

The Impact of Road Section Damage on Alternative Transportation Routes: A Systematic Literature Study

Iip Faturrohman¹, Andi Nugraha Saputra², Mushthofa³,
Asep Dian Heryadiana⁴, Muhammad Isradi⁵

¹⁻⁴Faculty of Civil Engineering, Universitas Majalengka, Indonesia

⁵Faculty of Engineering, Universitas Mercu Buana Jakarta, Indonesia

Email korespondensi: iipftrhmn@gmail.com, andinugrahaa4@gmail.com, Mushthofa800@gmail.com,
asepdian@unma.ac.id, isradi@mercubuana.ac.id

ARTICLE INFO	ABSTRACT
Keywords: Road geometry road damage Impact on society	<i>This study examined the effect of road damage on the operation of alternate transportation routes using the systematic literature review (SLR) method. This study focused on the impact of road geometry, various forms of road damage, and societal repercussions. Major academic databases were searched for literature from 2013 to 2023 using the predetermined inclusion and exclusion criteria. According to general studies, geometric elements, including lane width, curvature, slope, and shoulder conditions, are directly associated with different types of damage, such as cracks, potholes, grooves, and drainage failures. These damages result in decreased route capacity, longer delivery times, higher rates of vehicle damage, higher accident risks, and restricted access to essential services. The social effects are substantial in places with little redundancy in the infrastructure. The findings demonstrate the importance of integrated planning that takes preventative maintenance and geometric design into account to guarantee transportation resilience and community welfare.</i>

1. Introduction

Many nations around the world deal with the problem of road damage. The issue of road infrastructure is critical for many countries (Nurhasanah, 2024). The transportation infrastructure is frequently inadequate to meet the growing demands for mobility due to growing urbanization and population increase. Road damage can result in traffic jams, collisions, and detrimental effects on the economy in many regions of the world. The surface of roads experiences wear and degradation as time progresses due to various elements such as geographic location, age, traffic levels, climate conditions, engineering methods, and the materials employed in its creation. (Shim, 2022) There are several advantages and disadvantages to developing infrastructure and transportation networks. The key benefits include the creation of numerous job opportunities, the linking of remote locations, the improvement of logistics, and the transportation of commodities. These are all necessary for human growth. (de Abreu, 2022) Road networks in both developed and emerging nations are difficult to maintain and upgrade, and many are using contemporary technology for inspections and repairs. Since road degradation affects both domestic and foreign trade, this issue must be addressed worldwide. Attention to roadway infrastructure is essential since, without it, smart vehicles will struggle to function dependably, and we will never achieve fully autonomous driving. (Iparraguirre, 2022) The governments of numerous nations, including Indonesia, are quite concerned about road damage. Road damage can lower people's quality of life and impede economic growth. For instance, heavy traffic, severe weather, and a lack of regular maintenance have destroyed many essential and secondary roads in Indonesia. Rainwater can cause various harm to the road surface when it seeps into a damaged region. (Arya, 2024) The government has tried to allocate funds for infrastructure improvements, but these efforts are

usually derailed by issues with project management and implementation. Repairing damaged roads must be a primary goal on the national development agenda to provide accessibility and safety for all communities.

A country's social and economic development is correlated with its road infrastructure. Highways are necessary to facilitate the movement of people and goods. (Del Rosario, 2023) Road deterioration is another significant issue, especially in areas that are rapidly expanding. Considering the development of the economy and community advantages, a well-structured road system is a crucial matter. (Mythili, 2024) Many areas suffer from poor infrastructure, which is frequently brought on by improper investment and design. Regional road deterioration may have broader effects, including higher transportation expenses and a decline in economic competitiveness. Therefore, For these concerns to be sustainably and adequately addressed, collaboration between the national, regional, and local governments is crucial. (Rachman, 2025) To guarantee that transportation infrastructure can best support community mobility and economic progress, an integrated and sustainable approach is required.

