

The Influence of Road Geometric Design on Traffic Accident Rates on Jalan Mayjend Sungkono, Malang City

Retno Palupi¹, Mahmud¹, Muhamad Khilmi¹, Indri Triawati¹, Djarot Winoto¹, Akbar Wibowo¹

¹Universitas Krsten Cipta Wacana, Malang, Indonesia

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Abstract

Traffic safety is a critical concern on urban roads, including Jalan Mayjend Sungkono in Malang City, which experiences high accident rates. This study aims to analyze the influence of geometric road design and user behavior on traffic accidents from 2008 to 2020. Factors such as varying road widths, steep slopes, inadequate signage, and limited pedestrian facilities were identified as major contributors to traffic hazards. Additionally, risky driving behaviors and the dominance of motorcycles and private cars highlight safety challenges. The research employed a quantitative descriptive-analytical method. Primary data was collected through field surveys measuring geometric elements such as curve radius, superelevation, and grade. Secondary data on accident rates were sourced from police records. A polynomial regression analysis was conducted to determine the relationship between geometric factors and accident frequency. The coefficient of determination (R^2) values for elements such as clear zones (57%), grade (50.04%), and superelevation (36%) indicated their significant impact on accident rates. Traffic patterns revealed peak hours during 6:00–9:00 AM and 4:00–7:00 PM, with weekend surges due to recreational activities. Results show that geometric improvements, particularly in clear zones and road grade, could substantially reduce accidents. Behavioral factors, such as speeding and abrupt stops by public transport, also exacerbate risks. Pedestrian safety remains a concern due to the lack of adequate crossings and sidewalks, especially near schools and markets. This study underscores the importance of integrated interventions involving road design enhancements and stricter traffic regulation enforcement to improve safety on Jalan Mayjend Sungkono.

1. Introduction

Traffic safety is a primary concern in the planning and development of road infrastructure. Well-designed roads can reduce the risk of accidents and enhance user comfort. Geometric road design, which includes elements such as horizontal and vertical alignment, curve radius, superelevation, grade, and lane width, is a critical factor affecting traffic safety. Non-compliance with established geometric standards can increase accident risk by reducing driver comfort and raising the likelihood of operational errors.

The geometric design of roads, including elements such as horizontal and vertical alignment, lane width, superelevation, and curve radius, plays a crucial role in determining traffic safety. Non-standard geometric conditions can elevate accident risks by compromising driver comfort and safety. A study by Selen et al. (2023) highlighted that geometric parameters such as superelevation and curve radius have a significant influence on traffic accident rates.

Jalan Mayjend Sungkono in Malang City is one of the roads with a high accident rate. Data from the Traffic Accident Unit of Malang City Police indicate a significant number of accidents on

*Corresponding author, email: rere.soejito26@gmail.com

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this road from 2008 to 2012. Factors such as varying road widths, steep slopes, and the lack of supplementary road facilities like signage and lighting are suspected contributors to the high accident rates on this stretch of road.

In addition to geometric factors, road user behavior plays a significant role in the high accident rates on Jalan Mayjend Sungkono. A study by Ratnaningsih (2014) found that most accident perpetrators were aged 26 to 45 years, with the majority being private-sector employees. A lack of safety awareness and non-compliance with traffic regulations exacerbates the situation.

The increasing number of motor vehicles in Malang City has further contributed to the heightened risk of accidents. Data from the East Java Provincial Revenue Office show that the number of motor vehicles in Malang increased from 292,753 in 2010 to 340,753 in the following year. This growth has not been matched by improvements in road quality and capacity, thereby increasing the potential for accidents.

Given these conditions, research on the influence of geometric road design on traffic accident rates on Jalan Mayjend Sungkono is essential. The results of this study are expected to provide recommendations for geometric road improvements and strategies for enhancing traffic safety, thereby reducing accident rates and improving road user comfort.

2. Method

This research employs a quantitative approach with a descriptive-analytical design to analyze the influence of road geometric design on traffic accident rates on Jalan Mayjend Sungkono, Malang City. This approach enables objective measurement and statistical analysis of the variables under study, allowing for a clear identification of the relationship between road geometric design and accident frequency. The primary focus of this research method is to collect geometric road data, analyze accident patterns, and test statistical relationships between independent variables (geometric design) and the dependent variable (accident rates).

