

DESIGN MODELING USING DEM DATA AND APPLICATION OF GEOTECHNICAL STUDY ON CLAY 134 MINE PT SOLUSI BANGUN INDONESIA TBK, TUBAN PLANT

Umar Raihan Assagaf^{1*}, Wanda Nurlaily Charea²

¹Department of Geomatics Engineering, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia
E-mail: 5016201104@student.its.ac.id

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ABSTRACT

PT Solusi Bangun Indonesia Tbk is one of the companies engaged in the building materials solutions industry in Indonesia, with an annual cement production capacity of 14,8 million tons and operates four plant namely in Lhoknga, Narogong, Cilacap, and one of them is located in Tuban, East Java precisely in Mekarwang, Tambakboyo, Tuban, East Java. The mining operation can proceed if it fulfils the requirements of the Work Plan and Budget (RKAB) in accordance with the Minister of Energy and Mineral Resources Decree No. 1806 K/30/MEM/2018. The mine planning is important aspect in planning mine design as the production objective. mine planning is the most crucial aspect in the mine design planning as a reference to achieve production targets. The raw material targets production in 2024 for clay is 2 million tons and the calculated tonnage obtained is 1.95 million tons. The opening of a new area is carried out in two blocks, namely E3 and D3, which are divided into three sections of new open-pit mining. To provide practical, fast, and efficient mapping, mapping is carried out using UAV (Unmanned Aerial Vehicle) which produces topographic and orthophoto maps. To understand the relationship of slope stress-strain, slope stability is identified using a geotechnical study with the simplified bishop method. The results show that the north-south cut has a safety factor of 1.882, while the east-west cut has a safety factor of 1.845 and categorized as safe because it complies with the Minister of Energy and Mineral Resources Decree No. 1827 K30 MEM 2018, which states that a Safety Factor (FS) value is >1.5 . From this research, the researcher hopes for improvements in the quality of aerial photo data to produce accurate and optimal slope stability results.

Keyword: Simplified bishop, mine design, slope stability, orthophoto, mining excavation volume

Introduction

The rapid global development, supported by increasing infrastructure construction and technological advancements, is driving the growth of various industries in Indonesia[1]. Considering the current development in the industrial sector, cement industry has experienced quite rapid development with an average annual consumption growth of 10%. According to the Directorate General of Manufacturing Industrial Base of Ministry of Industry (Kemenprin) in July 2023, cement production data for the first semester of 2023 reached 29.3 million tons, with the national cement demand reaching 28 million tons [2]. Meanwhile, the cement production throughout 2022 exceeded 64 million tons, with a demand of 63 million tons.

PT Solusi Bangun Indonesia Tbk is one of the companies engaged in the building materials solutions

industry in Indonesia, with an annual cement production capacity of 14.8 million tons and operates four plants, one of which is located in Tuban, East Java, precisely in Mekarwang, Tambakboyo District, Tuban, East Java[3]. Tuban is an area that has abundant potential for clay deposits, making it one of the selected locations for industrial development[4]. The crucial step that must be taken before conducting mining is mine planning. The mining operation can proceed if it fulfills the requirements of the Work Plan and Budget (RKAB) in accordance with the Minister of Energy and Mineral Resources Decree No. 1806 K/30/MEM/2018 [5].

To calculate the volume of clay raw materials, using the final contour of the mining progress is facilitated by an Unmanned Aerial Vehicle (UAV) for data acquisition [6]. The contour data will be converted into Triangular Irregular Networks (TIN) data, then the

calculation is carried out using ArcScene software [7]. Open-pit mining design planning must undergo a preliminary slope stability analysis to contribute to a safe and efficient design [8]. The method used is the limit equilibrium method, namely the simplified bishop method, which can analyze the stress-strain relationship on slopes using the Slide software [9].

The single-bench geometry on Clay Slope 134 refers to the Geotechnical study conducted by PT Solusi Bangun Indonesia Tbk, Tuban Plant [10]. The purpose of this research is to analyze mine design planning to meet the production target and to identify slope stability on the Clay 134 mine.

Methodology

This research was conducted at PT Solusi Bangun Indonesia Tbk, Tuban Plant Quarry Workshop, and data acquisition was performed in the clay mine area located in Mliwang, Kerek, Tuban. Clay Quarry owned by PT Soulsi Bangun Indonesia Tbk has an IUP area of 134.2 hectares, as shown in Figure 1.

