increased material weight and decreased shear strength of the slope constituents [2]. Mining activities, such as excavating a slope, lead to significant changes in the forces acting on the slope, potentially disturbing its stability and causing possible landslides.

PT. X is a company involved in coal mining located in the Tanah Laut Regency, Panyipatan District, South Kalimantan Province, planning to employ an open-pit mining system that seen in Figure 1. PT. X has designed the highwall slope geometry of the mine until completion.

Changes in the groundwater level height are considered to assess the most critical slope conditions. As this height affects slope stability, a graph is created to illustrate the relationship between the groundwater level height, the safety factor, and the probability of landslides [3,4]. This graph helps determine how changes in the groundwater level height influence the safety factor and the likelihood of landslides. Therefore, analyzing the influence of the groundwater level height on slope stability is essential to understand its impact on the safety factor and the probability of landslides.

Figure 1. Location of PT. X, where the research was conducted

2. Research Methodology

The research method used is a quantitative method. This method is chosen due to the presence of numerical data that will be used to calculate the slope stability values [5]. The study uses various data, including primary and secondary data. Primary data is obtained from direct testing in the laboratory, involving testing the physical and mechanical properties of rocks, which include tests for physical properties, direct shear testing, and uniaxial compressive strength testing. From the laboratory testing conducted, values for cohesion, internal friction angle, dry and saturated unit weight, and uniaxial compressive strength are obtained. The data resulting from the laboratory tests are used as input parameters in conducting slope stability analysis. Secondary data is obtained from the geotechnical department of PT. X. The secondary data used in this analysis includes slope design, slope sections, borehole lithology, and slope types.

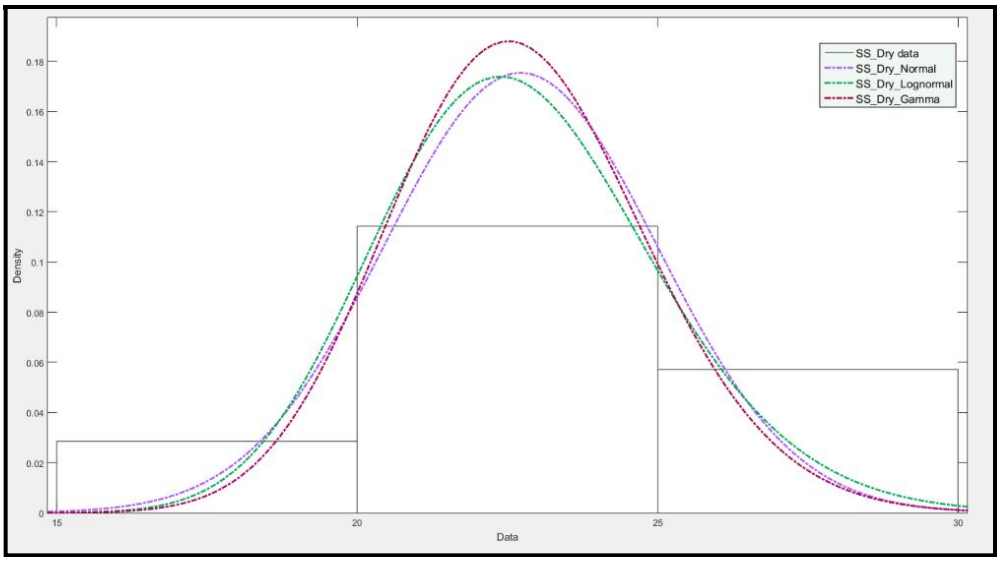

Figure 2. Example of a fitting test for sandstone material

The test results data will undergo a fitting test to obtain the best distribution that will be used as input parameters during the stability analysis, seen in figure 2. An example of the fitting test process can be seen in Figure 1. After the fitting test process for all materials has been completed, the next step is to design the mine slope in accordance with the section lines. Subsequently, slope analysis is performed uses Slide2, which is licensed software that adopts the finite element method from Rocscience Inc. to determine the values of the safety factor and the probability of landslides, as depicted in Figure 3.

