

# ANALYSIS OF THE SUITABILITY OF GRADE PARAMETERS, ANGLE OF TURN AND WIDTH OF PIT A MINE ROAD TO ENSURE THE SAFETY AND SECURITY OF THE MINE UNIT USING AERIAL PHOTOGRAPHIC DATA

Wahyu Soleh Setiaji<sup>1</sup>, Ahmad Zaki Alawi<sup>1</sup>

<sup>1</sup>Department of Geomatics Engineering, Faculty of Civil, Planning, and Earth Civil Engineering, Sepuluh Nopember Institute of Technology, Surabaya, Indonesia

E-mail: [zaki.alawi22@gmail.com](mailto:zaki.alawi22@gmail.com)

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## ABSTRACT

One of the applications of survey science that exists in mining is aerial photo surveys. Data from aerial photo surveys can be used and utilized in various jobs, one of which is monitoring work including monitoring the safety of mining roads. Monitoring of mining roads aims to ensure the security and safety of workers in the process of mineral mining. In this study, the implementation of an aerial photo survey to provide an evaluation of the safety of mining roads based on the Decree of the Minister of Energy and Mineral Resources No. 1827 K/30/MEM/2018. The evaluation of the safety of mining roads is based on three parameters, namely road grade, road width, and road turn angle. Planning for the evaluation of the mine road was carried out through the data collection stage through an aerial photo survey on July 12, 2022, and data processing using Agisoft Metashape and ArcGIS. The output in data processing is in the form of a mine road safety map per parameter. Based on the results obtained in the classification of road grade values, a grouping was carried out with 4 classes, namely the very safe class, the safe class, the warning class, and the hazard class. For road grade parameters, 31% of mining roads at pit A site Alhasanie PT Equalindo are included in the dangerous category. In the width parameter of the mining road, 70% of the status is safe and has been in accordance with the Decree of the Minister of Energy and Mineral Resources No. 1827 K/30/MEM/2018. In the parameters of the turning angle of the mining road, 73% of the status is safe and has been in accordance with the Decree of the Minister of Energy and Mineral Resources No. 1827 K/30/MEM/2018.

**Keyword:** Aerial Photo, Road Grade, KepMen ESDM No 1827 K/30/MEM/2018, Road Width Road Turning Angle

## Introduction

Based on Appendix II of Minister of Energy and Mineral Resources Decree (KepMen ESDM) No 1827 K/30/MEM/2018 Part C Point 3 regarding the understanding, a mining road is a special road intended for mining activities and is in a mining area or project area consisting of supporting and mining roads. While mining or production roads are roads located in mining areas and/or project areas that are used and traversed by mechanical earth-moving equipment and other supporting units in transporting overburden, mining minerals, and mining support activities [1]. In Attachment II to Minister of Energy and Mineral

Resources Decree No 1827 K/30/MEM/2018 Part E point 2 concerning mine feasibility studies, it states that studies in terms of planning for the transport and stacking of mining materials use mine or production road dimension trucks which include road width, grade, bend radius, and super elevation [1].

Mining operations urgently require mine roads as vital infrastructure facilities within the mine site and its surroundings. Mining roads link to essential locations in the area, including mining sites with crushing plants, waste dumps, processing areas, offices, employee housing, and other places. Mining roads have a critical role in the mining production

process. If the condition of the designed mine road is not in accordance with the mining system and road specifications, it will hamper the rate of production activities. Road conditions are greatly affected by bends, inclines, derivatives, or a combination of the three [2]. The use of heavy equipment in the mining process has a vital role in achieving the production target. Production activities are closely related to haul roads to support the smooth running of mining operations, especially in hauling activities and haul road geometry, which must be considered the same as roads in general, namely road width and road slope [3].

Currently, UAVs (Unmanned Aerial Vehicle) is developing very fast. It is not only used in the military field. However, it can be used for everyday life, including remote sensing, responding to disasters, security and traffic patrols, carrying and shipping goods, taking pictures, and monitoring ongoing construction processes. Using UAVs or drones to monitor the construction process includes evaluating road geometry using UAVs [4]. The use of UAV is used for road monitoring to find out the original condition of the road by utilizing the information obtained, and it can also be used as a basis for making decisions related to road conditions [5]. In order to obtain the latest road conditions, a 3-dimensional model of the road can be made by utilizing aerial photographs showing the current road conditions using a 3-dimensional model method. So that information from the latest road conditions can be obtained, for example, the condition of the road width from a model that is adjusted to field conditions [5].

This study aims to identify the level of mine road safety in pit A site Alhasanie using a weighting method based on Minister of Energy and Mineral Resources Decree No 1827 K/30/MEM/2018. Mine road safety parameters that will be identified are three things, namely road grade, road bend angle, and road width. The data used as the basis of this research is photogrammetric data in the form of orthophoto and digital elevation model (DEM). The final result of this research is a per-parameter mining road safety map.