The quality of life of people in the modern era is highly dependent on the ability of the infrastructure network to cope with hazards when they occur and to restore pre-disaster conditions or improve them as soon as possible. (Capacci, 2022) In other places, the local government and people are concerned about damage to alternate roadways. These roads are vital connections between different areas, yet they are frequently harmed by heavy traffic and poor upkeep. Bad road conditions can make it more difficult for people to move around, raise the chance of accidents, and hurt the local economy. The growth of mobility networks is happening quickly. The development of pavements and the extension of road networks have raised serious concerns about sustainability and the environment. (Alaloul, 2021) To guarantee the security and comfort of road users, alternative roads must be evaluated and repaired. To keep roads in good shape and perform at their best, community members and municipal governments must work together.

Due to the constant movement of people and things around the globe, transportation is the foundation of local, regional, and global economies. (Jelti, 2023) In most situations, the last two factors are the most important, especially when the road profile is uneven and the car travels fast. (Feng, 2023) Road damage is, therefore, a multifaceted and intricate problem that needs to be addressed by several stakeholders. At the same time, it adversely affects the environment during its construction, use, and maintenance phases. (Aryan, 2023) Addressing road damage must be a top priority in infrastructure planning and management, whether at the municipal, regional, national, or international level. Using methodical assessment and utilising contemporary technologies is crucial for these concerns to be sustainably and adequately addressed. Collaboration between the national, regional, and local governments is also vital. (Rachman, 2025)

2. Research Method

For this study, the Systematic Literature Review (SLR) method was used to collect and analyze data. SLR was conducted by locating, selecting, and evaluating content from various reliable sources, including research papers, conference proceedings, and scholarly publications. Finding relevant original papers, acquiring the required data, and assessing and synthesizing the results are the objectives of Systematic Literature Review (SLR) investigations to gain a more thorough and in-depth understanding of the subject being studied. This study employed the systematic literature review (SLR) method, also known as a systematic literature review, which is a sort of review that gathers multiple research studies and synthesizes them to provide robust answers to research issues. A more extensive, well-defined, and detailed strategy on the timeframe in which the material was chosen is necessary for a systematic

literature review. (Calveen, 2023) The literature selected and excluded was based on themes, the year of publication, and the calibre of the research.

Additionally, research was conducted to identify the approaches, patterns, and weaknesses in implementing road user safety. This method is used to increase public understanding of the effects of road damage. (Dwiani, 2024)

2.1 Database Used

A complete bibliometric investigation requires the usage of multiple databases. Selecting the correct database is essential to ensuring relevant and accurate results. The dataset used in this bibliometric research was produced by the Publish or Perish application. (Rifai, 2025) This study found relevant papers from 2020 to 2025 using the Google Scholar database. This selection of period ensures that more relevant publications will be included.

Academic publications from a wide range of subjects are covered by Google Scholar, including theses, books, conferences, journal articles, and other scholarly works. It is, therefore, a wise decision. With a more exhaustive information coverage, Google Scholar is more thorough than databases like PubMed and Scopus. For instance, prior studies have not explained the selection of Google Scholar over broader bibliometric research databases. For example, Web of Science (WoS) and Scopus were the informational databases. (Sofyan D. H., 2023) This approach has been employed over the last five years to guarantee thorough literature coverage and convenient access to pertinent papers, ensuring that this research represents the latest developments and trends in the field.

2.2 Method of Search

If the relevant content is correctly detected and the search query is retained, the bibliometric analysis is successful. You can look for research on the effects of road damage on alternate transportation routes by using keywords. Several works published as "bibliometric analysis" or "systematic review" were reviewed to formulate the search query. "Road Geography," "Road Damage," and "Impact on Society" are among the terms that are used. To locate pertinent papers, the Publish or Perish (PoP) software searches Google Scholar. To assess roundabout designs at unsignalized crossings, this study does a systematic assessment and bibliometric analysis of 1,000 publications published between 2020 and 2024. (Sari, 2025)

Works addressing intersection performance or roundabout design had to be published in English between 2000 and 2024 and meet a minimal quality standard established by a manual review of the abstract and title to be included. PoP used a Google Scholar search query to gather comprehensive academic metadata for academic works, such as citation counts, authors, journal names, and abstracts. After that, the material was forwarded for additional processing and examination. A more thorough analysis of the literature on the effects of roadside damage on alternative transport routes was made possible by the keyword segmentation of articles—detailed instructions for performing bibliometric analysis using VOSviewer are restricted to previously published research.