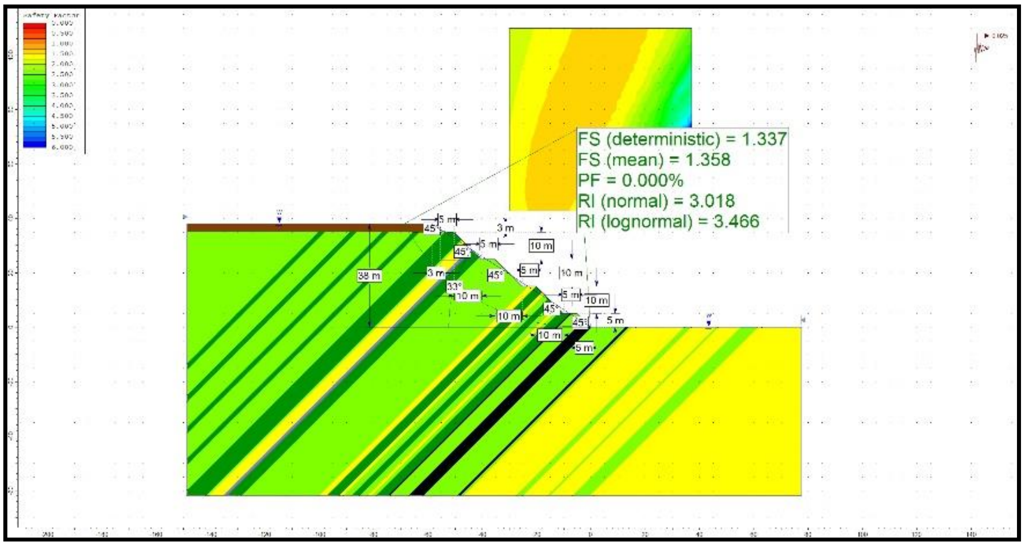

Figure 3. Example of an overall highwall slope analysis for cross section A-A'

The safety factor is calculated using the limit equilibrium method "Morgenstern-Price," while the probability of landslides is determined using the "Monte Carlo" method [6,7].

2.1 Morgenstern Price

The Morgenstern-Price method uses the same assumptions as the general limit equilibrium method, which implies a relationship between the shear forces between slices and the normal forces between slices, expressed by equation below [8].

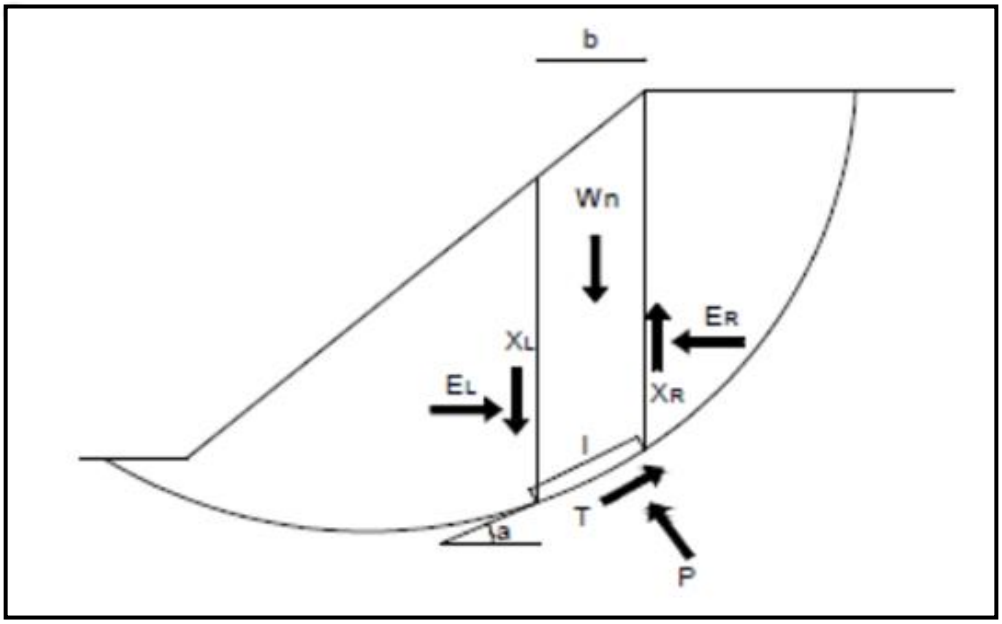

Figure 4. Forces acting on each slice

$$X = \lambda f(x)E \tag{1}$$

In the equation above, it shows that X is the shear force around the slice, λ is lambda, f(x) is the function of normal force, and E is the modulus of elasticity. The function f(x) has several functions that can be used, as depicted in Figure 4.