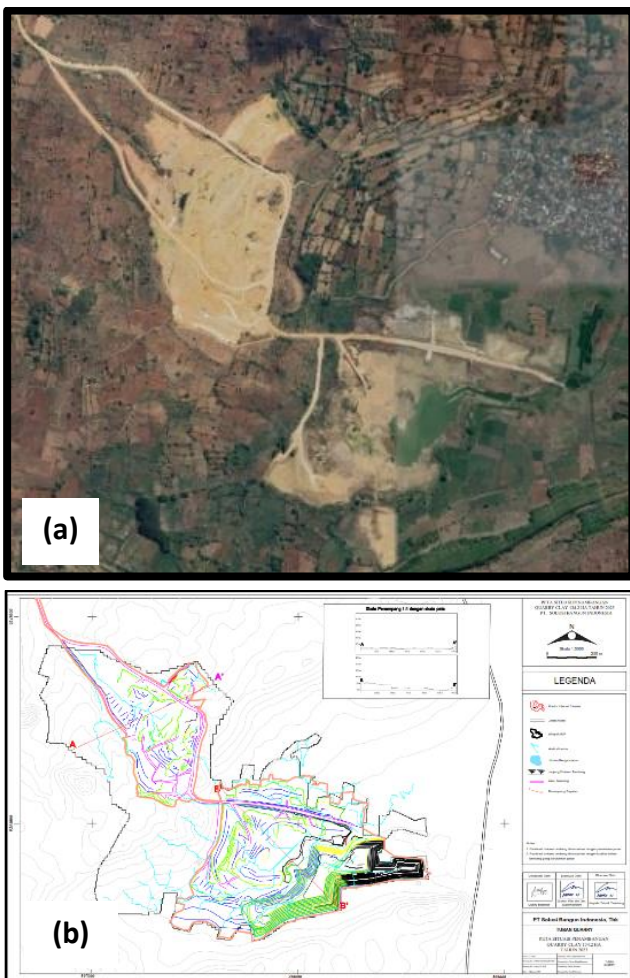


Figure 1. (a) Research Location IUP Clay 134 (Google Earth Satellite Image, 2023), (b) Map of the IUP Clay 134 Situation (SBI Quarry, 2023).

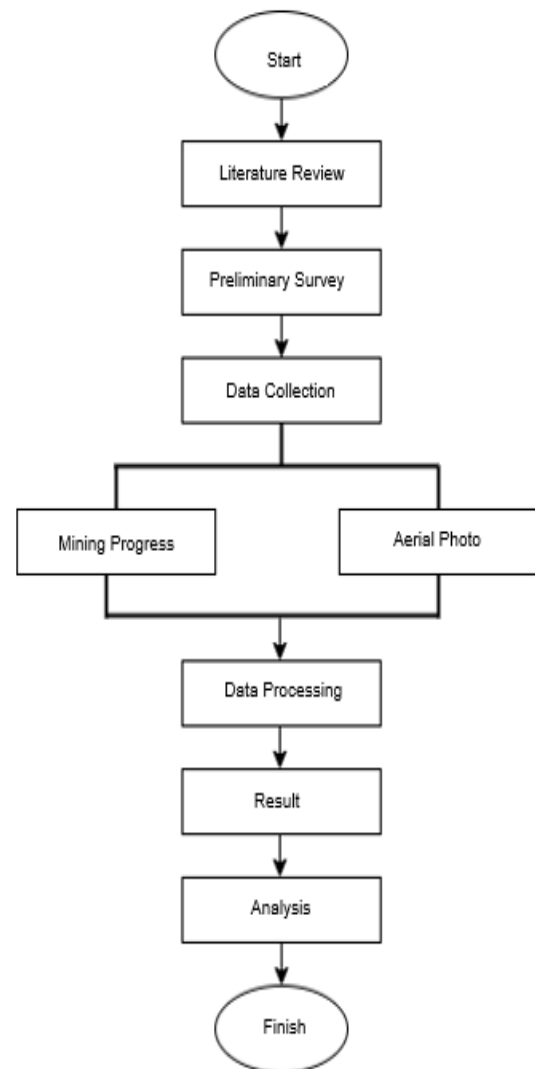


Figure 2. Research Flowchart

The research used secondary data, including the progress of the mine in the second quarter, the mining volume target for 2024, and the geotechnical IUP Clay 134. The mine progress data is used as a reference for mine opening plans and volume calculations using the contour method with ArcScene software [11].