Following article retrieval, VOSviewer, a potent bibliometric visualization tool, was used to evaluate the data. Using co-authorship, citation linkages, or keyword co-occurrence, Vosviewer may generate network maps. Following article retrieval, VOSviewer, a potent bibliometric visualization tool, was used to evaluate the data further. (Budiono, 2024) Vosviewer was utilized in the study to illustrate the connections between terms like "Road Geometry," "Road Damage," and "Impact on Society." A more profound comprehension of the topic of study was made possible by this mapping, which assisted in identifying patterns, clusters, and inequalities in modern literature. This organized approach uses cutting-edge tools to enhance and present the gathered data while guaranteeing a methodical and thorough search technique.

2.3 Collecting initial statistical data

All information is exported to Research Format Information Systems (RIS) for analysis using VOSviewer software—map visualization, overlay visualization, and Journal of Social and Humanities, Vol. 2 No. June 09, 20241948 Density visualization is three forms of data processing output used to visualize relationships and group keyword-related search topics. (Alfarizi M. R., 2024) PoP software may collect and present bibliographic information in a standardized RIS format, such as author names, citation counts, and publication sources. A thorough picture of research trends and information exchange can be obtained by mapping literature sources from foreign periodicals.

You can choose articles that correspond with specific study themes and phrases, particularly those about design effectiveness, to obtain a focused grasp of the relationship between roundabout design and safety performance. Although there are thorough instructions and visual examples on utilising VOSviewer for bibliometric analysis, the current work does not include complete instructions. The use of Publish or Perish is not explained in depth. Ultimately, data mapping carried out by scientific writing guidelines would make the bibliometric analysis's findings easier to comprehend and interpret.

3. OUTCOMES AND CONVERSATION

3.1 Keyword Relationships for Visualization Research

For this investigation, 1,000 scientific publications about terms like "geometry," "damage," "effect," "road," and "impact" were gathered from the Crossref database using Publish or Perish version 8. The association between the gathered research journals can be displayed using Vosviewer version 1.6.20. Bibliographic analysis also makes it possible to chart the evolution of scientific topics and find national and international networks. (Sinambela, 2024) The Impact of Road Damage on Alternative Transportation Routes reveals that it is highly beneficial for users, as indicated by a bibliometric analysis. (Van Dalen, 2021)

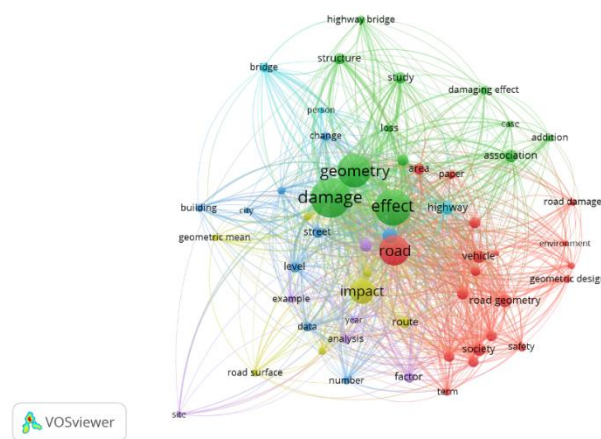


Figure 1. Visualisasi Jaringan Kata Kunci Menggunakan VOSviewer, Menyoroti Istilah Dominan Seperti "geometry", "damage", "effect", "road", dan "impact"

The most pertinent secondary keywords when using VOSviewer software for data visualization are "geometry," "damage," "effect," "road," and "impact," as seen in Figure 1. Keywords help summarize the main ideas of a research paper while honing and clarifying its core concepts. (Rifai, A. I., Isradi, M., Prasetijo, J., & Immanuel, G., 2024) This result is consistent with future studies that concentrate on the high number of traffic accidents that are brought on by other drivers.

Groups of comparable themes are shown by different colour groups.:

- Green: Displays technical features, including structure, impact, damage, and geometry, along with technical analysis techniques and the effects of damage on infrastructure parts.
- Red: Shows the effects of road damage on communities, cars, road geometry, and safety from a social and safety standpoint.
- Blue: Using tangible elements like roads, bridges, and buildings, it illustrates how road deterioration affects other municipal infrastructure.
- Yellow and purple: Contains terms relating to the effect of research and analytical techniques on road conditions, such as impact, data, analysis, path, and road surface.