2.2 Monte Carlo Method

The Monte Carlo method is a technique commonly used in probability analysis. This approach is highly useful for solving problems involving random variables. In addition to being straightforward, this method offers high flexibility in combining various probability distributions without requiring extensive interpretation. Furthermore, this method easily models correlations between the variables involved (Hammah et al., 2009).

$$PL = \frac{N-M}{M} \quad (2)$$

In the equation above, it shows that PL is the probability of a landslide, N is the total number of data, and M is the number of accepted data.

3. Results and Discussion

3.1. Research Parameters

The geotechnical laboratory testing involves various examinations, such as testing the physical and mechanical properties of rocks. The mechanical properties testing includes direct shear testing and uniaxial compressive strength testing, aimed at determining the cohesion and internal friction angle of the rock, as well as the overall compressive strength of the rock [9]. Additionally, the physical properties testing aims to determine the dry and saturated unit weight. All this data is gathered based on the lithology type of the rocks being studied. Presented in Table 1 are the data resulting from the geotechnical laboratory tests, categorized according to the rock lithology types.

Table 1. Parameters of the rock material testing in the geotechnical laboratory

Sample Code	Density (kN/m³)		Friction Angle (°)	Cohesion (kPa)	UCS (MPa)
	ɣdry	ɣsat			
SO1A	14.05	17.84	30.02	44.41	0.03
CS1B	18.45	21.30	28.94	56.10	0.32
CS1A	14.00	18.35	41.05	50.05	0.20
SL1A	24.82	25.50	32.01	67.95	8.91
SS1A	20.04	22.19	20.53	45.15	0.44
SS1B	22.40	23.65	36.06	87.21	2.71
MI1D	19.66	21.52	31.89	94.83	0.33
SS1A	19.55	20.25	40.16	55.30	7.20

3.2. Highwall Slope Design

The Highwall slope design for cross-section A-A' comprises an overall slope geometry of 38.04 meters and an overall slope inclination of 33˚, consisting of five individual slopes with a slope angle of 45˚. The individual slope heights are 3, 5, and 10 meters, with a 5-meter berm. The geometry of the highwall slope for cross-section A-A' can be seen in Figure 5, the lithology of the rock constituting the highwall slope is depicted in Figure 6, and the highwall slope design can be observed in Figure 7.

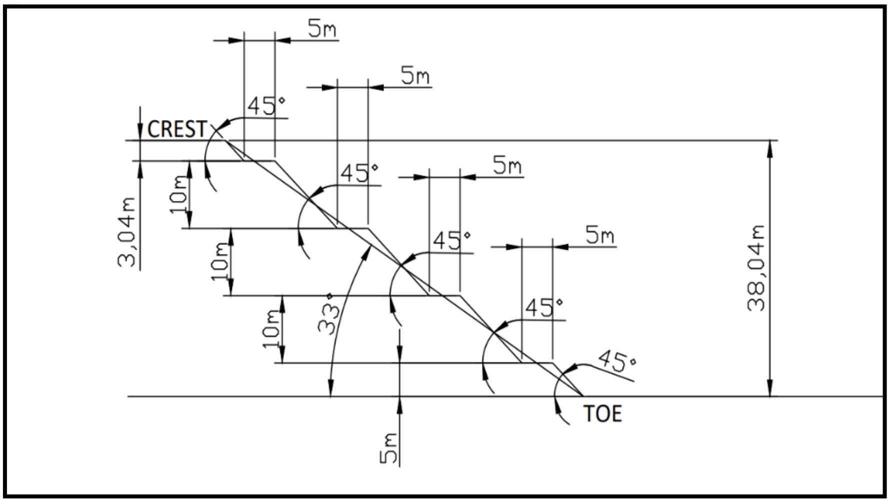

Figure 5. Design of highwall slope geometry A-A'

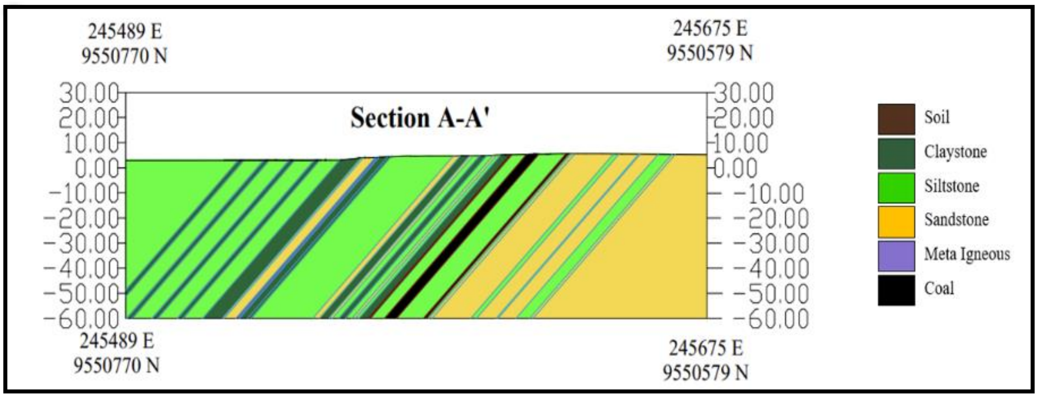

Figure 6. Lithology of the rock on highwall slope A-A'