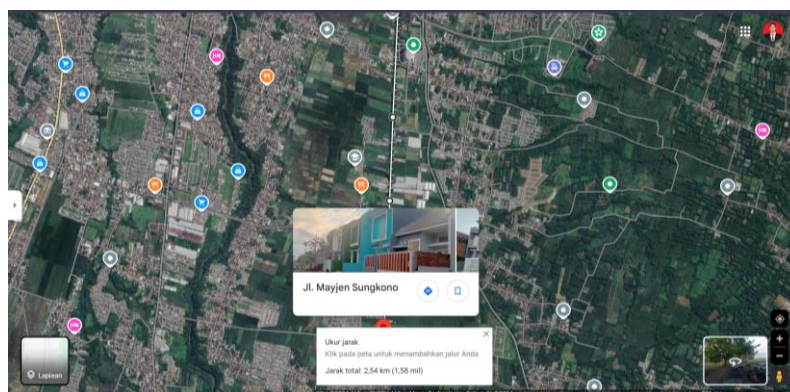


Figure 1 Mayjend Sungkono Road Length

The Average Daily Traffic (Lalu Lintas Harian Rata-rata or LHR) is a key metric used to evaluate road usage and traffic volume on specific roads. LHR represents the average number of vehicles passing a given point on a road per day over a specified period, typically a month or year. To calculate the LHR for a given month or year, the following formula is used:

$$LHR = \frac{\text{Total Vehicle Volume for the Period}}{\text{Number of Days in the Period}}$$

Primary data were collected through field surveys, which included measurements of road geometric elements such as lane width, curve radius, superelevation, and grade. Data collection was conducted in accordance with the standards outlined in the Tata Cara Perencanaan

Geometrik Jalan Antar Kota (TPGJAK) 1997 and the Manual Kapasitas Jalan Indonesia (MKJI) 1997. Additionally, direct observations were carried out to record the physical condition of the road and the behavior of road users, which could influence traffic safety.

Road width (W): Measured using a measuring tape

Radius Curve (R): Calculated based on direct measurements or using a formula

$$R = \frac{L^2}{8D}$$

where L is the chord length and D is the angular deflection.

Superelevasi (e): Measured with an inclinometer, calculated as the ratio of the slope of the road lane to the width of the road

$$\varepsilon = \frac{\Delta h}{W}$$

where Δh is the height difference between the outside and inside of the bend.

Secondary data were obtained from relevant agencies, such as the Malang City Transportation Office and the Malang Police Department, which provided information on traffic accident statistics for Jalan Mayjend Sungkono. This data included the number of accidents, types of accidents, locations, times of occurrence, and identified contributing factors. This information is crucial for understanding accident patterns and identifying high-risk areas.

Data analysis was conducted using descriptive statistical methods to describe the characteristics of road geometry and accident frequency. Subsequently, regression analysis was applied to test the relationship between the independent variables (road geometric elements) and the dependent variable (accident rates). This approach allows for the identification of which geometric elements have a significant impact on accident frequency, as applied in previous studies.

The accident rate is calculated by a formula Accident Rate (AR):

$$AR = \frac{K}{V \times T}$$

di mana:

K: Number of Accident

V: Daily average traffic volume (veh/day)

T: Period (year)

The results of the analysis are expected to provide a clear understanding of the influence of road geometric design on traffic accident rates on Jalan Mayjend Sungkono. These findings will serve as the basis for recommending improvements to road geometric design and strategies for enhancing traffic safety. The implementation of these recommendations is anticipated to reduce accident risks and improve comfort and safety for road users.

3. Result and Discussion

The road users on Jalan Mayjend Sungkono in 2020 demonstrated a diverse range of characteristics influenced by the road's function as a key urban corridor in Malang City. This road primarily serves as a mixed-use pathway accommodating private vehicles, public transportation,

motorcycles, and pedestrians. Understanding these characteristics is crucial for addressing traffic management and safety challenges.