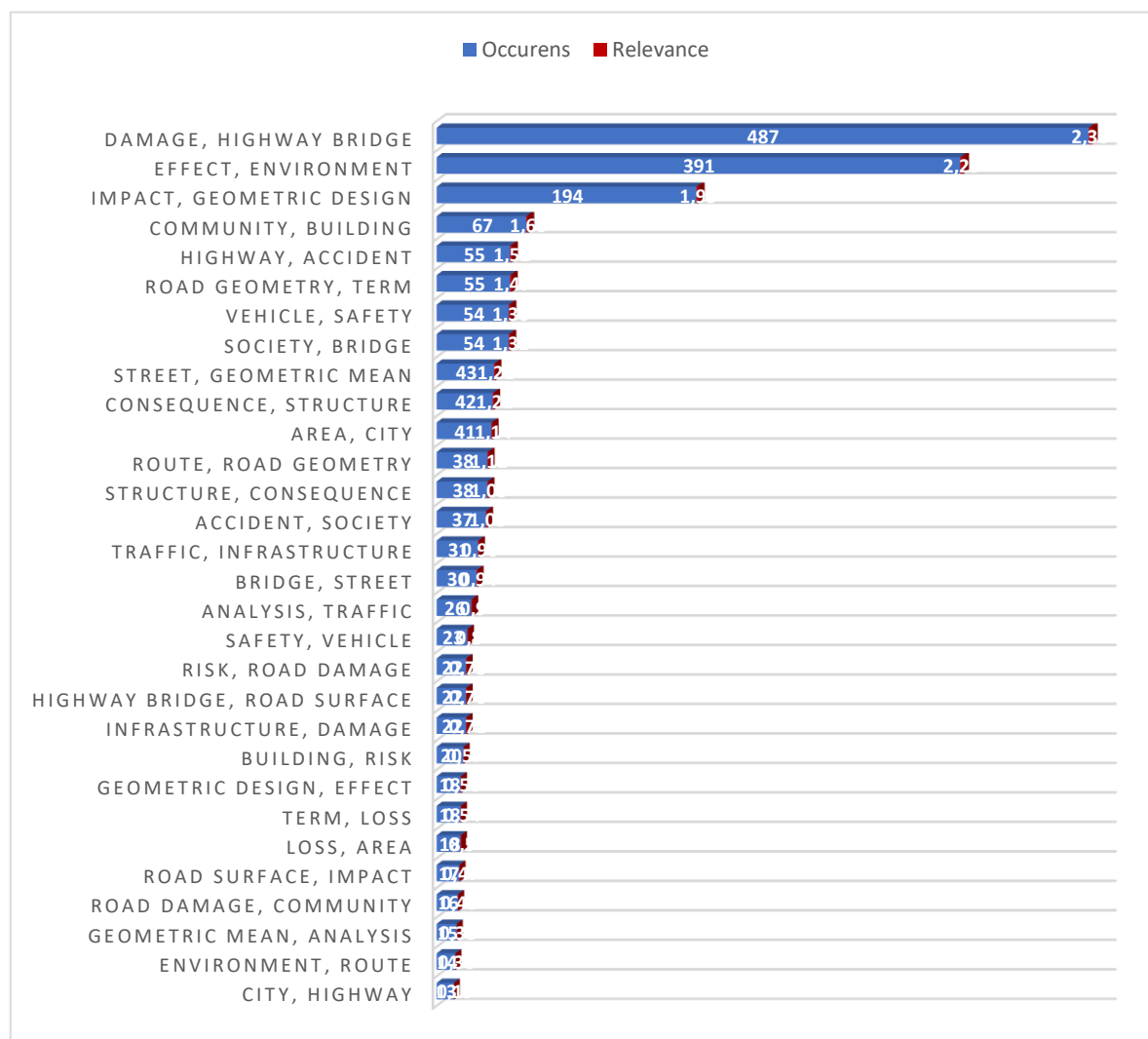


Figure 2 Grafik kata kunci berdasarkan kemunculannya

Following a review of the literature on road geometry, damage, and its effects on society, we discovered the graph above, which illustrates the relationship between keyword relevance and frequency. The relevance value (red) and the quantity of occurrences (blue) are displayed on the horizontal axis. Despite having the most appearances (487), the keyword pair "influence, environment" has the lowest relevance value (0.72). This demonstrates that although the word is commonly used, it may not always be directly related to the significant issue focus.

