



## Geometry of Mining Haul Roads from Mining Pits to Stockpiles at Nickel Mining Companies in South Palangga District

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### ABSTRACT

This study focuses on haul road geometry in nickel mining operations, specifically examining the design of mine haul roads from the mine pit to the stockpile in South Palangga District. Given the critical role of haul roads in supporting efficient hauling operations, this study investigated key geometric factors such as road width, curve radius, superelevation, gradient, and cross slope. Data were collected through field observations and primary measurements at the mine site, including direct assessment of road dimensions and alignment. The results indicate that mine haul road design is critical for optimizing the movement of large haul vehicles, with an average straight road width of 8.05 meters and curved roads up to 8.95 meters. In addition, this study examined the impact of curve radius and superelevation, which were found to affect vehicle stability and operational safety. Road gradient measurements revealed varying slope conditions, with a maximum slope of 5.75% found in some segments. A cross slope of 0.895 mm/m was identified as critical for good drainage. The study emphasized the importance of adhering to standard design principles, such as a minimum straight-line width of 8.57 meters, a curve width of 12.58 meters, and appropriate superelevation values. These findings contribute to safer and more efficient mining operations, highlighting the need for ongoing haul road optimization and maintenance in mining operations.

## INTRODUCTION

Indonesia is an archipelagic country rich in mineral resources. If optimally managed, this mineral potential can significantly contribute to the economy—including through export revenues, regional development, increased economic activity, job creation, and revenue for regional and central budgets (Gouda et al., 2024; Nikbin et al., 2025). One sector that makes a significant contribution is the mining industry, known for being capital-intensive, technology-intensive, and high-risk (Peroni et al., 2025; Han et al., 2024).

For mining activities to deliver maximum benefits, careful planning is required from the initial stages—including the planning and design of mine roads, or "haul roads" (Baek & Choi, 2017; Regensburg & Tannant, 2001). Mine roads are vital infrastructure at and around mine sites, significantly impacting production and operational costs (Zimar et al., 2024; Thoeni et al., 2024). This infrastructure serves as a connecting link between the mine site and other critical facilities—such as the crushing plant, mineral processing facilities, port areas, worker housing, and other supporting facilities within the mining zone—so that mine accessibility and connectivity depend on the quality of the mine roads (Baek & Choi, 2017; Gouda et al., 2024). Therefore, mine road design must be carefully executed to meet applicable engineering criteria and safety standards (Peroni et al., 2025; Mutyaraharjo, 2024).

In modern mining practices, mine road design and management—including geometry, pavement structure, surface material selection, soil stabilization and drainage, and maintenance—play a critical





role in ensuring the efficiency, safety, and sustainability of mine operations (Han et al., 2024; Gouda et al., 2024; Zimar et al., 2024). Mistakes in the design or maintenance of mine roads can lead to decreased productivity, increased operational costs, increased fuel consumption, increased vehicle wear and tear, and even the potential for accidents in mining areas (Peroni et al., 2025; Thoeni et al., 2024). Therefore, evaluating and optimizing the condition and design of mine roads is necessary to maintain smooth production and occupational safety in mining areas (Das et al., 2024; Han et al., 2024).

## RESEARCH METHODS

### Data Collection

The data collection phase is crucial for the internship. This stage involves gathering the data necessary for report preparation. This data comes from direct observation of current activities within the company to support the report writing process.

### Data Sources

The data collected for this report comes from field observations. This data includes both primary and secondary data. Primary data includes information obtained directly from the field, while secondary data is collected from other supporting sources.

#### a. Primary Data:

- Road width and alignment.
- Curve radius and superelevation.
- Road slope (Grade).
- Transverse slope.

#### b. Secondary Data:

- Location map.
- Topographic map.
- Mining equipment specifications.

### Data Processing

After collecting primary and secondary data, the next step is data processing. The data will be analyzed to produce relevant calculations. Data processing consists of the following steps:

- a. Determining road width and alignment.
- b. Calculating curve radius and superelevation.
- c. Analyze road gradient (slope).
- d. Evaluate cross slope.

### Report Writing

The final stage involves writing the report. This stage is crucial for summarizing and presenting the findings from the internship. This report will be prepared by students under the guidance of the Department of Mining Engineering, Faculty of Engineering, Southeast Sulawesi University.

## RESULTS AND DISCUSSION

### Results

#### Hauling Road Geometry

The geometry of a hauling road encompasses several aspects of road construction, as defined by the American Association of State Highway and Transportation Officials (AASHTO) Manual for Rural





Highway Design (1973). Hauling road construction can include road width, curve radius, superelevation, grade, and cross slope. The primary function of a hauling road is to support smooth hauling operations during mining operations. The hauling equipment used is generally large, so the road must be sized to accommodate the equipment to ensure smooth movement at normal speeds and safety.

### Mining Haul Road Width

The width of a mining haul road significantly impacts the smoothness of hauling operations. The wider the haul road used by the hauling equipment, the smoother the productivity of the operations. Conversely, the narrower the haul road, the more it will hinder ore transportation. The mining haul road at the research site consists of two sections: a straight haul road and a curved haul road.

#### a. Straight Haul Road Width



**Figure 1.** Actual straight road width conditions

The actual haul road width measurement on the straight road was divided into fifteen segments along the road from the pit marsh to the stockpile. The S-T segment measurement yielded an actual road width of 8.05 meters, as shown in the figure.

#### b. Haul road width on curves

The actual haul road width measurements on curves were divided into fourteen segments along the road from the pit marsh to the stockpile. The J-K segment measurements yielded an actual road width of 8.95 meters, as shown in the figure.