Meanwhile, primary data was acquired using an Unmanned Aerial Vehicle (UAV) with the DJI Phantom 4 V2 Pro drone. This photo data will generate DTM data and will be used for mine design planning using AutoCAD Civil 3D 2018 and analyze slope stability using the simplified bishop method with Global Mapper 21.1 software and Slide 6.0 in the clay mine, which requires periodic monitoring due to clay being a rock with low mass density and prone to landslides [12]. The stages of this research can be seen in Figure 2.

Result and Discussion

Volume Calculation Results

The volume was obtained from the primary data of mine progress in the second quarter, relying on raster files from DEM data acquired on July 2, 2023. Based on the calculation of the planned production volume of raw materials, the data obtained is presented in the units shown in Table 1 as follows.

Tabel 1. Volume Calculation Results

	Block		
	E3	D3 Northwest	D3 Southwest
Elevation (m)	49	34	61
Area(m ²)	16921.47	25642.56	36690.75
Volume (m ³)	357410.99	304220.11	557454.06
Tonnage (ton)	571857.584	486752.176	891926.496

The mine opening plan for Clay 134 refers to the Forecast Study (FS) to open two blocks, namely E3 and D3, with the opening direction in block E3 to the east, while block D3 to the northeast and south [13]. The calculated volume results in (m³) were multiplied by the rock clay mass density, which is 1.6 tons/m³. As a result, the total area of the planned land opening for both blocks reached 7.8 hectares, with a total tonnage of 1950539.46 tons.

Block E3 has an initial elevation of 73 m, decreasing 49 m. Block D3 in the northwest has an initial elevation of 52 m, decreasing to 34 m. Meanwhile, Block D3 in the southwest has an initial elevation of 82 m, decreasing to 61 m, with the deepest excavation located in Block E3. Elevation is determined based on the resource requirements to be mined for the production of raw materials.

Clay is a direct extractable resource, eliminating the need for overburden removal. Based on the calculation result, the data can be used as the work plan reference as it aligns with the forecast study or feasibility study for clay raw material production at PT Solusi Bangun Indonesia Tbk, Tuban Plant, in 2024, which is 2 million tons.

Mine Design Result

The mine design is used to determine the direction of mining and the formation of slopes (crest and toe) based on the specified elevation boundaries. After calculating the volume, the formation of crest and toe will be undertaken. The formation of crest and toe is based on the geotechnical study of PT Solusi Bangun Indonesia Tbk, Tuban Plant, with a single slope having a height of 3 meters and a bench width of 5 meters,

forming a slope inclination angle between the crest and toe of 55°.

The mine opening plan for Clay 134 refers to the forecast study (FS) open two blocks, namely E3 and D3, with the opening direction in block E3 to the east, while block D3 to the northeast and south. The results of the mine design plan can be seen in Figure 2.

Topographic Map Results

The measurements using photos acquired on August 29, 2023, resulted in Digital Elevation Model (DEM) data, which was then processed using ArcGIS software to generate contours with a contour interval of 5 m. On this topographic map, the highest elevation is 95 m, and the lowest is 35 m. The results of the topography of Clay 134 mine from PT Solusi Bangun Indonesia Tbk, Tuban Plant, are presented in the form of a Topographic Map, which can be viewed in Figure 3.