## Methodology

The research location is located in pit A site Alhasanie PT. EMAS is located in Sanga – Sanga District, Kutai Kartanegara Regency, East Kalimantan. Sanga - Sanga District is located between 117° 01' to 117° 17' East Longitude and 0° 35' - 0° 45' South Latitude. The total mining area is approximately 900 Ha. Sanga-Sanga

District is directly adjacent to Anggana District to the north and east, Muara Jawa District to the south, and Samarinda City to the west.



Figure 1. Research Study Location

The data used in processing and research is in the form of Orthophoto data, DEM, SHP Mining Permit Limits, and Mining Transport Equipment Data used.

The implementation phase of the research consisted of a literature study conducted with reviews of both national and international journals regarding mine road safety and how to process DEM data in ArcGIS to obtain road grades, road bend angles, and road widths. Literature studies were also carried out by studying road safety standards based on Minister of Energy and Mineral Resources Decree No 1827 K/30/MEM/2018 and the specifications of the largest heavy equipment on the mine site.

Aerial photo data were processed using Agisoft Metashape Professional software to obtain orthophoto and DEM results. From the results of these data, an analysis of the geometry of the mining road can then be carried out. The road grade parameter refers to the Minister of Energy and Mineral Resources Decree. The road grade is the difference in road elevation in the transverse direction and is usually expressed in percent (%). The percentage referred to here is the ratio between the difference in road height between two points in the transverse direction to the horizontal distance of the two points. Mining road grade based on the Minister of Energy and Mineral Resources Decree may not exceed 12% (twelve percent). The road bend angle is the angle formed between two different roads.

The turning angle on mine roads shall not be less than 70° (seventy degrees). Meanwhile, the width of the mine road should be at least three and a half times the width of the largest heavy equipment. There are two largest cargo units at the Alhasanie site, namely Caterpillar HD 773E for OB loads and Scania P410 XT for coal loads.

The final stage in this work is the presentation of the results. The results are presented in the form of a map that has been layout. Layouting is a process for making a display arrangement of the map that includes the necessary information so that the visualization results can be understood clearly.

### Result and Discussion

The results of the aerial photo survey will produce results in the form of an orthophoto map and also a dem. In dem data, the highest height is 63.59 meters, while the lowest is -19.97 meters.

#### Slope/Grade of the Road

The results of the road grade map will display a green to red line according to the road grade value. Classification of street colour symbology is divided into 4 classes.

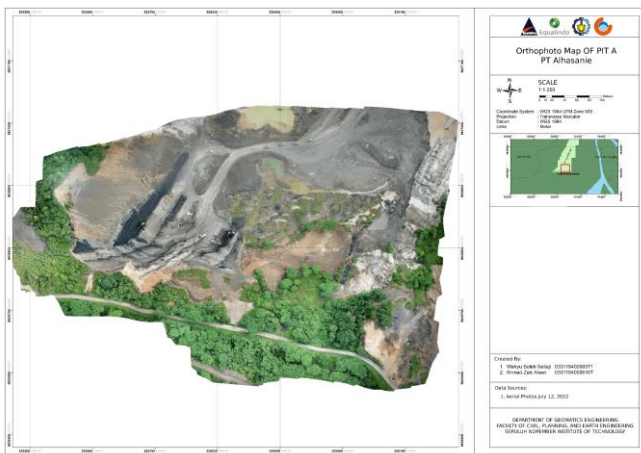


Figure 2. Orthophoto Map Results

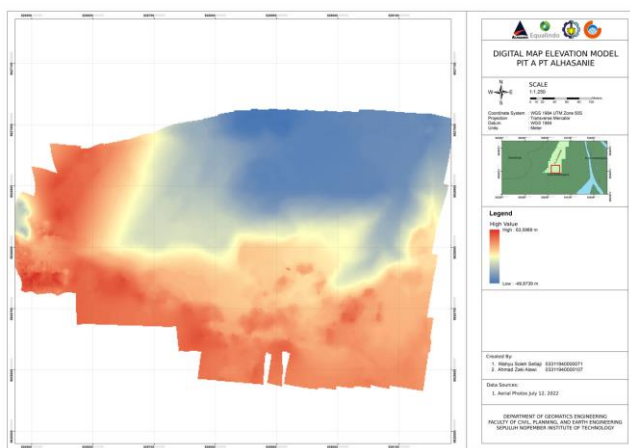


Figure 3. Digital Elevation Model Map Results

Table 1. Road Grade Classification

Class Type	Road Grade Value
Highly Secure	0% - 8%
Secure	8,000001% - 10%
Warning	10,000001% - 12%
Danger	>12%

The smallest road grade value was 2.23%, and the highest road grade value was 27.11%. According to the Decree of the Minister of Energy and Mineral Resources No. 1827 K/30/MEM/2018, the percentage of the slope/grade of the mining road itself cannot be more than 12% (twelve percent). This policy is to ensure the safety of mining activities and the efficiency of the mining activities themselves. The road grade discrepancy is because, in that area, excavating the overburden layer has just been carried out to extract the coal underneath. So, it still needs to be carried out on an ongoing basis.