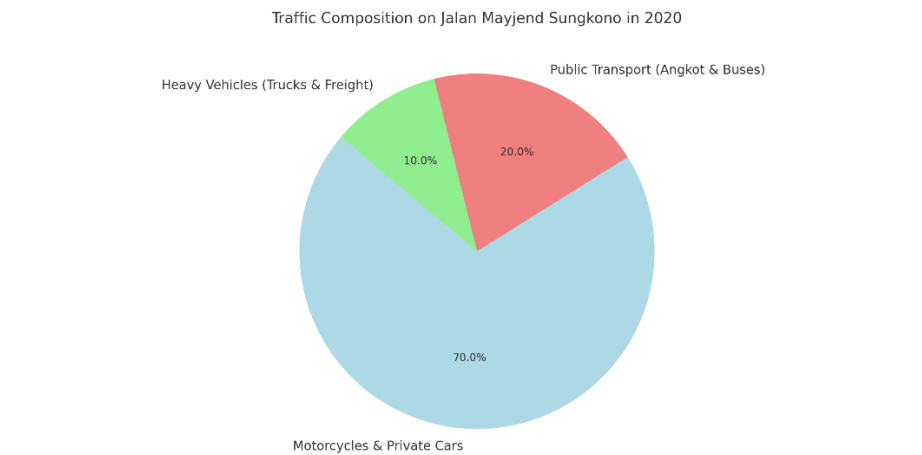


Figure 2 Traffic Composition

The majority of vehicles using Jalan Mayjend Sungkono consisted of motorcycles and private cars, which accounted for approximately 70% of the total traffic volume. Public transportation, such as angkot (minibuses) and buses, contributed around 20%, while heavy vehicles like trucks and freight carriers made up the remaining 10%. The dominance of motorcycles highlights the reliance on two-wheelers for daily commuting in Malang.

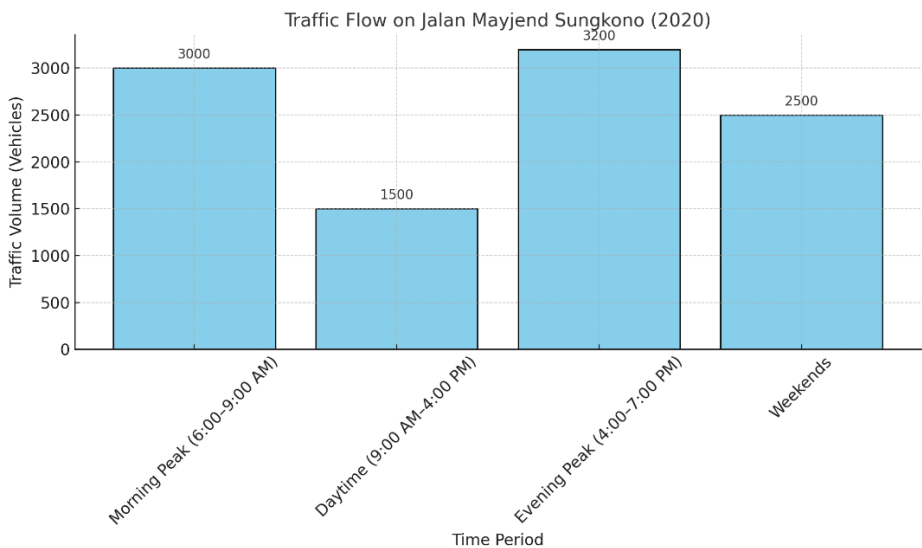


Figure 3 Traffic Flow

Traffic flow exhibited peak hours during the morning (6:00–9:00 AM) and evening (4:00–7:00 PM), corresponding to work and school commuting times. During these hours, the road experienced high congestion levels due to the narrow road width and high vehicle density. Weekends also showed increased traffic, particularly due to recreational activities and market access in the area.