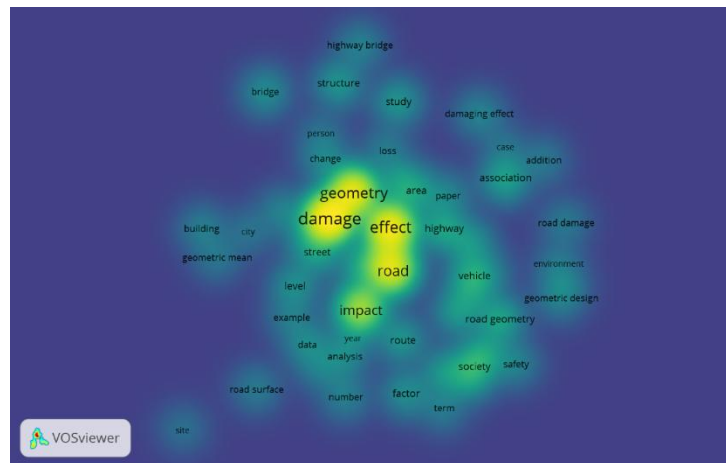


Figure 3 Kepadatan Kata Kunci

Conversely, low-frequency pairs like "city, highway" or "geometric mean, analysis" are significant. This implies that these word combinations are more focused and more unique to the primary issue being studied, like how geometry affects road efficiency. Using this graph, researchers can identify phrases that are commonly used yet irrelevant. Consequently, this analysis can assist in mapping the literature and identifying a more suitable area of study.

Tabel 1 Kata kunci menurut studi tertinggi

Kata Kunci	Total Studi
Damage	487
Effect	391
Impact	194
Community	67
Highway	55
Road Geometry	55
Vehicle	54

The density map of the bibliometric analysis results using VOSviewer is displayed in the graph above. The density level of keyword occurrences in the examined collection of scientific literature is shown in this graph. Areas with more keywords are indicated in yellow, while those with fewer keywords are indicated in green and blue. In this analysis, VOSviewer mapped the authors' keywords (Sofyan D. A., 2022) roadways, impact, damage, and geometry are the ones that appear most frequently, suggesting that they will be pertinent research topics.

Furthermore, a high word density suggests that words are closely related to one another and frequently occur together in written materials. Road damage and its effects on automobiles, buildings, and safety are nevertheless considered, as seen by the prominence of other terms with lower intensity, such as impact, vehicle, road geometry, and safety. This graph helps researchers identify the most frequently used keywords in their field of study and gain a better grasp of literature trends.

3.2 Development Of Publications By Year

The Publish or Perish 8 application will generate a map using all VOSviewer data. (Jenny, 2024) Between 2000 and 2025, the number and depth of studies examining the impacts of roadway deterioration on alternative transportation routes are expected to increase. (Varghese, 2025) Technical

problems, including road structural deterioration and its effects on travel time and vehicles, were not well studied in the early 2000s. Research was typically conducted on major roadways, with less attention to alternate routes or wider socioeconomic effects. Spatial-based analysis and integrated transportation systems did not develop quickly because of a lack of data and technology.

The project will integrate interdisciplinary methods like social impact assessments, transportation network models, and geographic information systems (GIS) between 2010 and 2020. In addition to road damage, attention will be paid to how disruptions lead to other forms of congestion, the usage of alternate routes, and the interruption of interregional connectivity. This issue will gain more significance between 2020 and 2025 due to climate change, urbanization, and natural disasters. The latest publication, using big data and real-time spatial analysis, focuses on road infrastructure resilience, changes in transport routes, and the impacts of these changes on logistics safety, society as a whole, and users. (Ang, 2022)