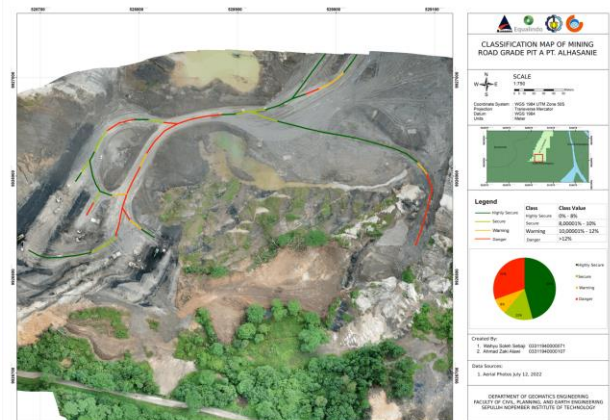


Figure 4. Road Grade Classification Map

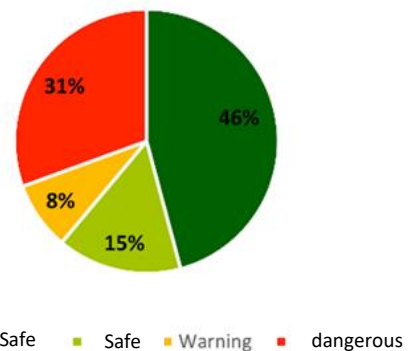


Figure 5. Percentage of Mine Road Grade Classification at PIT A Site Alhasanie

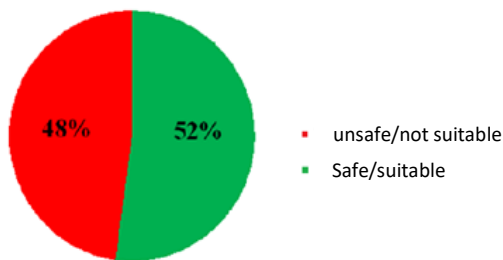
From the overall results obtained, 46% of the total data is included in the very safe category, in second place with a safe category of 15% of all data. In the dangerous category, it is 31%, where the road grade value is still less than the road safety standards stipulated in the Decree of the Minister of Energy and Mineral Resources No. 1827 K/30/MEM/2018, the road grade value may not exceed 12% so that the dangerous category must be repaired.

**Road Width**

The aerial photo data processing results for the road width parameter at Pit A site Alhasanie PT Equalindo obtained that the smallest road width is 7 m and the largest road width is 22 m. From the overall results, it was found that 52% of all roads in Pit A had safe status or were following existing laws and regulations. The results of the width classification for each segment are listed in table 2.

**Table 2.** Road Width Value Category Classification

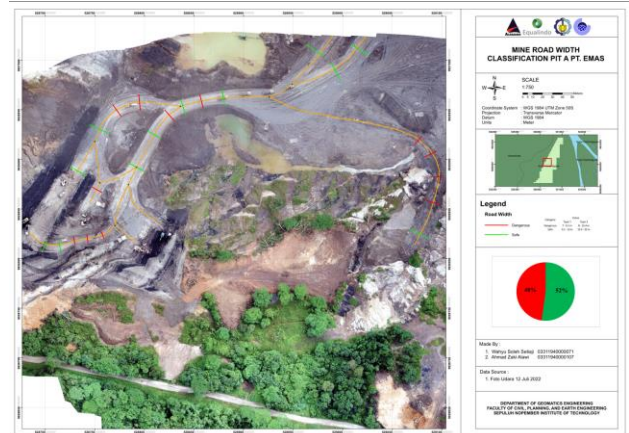
Categories	Value	
	Type 1	Type 2
Dangerous	7 – 9.1 m	8 – 15.4 m
Safe	9.1 – 13 m	15.4 – 22 m



**Figure 6.** Percentage of Mine Road Grade Classification at PIT A Site Alhasanie

Evaluation of mine road safety is based on the road width parameter where the safety level is 52%, which means 48% of mine roads do not have a width that complies with the provisions of the Minister of Energy and Mineral Resources Decree No. 1827 K/30/MEM/2018. The parts of the mine road that are not suitable need to be repaired to ensure the safety and security of mining workers. The discrepancy in road width in pit A is caused by several things that are, (1) the characteristics of the mine road constantly change every day due to mining that occurs for 24 hours, so the geometry of the road also continues to change due to the construction of new roads, (2) the weather factor affects the pit A mining road which is still in the form of dirt, so if it rains, there will be a change in the geometry

of the road, either due to landslides on the shoulder of the road or because the road is covered with flowing soil, (3) changes to the mine road because it collapsed and was unable to withstand the weight of heavy mining equipment that passed for 24 hours, and (4) changes and road construction in the mining pit are carried out continuously so that the width of the road must also change.