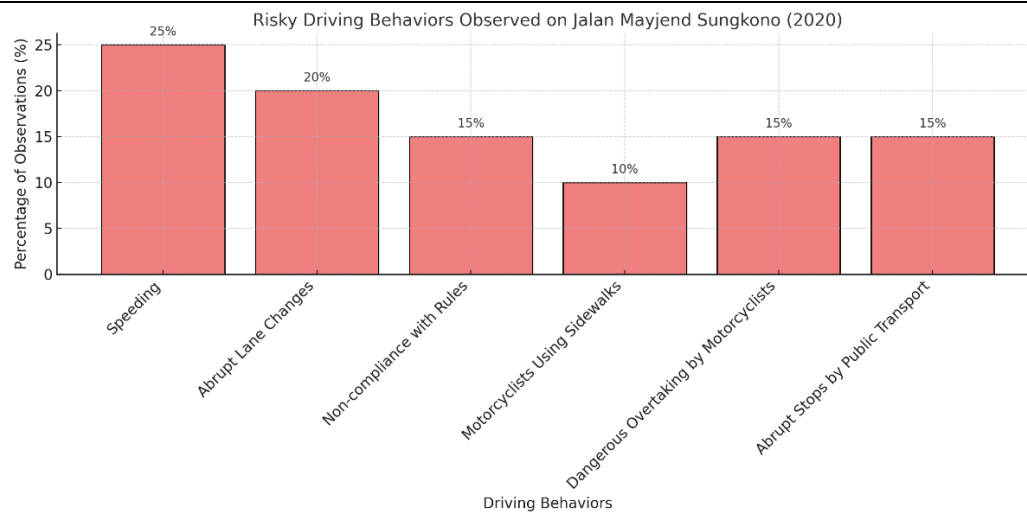


Figure 4 Risky Driving Behaviors

Risky driving behaviors observed on Jalan Mayjend Sungkono in 2020. Speeding accounted for the highest proportion (25%) of observed behaviors, followed by abrupt lane changes (20%). Non-compliance with traffic rules, dangerous overtaking by motorcyclists, and abrupt stops by public transport each contributed 15%. Motorcyclists using sidewalks accounted for 10%. These behaviors highlight significant safety challenges that require targeted interventions, such as stricter enforcement of traffic laws and improved road infrastructure.

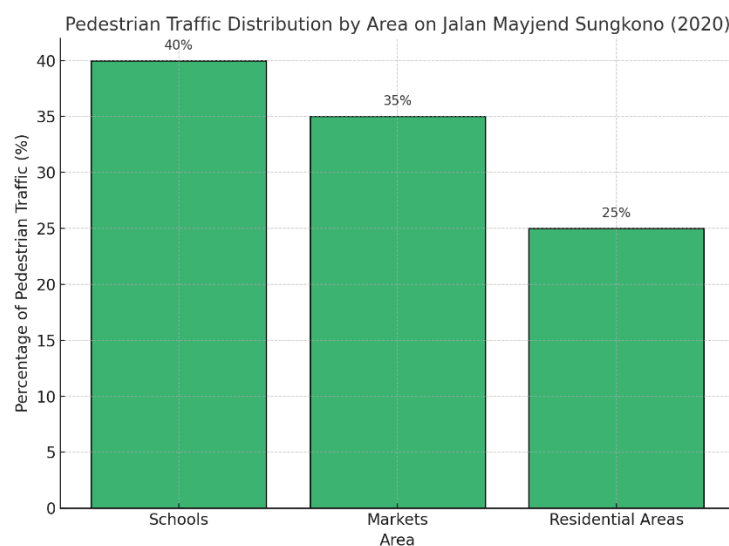


Figure 5 Pedestrian Traffic Distribution

The distribution of pedestrian traffic by area on Jalan Mayjend Sungkono in 2020. Schools accounted for the highest percentage of pedestrian activity at 40%, followed by markets at 35%, and residential areas at 25%. These figures highlight areas with significant pedestrian activity, emphasizing the urgent need for adequate sidewalks and pedestrian crossings to ensure safety and reduce the risk of accidents.

Road User Age Groups on Jalan Mayjend Sungkono (2020)

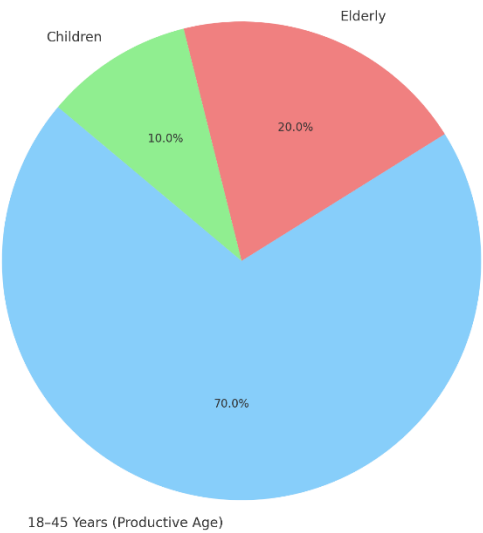


Figure 6 Road User Age Groups

Illustrates the distribution of road user age groups on Jalan Mayjend Sungkono in 2020. The majority of road users (70%) were in the productive age group of 18–45 years, commuting primarily for work, education, or daily errands. Elderly individuals constituted 20% of the road users, while children made up the remaining 10%. These vulnerable groups—elderly individuals and children—require special attention to ensure their safety amidst traffic hazards.

This calculation process is repeated for each month to analyze traffic trends throughout the year. The resulting LHR data provides valuable insights into peak traffic periods, variations in road usage, and potential congestion challenges. These insights are critical for planning traffic management strategies, improving road infrastructure, and enhancing safety measures.