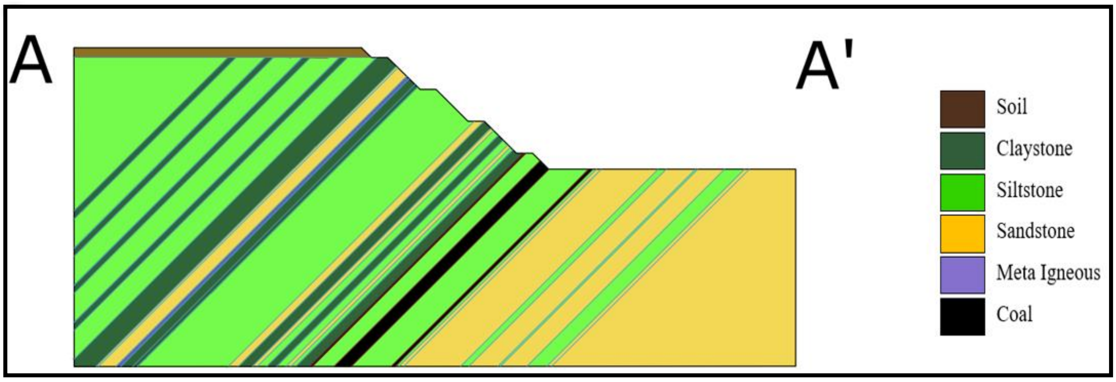

Figure 7. Design of highwall slope A-A'

3.3. Groundwater Level Design

The groundwater level is designed for every 10% increase in the overall highwall slope height on cross-section A-A', which has a height of 38.04 meters. The groundwater level (GWL) height model can be seen in Figure 8.

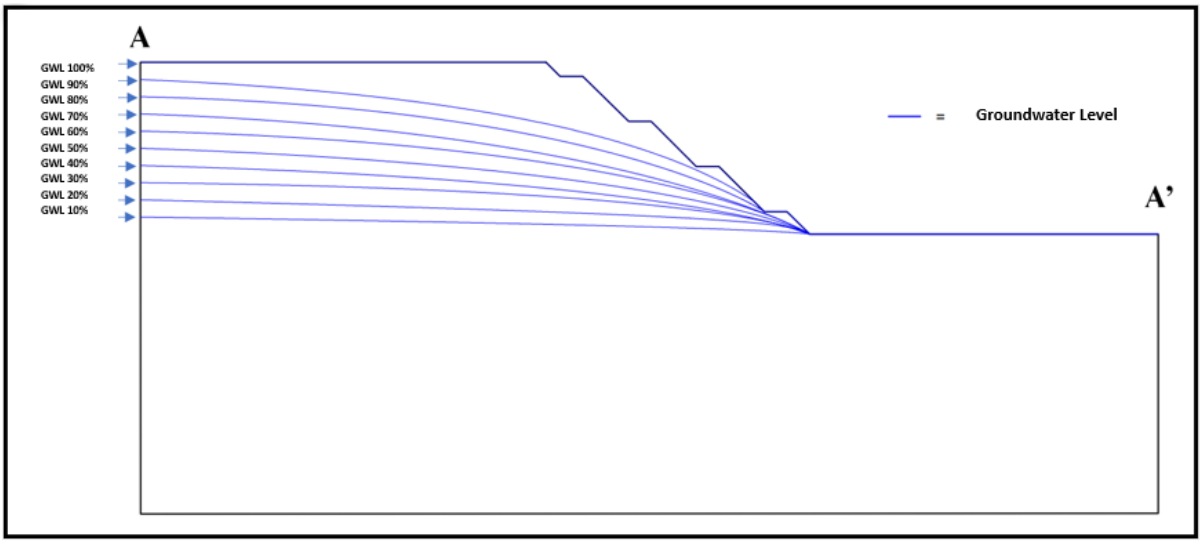

Figure 8. Groundwater level height model for cross-section A-A'

3.4. Analysis of the Influence of Groundwater Level on Slope Stability

The analysis of the influence of the groundwater level on slope stability focuses solely on the highwall slope section A-A'. The groundwater level has a significant impact on the safety factor and the probability of landslides. The presence of groundwater can reduce slope stability by causing a decrease in soil shear strength due to increased pore water pressure. Additionally, the material weight increases due to the presence of groundwater, which adds to the driving force on the slope. Furthermore, water movement in the soil can generate seepage forces that can affect slope stability.