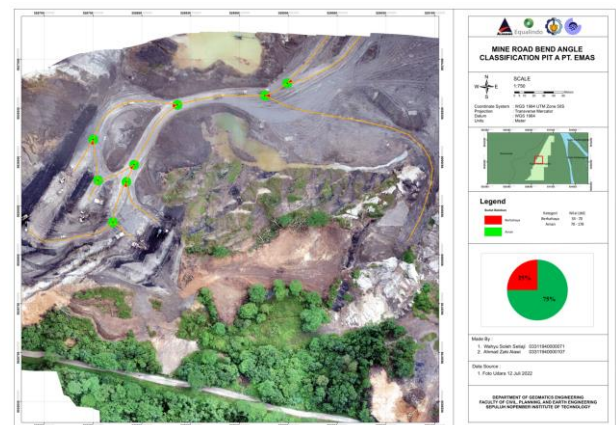


**Figure 7.** Road Width Classification Map

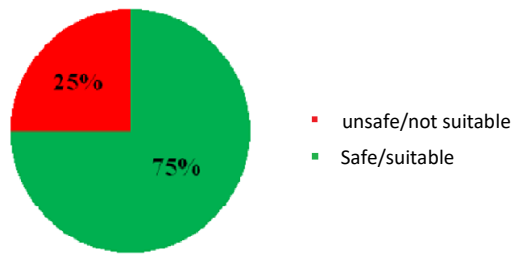
The results of processing aerial photo data for the parameter of the road bend angle at Pit A site Alhasanie PT Equalindo, the smallest road angle value is 33 degrees, and the largest road width is 178 degrees. From the overall results, it was obtained that 75% of all roads in Pit A had safe status or were following existing laws and regulations. The results of the angle classification of each segment are as follows.

**Table 3.** Road Bend Angle Value Category Classification

Categories	Value (dd)
Dangerous	33 – 70
Safe	70 - 178

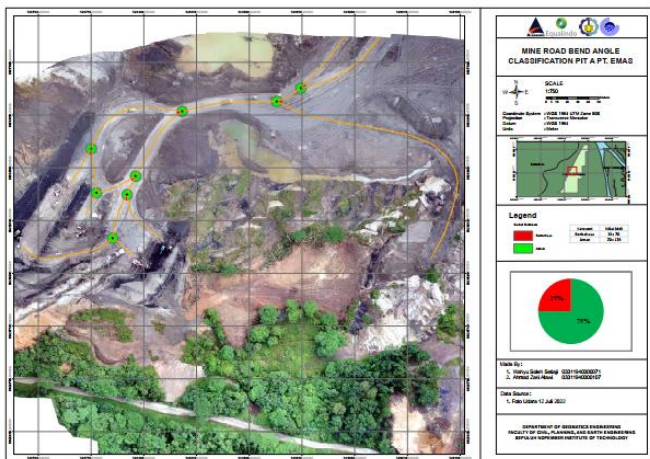


**Figure 8.** Classification Map of Road Turns PIT A PT Alhasanie



**Figure 9.** Percentage of Mine Road Bend Angle

Evaluation of mine road safety is based on the parameter of the road bend angle where the safety level is 75%, which means that 25% of the mine road turns do not have a turn angle according to the provisions of the Minister of Energy and Mineral Resources Decree No. 1827 K/30/MEM/2018. Parts of the mine road that are not suitable need to be repaired to ensure the safety and security of mining workers. The discrepancy between the width of the road in pit A is caused by several things, that are (1) the characteristics of the mine road which always change every day due to mining that occurs for 24 hours so that the geometry of the road also continues to change due to the construction of new roads, (2) the angle of the road turns changes due to mine roads which also change according to the location of the excavation and the location of the coal minerals that change.



**Figure 10.** Road Bend Angle Classification Map

## Conclusion

From this study, it was concluded that, for the road grade parameter, 31% of the mining road at PT Alhasanie's pit A site was included in the dangerous category and was not following the Minister of Energy and Mineral Resources Decree No 1827 K/30/MEM/2018, so improvements had to be made. For the suitability parameter for the width of the mining

road at PT Alhasanie's pit A site, 70% has a safe status and is in accordance with the Minister of Energy and Mineral Resources Decree No 1827 K/30/MEM/2018. For the suitability parameter for the corner angle of the mining road at PT Alhasanie's pit A site, 73% has a safe status and is under the Decree of the Minister of Energy and Mineral Resources No. 1827 K/30/MEM/2018.

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