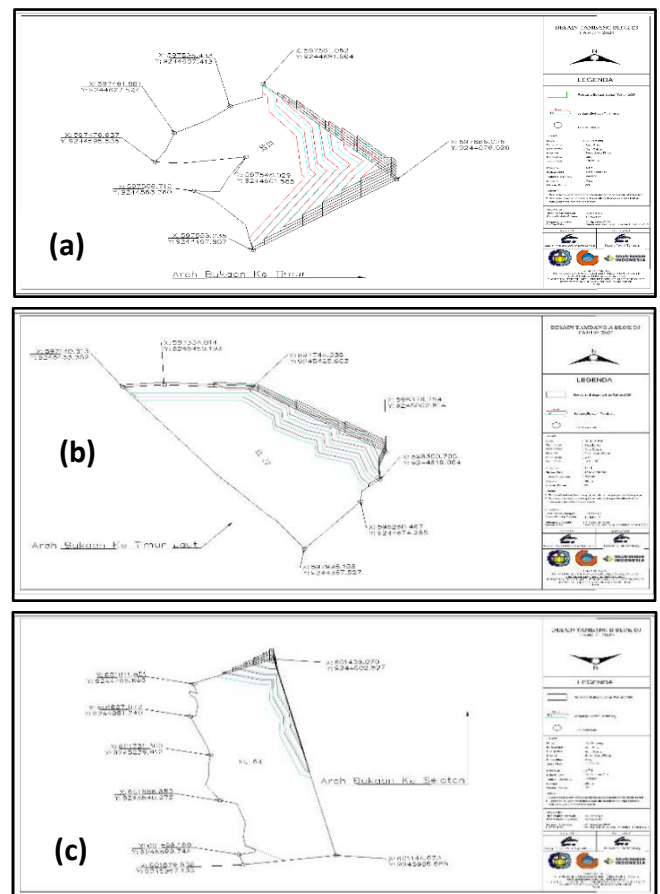


Figure 2. (a, b, c) Quarry Clay 134 PT SBI Tuban Mine Design Plan for the Year 2024

From the generated topographic data, it is possible to create a profile section of the map between two points. Furthermore, this topographic map or mining progress can be used to monitor the extent to which the mine is excavated or opened. This way, for future mining plans, the direction of openings and the

magnitude of the earth volume to be excavated are known.

Orthophoto Map Results

Aerial photos acquired on August 29, 2023, are presented in UTM projection with zone 49S in the form of an orthophoto map for Clay 134 from PT Solusi Bangun Indonesia Tbk, Tuban Plant, as shown in Figure 4.

The results of orthophoto processing fall within the tolerance based on BIG Regulation No. 1 of 2020, with a GSD of 5.6 cm/pixel and an RMSE error of 1.80849 meters. Consequently, this orthophoto map can be used for the creation of a 1:10,000 scale map [14].

The orthophoto map will be used for the formation of situational maps and reclamation plans for the IUP Clay 134. In addition, routine aerial monitoring of the mine is conducted every three months (quarterly) to assess mining progress using remote sensing technology.

Slope Stability Result

Based on geotechnical study, geotechnical monitoring is conducted periodically, once every year, following the latest progress of the mine to assess the safety level of the excavated slopes [15]. Data to assess slope stability is collected from the width of benches, bench height, and bench slope angles.

Slope stability analysis is conducted using the simplified bishop method, considering several factors that can influence stability, such as cohesion coefficient, seismicity, and friction angle. Slope stability analysis using a cohesion coefficient of 34.17 kPa, with vertical and horizontal seismic influences of 0.689, and a friction angle of 27.6°.

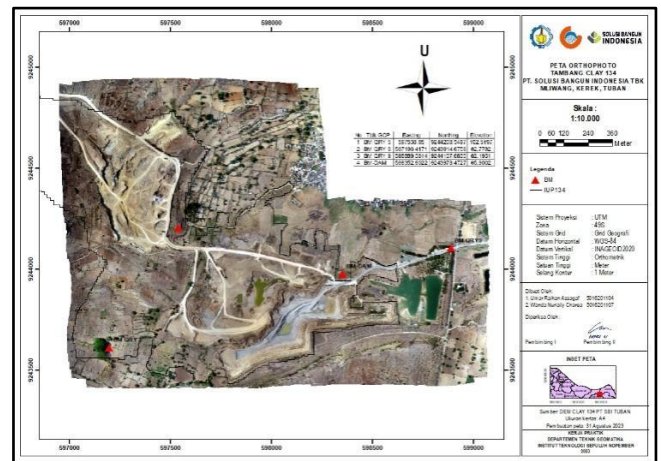


Figure 4. Orthophoto Map of Quarry Clay 134 PT SBI Tuban

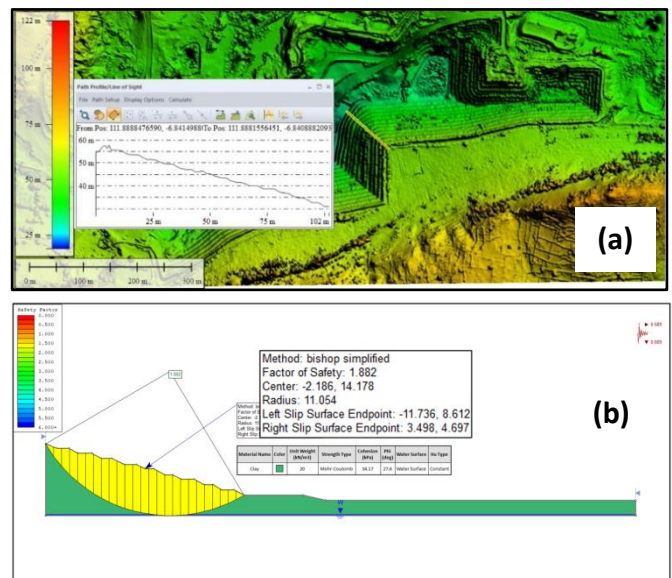


Figure 5. (a) Cross-Section of South - North Profile Cut, (b) Results of Slope Stability Analysis South – North