The groundwater level is designed for every 10% increase in the overall highwall slope height on the A-A' cross-section, which measures 38.04 meters in height which is shown in the Table 2. The analysis results using Slide software indicate that as the groundwater level height increases, the safety factor decreases. This is due to the influence of the groundwater level on the increased unit weight of the material in the slope. The increase in material unit weight leads to an increase in driving forces on the slope, thereby decreasing the safety factor. Additionally, groundwater can reduce the shear strength of the material due to the increased pore pressure.

Table 2. Influence of GWL height on safety factor (FK) and probability of landslide (PL) for cross-section A-A'

GWL	SF Deterministic	SF*Mean*	PL
0%	2,112	2,123	0%
10%	2,108	2,12	0%
20%	2,079	2,089	0%
30%	2,047	2,067	0%
40%	2,03	2,051	0%
50%	1,982	2,002	0%
60%	1,91	1,944	0%
70%	1,875	1,913	0%
80%	1,76	1,792	0%
90%	1,648	1,679	0%
100%	1,337	1,358	0%

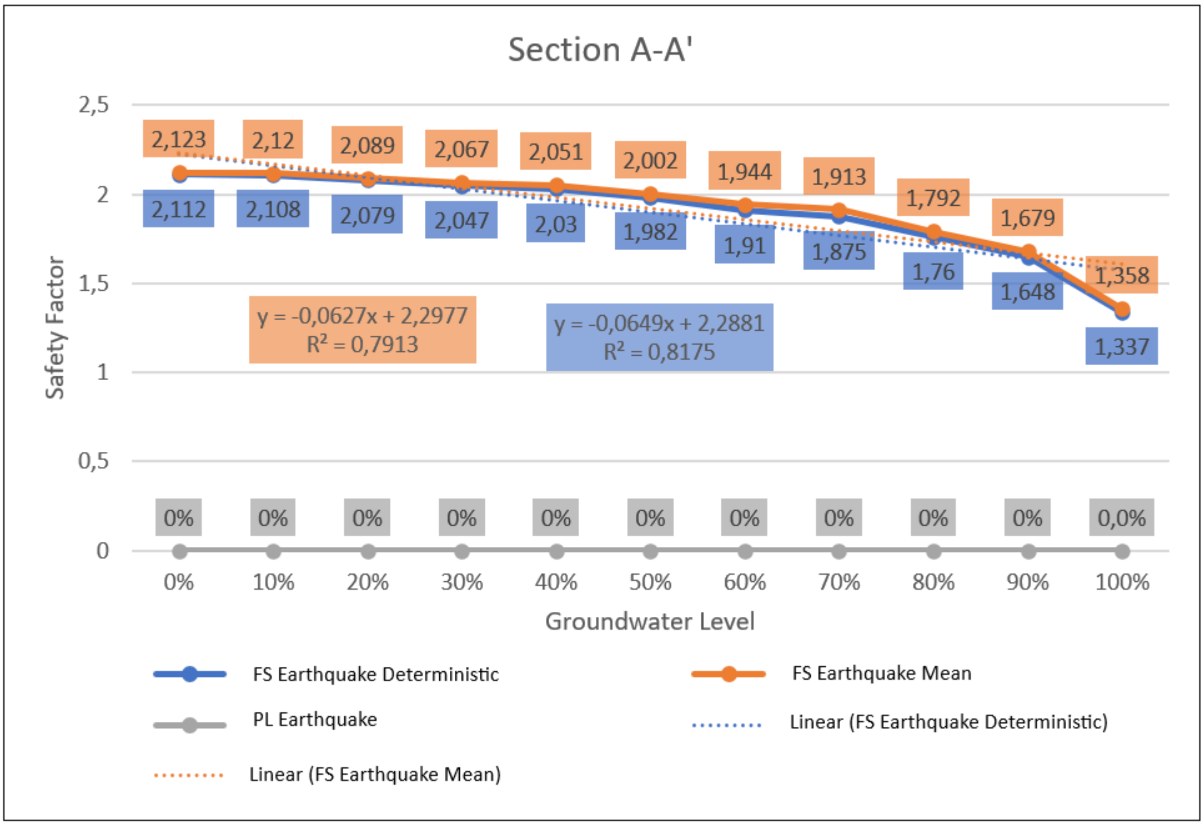

Figure 9. Graph of the influence of GWL on the FK and PK values for cross-section A-A'