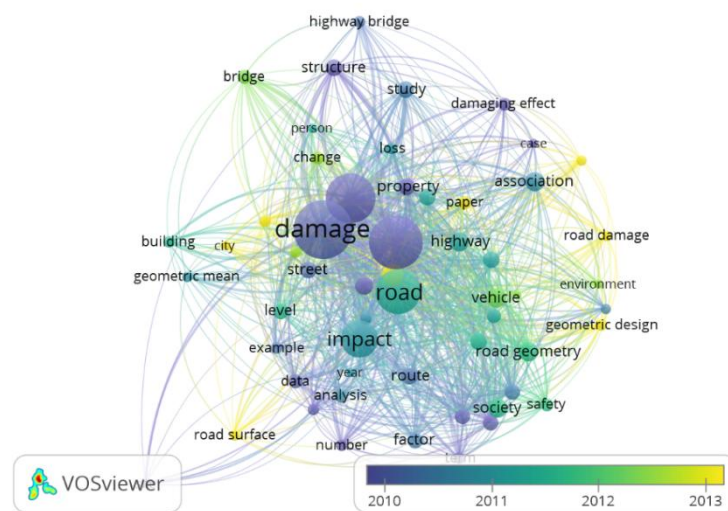


Figure 4 Jumlah penelitian menurut penerbit

This figure shows a network visualization created by VOSviewer, which illustrates the relationships between essential terms in research on road safety and geometric design. This study uses the VOSViewer application to do bibliometric analysis. According to the goals of this study, a thorough search was carried out utilizing the Scopus database. (Alpen, 2022) On the graph, the most used terms from before 2010 (about 2010) are displayed in blue, while the most used words from 2013 onward are shown in yellow. Circles are where keywords like "damage," "road," and "effect" are most commonly found. Connecting lines are used in various publications to show how keywords relate.

This graphic illustrates how damage, structure, effects, and qualities were the main areas of study in 2010–2011. This demonstrates that the structural and technical aspects of road degradation were prioritized initially. The graph's right-hand yellow indicates that attention is now being paid to increasingly intricate components like road geometry, society, the environment, and geometric design. This demonstrates the advancement of studies on the effects on society and the environment, as well as improved road geometry layout. This suggests that road geometric design and driver behaviour are critical components analyzed in this research. Driving performance, environmental awareness, risk-taking propensity, and cognitive abilities are just a few variables and aspects that might influence driving behaviour. (Mohammadnazar, 2021) This graphic illustrates the evolution of scientific interest in transportation infrastructure, including roads.

3.3 Research Types Are Determined By The Publisher And Research Classification.

Table 2 Jumlah penelitian menurut penerbit

Penerbit	Studi
Elsevier	217
books.google.com	83
ascelibrary.org	68
Springer	60
Wiley Online Library	52
ACS Publications	50
Taylor & Francis	50
Google Patents	31
ieeexplore.ieee.org	27
mdpi.com	25
Lain Lainnya	367
Total	1030

According to the distribution table of research from different publishers, 367 studies fall within the "Other" category. This demonstrates that the literature collection still includes valuable works from various sources unrelated to large publishers. Elsevier is the biggest publisher, with 217 studies. Ascelibrary.org has 68 publications, compared to 83 on Books.google.com. All three offer a crucial starting point for earlier literary studies.

Additional noteworthy sources included 50 papers from ACS Publications and Taylor & Francis, 60 research from Springer, and 52 studies from the Wiley Online Library. Additionally, database systems like Google Patents and ieeexplore.ieee.org made a significant impact. A total of 1030 studies were gathered, demonstrating the breadth of the research and the range of sources consulted. This distribution illustrates how to carry out a thorough evaluation of the literature.

4. Conclusion

This study uses the Systematic Literature Review (SLR) approach to find and examine how road segment deterioration affects alternate routes for transit. Road shape and damage levels are strongly correlated with greater social risk and poor transportation performance, according to the findings of 1030 publications from diverse sources. Most pertinent literature is available from publishers like Elsevier, Springer, and Google Books. These publishers show how the academic community is actively involved in this subject. These findings suggest that resilient road design and suitable maintenance techniques are crucial for minimizing future transportation interruptions.

Furthermore, the results of the bibliometric visualization reveal noteworthy patterns in essential terms like "damage," "geometry," and "impact," which have dominated the literature for the previous 20 years. This study demonstrates how road deterioration affects physical infrastructure, road user safety, and social connectivity. Therefore, more studies integrating technological, social, and policy methods would likely enhance transportation systems' resilience. Furthermore, this work significantly contributes to the development of the scientific basis required for the planning and formulation of more sustainable transportation infrastructure policies.

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It is hoped that this publication will help further research, particularly in traffic performance and safety.

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