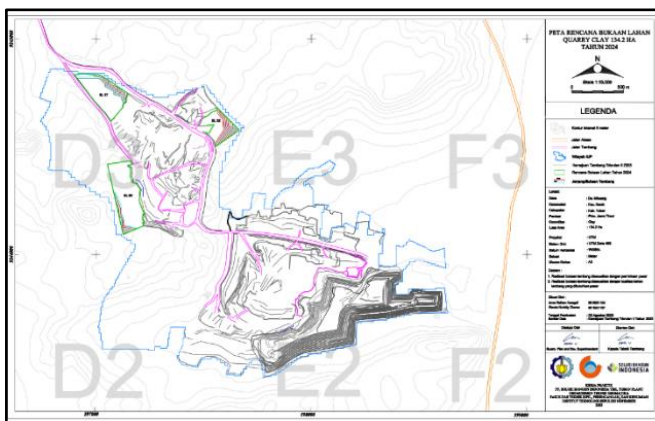


Figure 3. Topographic Map of Planned Quarry Opening Area for Clay 134 at PT Solusi Bangun Indonesia Tbk Tuban Plant

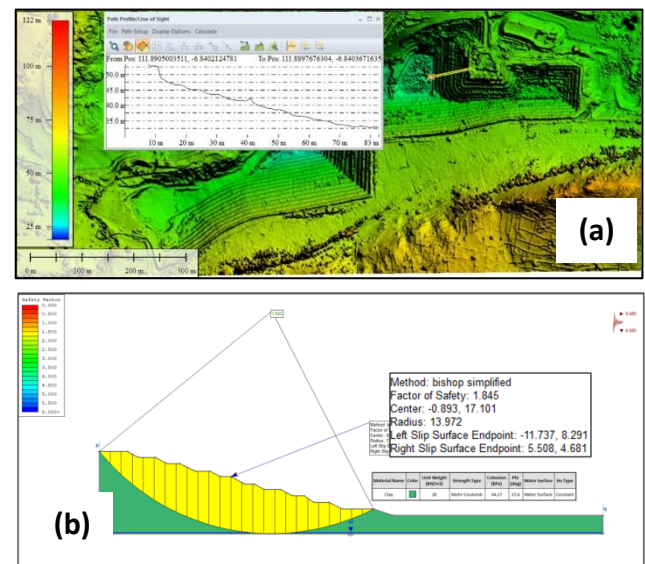


Figure 6. (a) Cross-Section of East- West Profile Cut, (b) Results of Slope Stability Analysis East- West

This testing refers to Minister of Energy and Mineral Resources Decree No. 1827 K30 MEM 2018, with a minimum safety level of 1.5. Therefore, the results obtained from the testing of both slopes are categorized as safe because they have an SF value >1.5[16]. The test results for each cut can be seen in Figures 5 and 6, and a summary of the slope stability analysis is presented in Table 2.

Tabel 2. Slope Stability Test Results

Cut	Safety Factor	Result
South- North	1.5	1.882
East- West	1.5	1.845

Conclusion

From the results obtained during the research at PT Solusi Bangun Indonesia Tbk, Tuban Plant, for the formation of mine design using DEM data and geotechnical study, the following conclusions can be drawn

1. The calculated volume for the land opening is 1,950,539.46 tons with an area of 7.9 hectares, and it aligns with the forecast study for the mine design planning in 2024.
2. The mine design planning aligns with the opening direction specified in the forecast study for the mine opening planning in 2024.
3. The processing result of the orthophoto is within tolerance according to Regulation BIG No. 1 of 2020, with a GSD value of 5.6 cm/pix and an error of 1.80849 m, making it suitable for the creation of a 1:10,000 scale map.
4. The slope stability analysis obtained for the south-north cut is 1.845, and for the east-west cut is 1.882, both categorized as safe and in accordance with the standard of Minister of Energy and Mineral Resources Decree No. 1827 K30 MEM 2018, which specifies that the Safety Factor (SF) should be above 1.5.

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