**Figure 2.** Actual condition of the width of the road on the bend



### Turn Radius

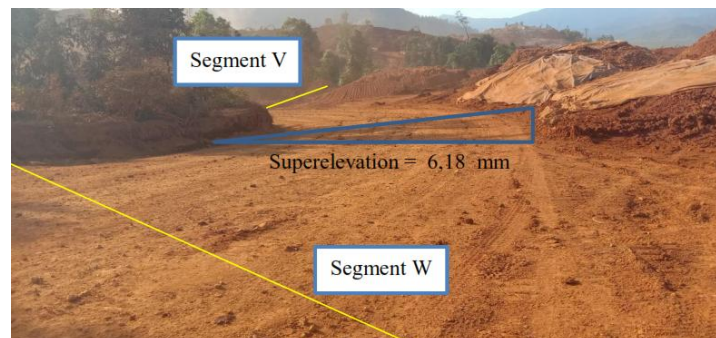
The actual turn radius was determined by dividing the road from pit 1 to the stockpile into fourteen segments. The T-U segment yielded an actual turn radius of 11.15 meters, as shown in the figure.



**Figure 3.** Actual bend radius conditions

### Superelevation

The actual superelevation value was determined by dividing the road from pit 1 to the stockpile into fourteen segments. The V-W segment yielded an actual superelevation value of 6.18 mm/m, as shown in the figure.



**Figure 4.** Actual superelevation conditions

### Road Gradient (Grade)

Actual road gradient (grade) measurements were conducted on twenty-nine segments along the road from pit 1 to the stockpile. On segments K-L, the actual grade was 5.75%, as shown in the figure.

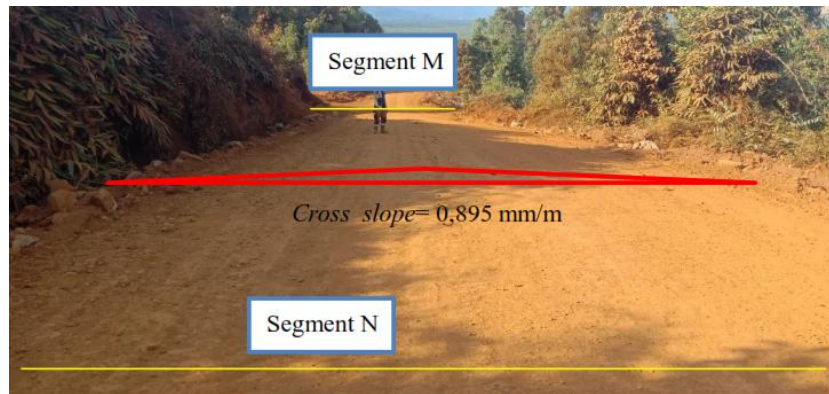


**Figure 5.** Actual road grade conditions



## Cross Slope

The actual cross slope measurement was divided into fifteen segments along the road from the pit mars to the stockpile. The M-N segment yielded an actual cross slope of 0.895 mm/m, as shown in the figure.



**Figure 6.** Actual cross slope conditions

## Discussion

### Hauling Road Geometry

The geometry of a hauling road encompasses several aspects of road construction, as defined by the American Association of State Highway and Transportation Officials (AASHTO) Manual for Rural Highway Design (1973). Hauling road construction can include road width, curve radii, superelevation, grade, and cross slope. The primary function of a hauling road is to support the smooth operation of hauling operations during mining operations. The hauling equipment used is generally large, so the road must be sized to accommodate the equipment to ensure smooth movement at normal speeds and safety.

### Haul Road Width on Straight Roads

The width of a haul road significantly influences and determines the smoothness of hauling operations. Calculating the width of a straight road differs from that of a curved road because the width of the road on a curved road is greater than that on a straight road. The haul road has two lanes (n) using a 2.6-meter-wide Hino dump truck hauling unit. Based on AASHTO theory, the haul road width must be increased by half the width of the hauling vehicle on the right, left, and center edges of the haul road for two lanes. From the calculation of the straight road width using equation 2.1, the minimum road width on a straight road is 8.57 m.

### Haul road width on curved roads

The haul road width on curved roads is generally always wider than on straight roads. This is intended to anticipate deviations in the haul road width caused by the angle of the truck's front wheels when negotiating the curve. Based on calculations, the haul road width on curved roads is 12.58 meters.

### Curve Radius and Superelevation

Dump trucks' ability to navigate curves is very limited, so curve design must consider the curve radius. Curve radius on mining haul roads requires determining the design speed of the dump truck, the coefficient of friction, and the maximum superelevation value. From the curve radius calculation, the minimum radius is 14.38 meters. Equation 2.4 can then be used to determine the superelevation value, resulting in a minimum superelevation value of 40 mm/m.





### Road Gradient (Grade)

The slope of the haul road must always be considered because the incline of the haul road, its slope or steepness, will significantly affect the production of the hauling equipment. Therefore, the slope (grade) of the haul road creates uphill resistance that the hauling equipment's engine must overcome. The maximum road gradient that can be successfully traversed by hauling equipment, especially dump trucks, ranges between 7% and 10%. Meanwhile, for uphill and downhill roads, a maximum road gradient of 8% is safer.

### Cross slope

A cross slope is the angle formed by the two sides of a road surface relative to the horizontal plane. A cross slope is essential to address surface drainage issues, especially during rainy seasons. A good haul road has a cross slope.

### CONCLUSION

Based on the results and discussion of haul road geometry in this study, it can be concluded that the construction of haul roads in the mining industry must adhere to government regulations and rules to create a safe and comfortable work environment. Priorities for haul road geometry include a minimum straight road width of 8.57 meters, a minimum curve width of 12.58 meters, a minimum curve radius of 14.38 meters, and a minimum superelevation of 40 mm/m. The minimum grade is 8%, and the minimum cross slope is 20 mm/m.

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