From the analysis results conducted, it's been determined that the highwall slope condition in cross-section A-A' remains stable under various groundwater level heights. Figure 9 indicates that as the groundwater level height increases, the safety factor and slope probability values decrease. This is because the higher the groundwater level, the value of the safety factor will decrease because the groundwater level has an effect on increasing the bulk weight of the material on the slope. The increase in the bulk weight of the material causes the driving force on the slope to increase so that the safety factor value will increase. reduced and groundwater can also reduce the shear strength of the material due to increased pore water pressure. The lowest safety factor value is observed at a groundwater level height of 100% of the overall slope height. Refers to the standard permitted by the company for the slope safety factor limit which is 1.3, at this 100% groundwater level height condition can be stated as stable because the deterministic safety factor value is 1.337, the mean safety factor is 1.358, and the landslide probability is 0%.

4. Conclusion

The conclusions drawn from this research are as follows:

1. The higher the groundwater level, the lower the safety factor.
2. Under all groundwater level height conditions, the highwall slope in cross-section A-A' remains stable.
3. At a groundwater level height of 100% of the overall slope height, the deterministic safety factor value is 1.337, the mean safety factor is 1.358, and the landslide probability is 0%.
4. The groundwater level significantly affects the safety factor as the presence of groundwater can reduce slope stability by causing a decrease in soil shear strength due to increased pore water pressure. Moreover, the material weight increases due to the presence of groundwater, adding to the driving force on the slope.

References

[1] Bowa, V. M., dan Gong, W. (2021): Analytical technique for stability analysis of the rock slope subjected to slide head toppling failure mechanisms considering groundwater and stabilization effects, *International Journal of Geo-Engineering*, **12**(1). https://doi.org/10.1186/s40703-020-00133-0

[2] Devy, S. D., dan Hutahayan, P. P. (2021): Groundwater Effect on Slope Stability in Open Pit Mining: a Case of West Kutai Regency, East Kalimantan, Indonesia, *Journal of Geoscience, Engineering, Environment, and Technology*, **6**(4), 192–205. https://doi.org/10.25299/jgeet.2021.6.4.6226

[3] Latief, R. H., dan Zainal, A. K. E. (2019): Effects of water table level on slope stability and construction cost of highway embankment, *Engineering Journal*, **23**(5), 1–12. https://doi.org/10.4186/ej.2019.23.5.1

[4] Hemid, E. M., Kántor, T., Tamma, A. A., dan Masoud, M. A. (2021): Effect of groundwater fluctuation, construction, and retaining system on slope stability of Avas Hill in Hungary, Open Geosciences, 13(1), 1139–1157. https://doi.org/10.1515/geo-2020-0294

[5] Azizi, M. A., Kramadibrata, S., Wattimena, R. K., S, I. D., dan Andriansyah, Y. (2012): Analisis risiko kestabilan lereng tambang terbuka (studi kasus tambang mineral x), *Geomekanika*, **l** (Menggagas Masa Depan Rekayasa Batuan & Terowongan di Indonesia), 19–27.

[6] Hammah, R., Yacoub, T. E., dan Curran, J. H. (2009): Numerical modelling of slope uncertainty due to rock mass jointing, *International Conference on Rock Joints and Jointed Rock Masses*, 1–8.

[7] Young, N. L., Ospina, J. A., Lemieux, J. M., dan Locat, P. (2023): Deep Hydraulically-Active Fractures in Sensitive Clay Deposits: Implications for Groundwater Flow and Slope Stability, *Geophysical Research Letters*, **50**(9), 1–10. https://doi.org/10.1029/2023GL103156

[8] Takwin, G. A., Turangan, A. E., dan Rondonuwu, S. G. (2017): Analisis Kestabilan Lereng Metode Morgenstern-Price (Studi Kasus : Diamond Hill Citraland), *Tekno*, **15**(67), 66–76.

[9] Hoek, E., dan Bray, J. (1981): *Rock Slope Engineering "Civil and Mining"*, *Taylor & Francis e-Library*, **3**, 1–431.