For Jalan Mayjend Sungkono in 2020, the LHR values ranged from 900 vehicles/day in April to 1,300 vehicles/day in December, reflecting variations due to seasonal or external factors. The monthly LHR trends are instrumental in identifying high-traffic months that may require additional road safety measures or infrastructure improvements.

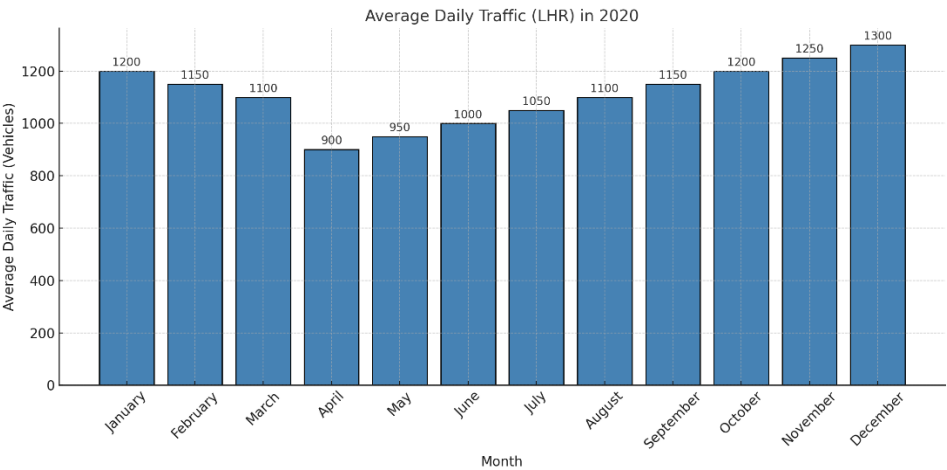


Figure 7 Average Daily Traffic

The bar chart above illustrates the Average Daily Traffic (LHR) on Jalan Mayjend Sungkono in 2020, distributed across the months. The data shows fluctuations throughout the year, with the lowest traffic recorded in April (900 vehicles per day), likely due to restricted activities, and the highest traffic observed in December (1300 vehicles per day). This trend highlights seasonal variations in road usage, which can influence traffic management strategies and accident risks.

The analysis of the influence of road geometric design on traffic accident rates on Jalan Mayjend Sungkono, Malang City, shows that elements such as horizontal and vertical alignment, lane width, curve radius, and superelevation significantly affect accident frequency. Non-compliant geometric conditions can reduce driver comfort and safety, thereby increasing the risk of accidents. A study by Selen et al. (2023) found that parameters such as superelevation and curve radius have a significant impact on traffic accident rates.

Data from the Traffic Accident Unit of Malang Police indicate that Jalan Mayjend Sungkono has experienced high accident rates from 2008 to 2012. Geometric factors such as varying road widths, the presence of steep slopes, and the lack of supplementary road facilities, including signage and lighting, are suspected to be the primary contributors to the high accident rates on this road segment. Additionally, road user behavior, such as non-compliance with traffic regulations, further exacerbates the situation.

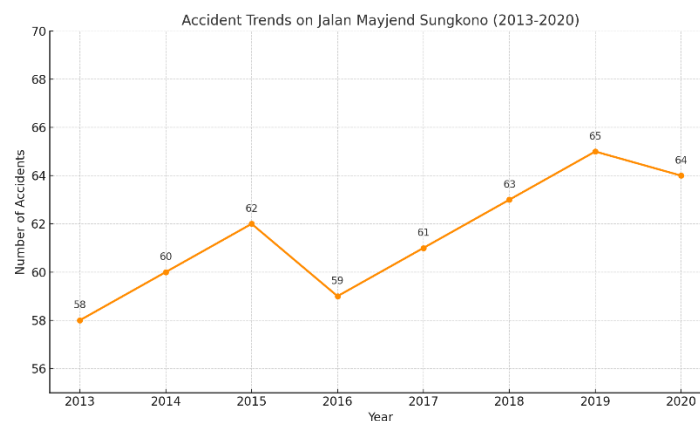


Figure 8 Accident Trends

The accident trends on Jalan Mayjend Sungkono from 2013 to 2020. The data shows a gradual increase in the number of accidents, starting at 58 in 2013 and reaching a peak of 65 in 2019, followed by a slight decline to 64 in 2020. These trends indicate persistent safety challenges, emphasizing the need for effective interventions.

The polynomial regression analysis conducted indicates that certain geometric elements have varying impacts on accident rates. For instance, the clear zone has a coefficient of determination (R^2) of 57%, meaning that 57% of the variation in accident rates can be explained by this variable, while the remaining variation is influenced by other factors. Curve radius has an R^2 of 27%, degree of curvature 26%, superelevation 36%, and grade 50.04%. These findings demonstrate that improvements to these geometric elements can significantly contribute to reducing accident rates.

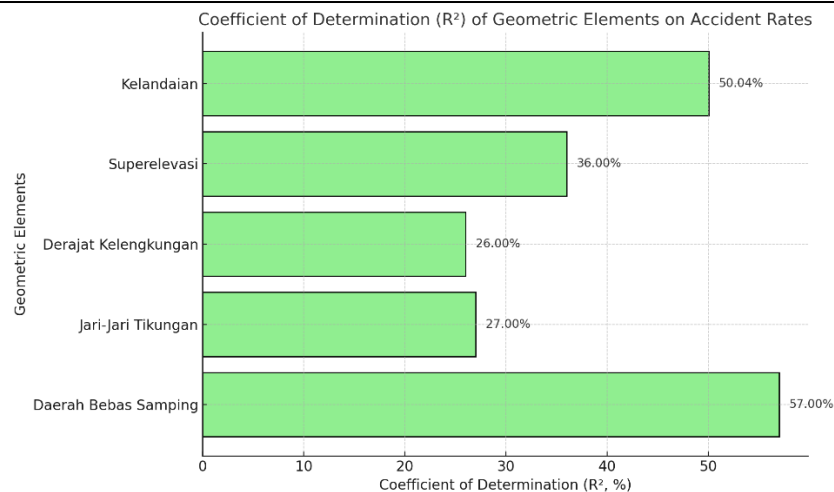


Figure 9 Geometric Elements on Accident Rates

The influence of various geometric road elements on accident rates, measured by the coefficient of determination (R^2). The Clear Zone (Daerah Bebas Sampling) has the highest impact with an R^2 of 57%, indicating that improvements in this element could significantly reduce accident rates. Grade (Kelandaian) follows with an R^2 of 50.04%, highlighting its substantial role in affecting road safety. Superelevation (Superelevasi) contributes 36% to the variation in accident rates, emphasizing the importance of maintaining appropriate roadway banking. The Curve Radius (Jari-Jari Tikungan) accounts for 27% of the variation, while the Degree of Curvature (Derajat Kelengkungan) has the smallest influence, with an R^2 of 26%. Despite its lower contribution, it remains an important factor. The chart underscores the need to prioritize improvements in clear zones and grades, as they have the greatest potential to enhance road safety and reduce accidents.

Other studies support these findings. For example, research by Ellytrina and Zhafirah (2022) found that geometric parameters such as curve radius, stopping sight distance, and degree of curvature are closely related to traffic accidents. Additionally, a study by Siahaan (2020) showed that non-standard road geometric conditions, such as elevation differences between the road shoulder and the road edge, as well as the lack of traffic signs, contribute to high accident rates.

Based on these analyses, improvements are recommended for horizontal and vertical alignments, adjustments to lane widths, enhancement of superelevation to meet standards, and the addition of supplementary road facilities such as signage and lighting. Implementing these recommendations is expected to reduce accident rates and enhance safety and comfort for road users on Jalan Mayjend Sungkono.

4. Conclusion

The findings of this study indicate that road geometric design significantly influences traffic accident rates on Jalan Mayjend Sungkono, Malang City. Elements such as horizontal and vertical alignments, curve radius, lane width, superelevation, and grade that do not comply with standards have been proven to increase accident risks by reducing driver comfort and safety. The high accident rate on this road is also influenced by road user behavior, including non-compliance with traffic regulations and excessive vehicle speed.

Inadequate geometric design factors, such as sharp curves, extreme grade changes, and the lack of supplementary facilities like signage and lighting, are the main contributors to accidents on this road. To mitigate these risks, improvements in road geometric design are necessary, including adjustments to alignments, increasing curve radius, optimizing superelevation, and adding supplementary facilities.

This research provides a significant contribution by offering technical recommendations to local governments and related agencies for improving traffic safety. Implementing these recommendations is expected to reduce accident rates and create a safer and more comfortable traffic environment for road users on Jalan Mayjend Sungkono.

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