Journal of Social Research

P-ISSN:2827-9832
E-ISSN: 2828-335x
Vol. 5, No. 6, May 2026
http://ijsr.internationaljournallabs.com/index.php/ijsr

Traffic Performance Analysis on Road Sections Affected by the Construction of the Underpass Leading to the Indonesian National Armed Forces (*TNI*) Headquarters

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Keywords:
congestion; intersection; underpass; degree of saturation; level of service.

ABSTRACT:
The Mabes Hankam intersection is one of the main intersections that frequently experiences traffic congestion, particularly during peak hours in the morning and evening. This problem leads to delays, long queues, and a decrease in the quality of road service. This research aims to evaluate the traffic performance at the intersection and provide an overview of possible solutions to reduce congestion levels while ensuring that access for vehicles heading to the *TNI* Headquarters is not disrupted. The data used in this study include traffic volume and road capacity, obtained from PT. Armada and the Ministry of Public Works. The analysis was carried out using the Indonesian Highway Capacity Guidelines (PKJI 2023) with performance indicators such as degree of saturation (DS), average delay, queue length, and Level of Service (LOS). The results indicate that during peak hours, the degree of saturation approaches or exceeds 1.0, with the level of service ranging from LOS E to F, indicating saturated traffic conditions and frequent congestion. This condition highlights the need for appropriate traffic management efforts, such as the construction of an underpass, signal timing adjustments, or other traffic management strategies to mitigate congestion impacts. This research is expected to provide practical benefits as input for relevant institutions in formulating traffic control strategies in high-volume areas. In addition, it also contributes academically as a reference for the development of transportation studies, particularly in evaluating the performance of urban intersections with high traffic density.

INTRODUCTION

The rapid development of urban areas in recent years has encouraged increased human movement and motor vehicle movements (Almatar, 2024; Filippi, 2022; Shawly, 2022). This condition has a direct impact on increasing traffic volume, especially on main roads and strategic areas (Bucsky & Juhász, 2022; Fattah et al., 2022; Geremew, 2026; Rodríguez-Sánchez et al., 2024). The imbalance between traffic growth and road capacity has the potential to reduce the performance of the road network, which is characterized by an increase in the degree of saturation, a decrease in vehicle speed, and an increase in delays and queues of vehicles.

The Indonesian National Army Headquarters (*TNI* Headquarters) area is a strategic area with a high level of importance that demands smoothness, security, and control of traffic access (Anggana, 2025; Sarjito & Sutawidjaya, 2024; Sudarya, 2022). The operational activities of the *TNI* Headquarters require a reliable movement path and are separate from general traffic to

minimize vehicle flow conflicts and support the effectiveness of operational activities. One of the efforts that can be made to meet these needs is the construction of an underpass as a special access lane, which is expected to be able to improve smooth movement and reduce traffic disturbances around the *TNI* Headquarters area (Ariansyah et al., 2017).

On the other hand, the construction of underpasses as part of transportation infrastructure has the potential to have a traffic impact, both at the construction and operational stages (Xiao et al., 2018; Mashhadi et al., 2024). During the construction period, the narrowing of the road section, changes in the geometry of the road, and the diversion of traffic flow can cause a decrease in traffic performance on the road sections around the construction site (Iqbal et al., 2020; Wibowo et al., 2024). This condition can increase the level of road saturation and reduce the level of traffic services if it is not accompanied by adequate traffic management (Ariansyah et al., 2017; Yao et al., 2024).

Traffic Impact Analysis (Andalalin) is an important instrument in the planning and control of transportation infrastructure development to identify and evaluate changes in traffic conditions due to a development activity (Padma et al., 2020; Tamin, 2021). Andalalin aims to assess the magnitude of and formulate the necessary mitigation measures so that the performance of the road network remains at an acceptable level of service (Padma et al., 2020; Kurnia et al., 2026). In its implementation, the current analysis of traffic performance in Indonesia refers to the 2023 Indonesian Road Capacity Guidelines (PKJI), which is used to evaluate road capacity, degree of saturation, and road service levels in accordance with the latest traffic conditions (Ministry of Public Works and Public Housing, 2023; Amri et al., 2025; Fazahudiya et al., 2024).

Various studies show that the construction of underpasses can have a positive impact on traffic performance by reducing the degree of saturation and increasing the level of road service. However, changes in vehicle movement patterns due to the existence of underpasses also have the potential to cause new burdens on certain roads around it. This shows that the construction of the underpass needs to be accompanied by a comprehensive traffic performance analysis so that the benefits obtained can be optimal and do not cause new traffic problems (Cahyono et al., 2014; Suthanaya & Rosita, 2017).

This research is important and relevant because the implementation of underground projects such as underpasses on roads that experience high traffic volumes can significantly reduce the level of road services during the construction period (Almani & Santoso, 2019). Traffic disruptions such as increased queues, congestion, and increased travel time not only have an impact on the comfort of road users, but can also result in significant economic losses (Putra et al., 2020).

In addition, in the latest study, it was found that traffic performance evaluation in the construction phase is still not much focused on the use of the latest standards such as the 2023 Indonesian Road Capacity Guidelines (PKJI) (Pratama & Wijaya, 2023). This shows that there is a knowledge gap that needs to be closed, especially in the context of complex urban infrastructure projects.

Evaluation of traffic performance during construction is crucial because it can help map problem points and determine effective traffic management strategies, so as to minimize negative impacts on community mobility and economic productivity (Hidayat & Nugroho, 2021). With this research, it is hoped that the results can make a practical contribution to

contractors, transportation agencies, and policy makers in planning to mitigate the impact of construction on strategic roads.

Based on this description, a study is needed to analyze the impact of traffic on the construction of the underpass as a special access route for the *TNI* Headquarters. This research is focused on evaluating traffic performance which includes vehicle volume, road capacity, degree of saturation, and road service level on affected sections using the PKJI 2023 approach. The results of this study are expected to be the basis for the preparation of traffic management recommendations and support safe, effective, and sustainable transportation infrastructure planning in the *TNI* Headquarters area and its surroundings (Putra, 2020).

Based on this background, this study formulates problems regarding the impact of the construction of the underpass on the flow and traffic performance in the access intersection area of the Cilangkap Military Headquarters Military Complex, the factors that cause traffic disruption during the construction process, and steps or strategies that can be applied to minimize negative impacts during the construction period. The purpose of this study is to analyze the impact of the underpass construction on traffic flow and performance in the study area, identify and analyze the factors causing traffic disruptions during the construction process, and formulate mitigation strategies that can be applied to reduce these negative impacts. In order to make the research more directed, the discussion was limited to the impact of the underpass construction on traffic flow and performance in the access intersection area of the Cilangkap *TNI* Military Headquarters Complex, especially the negative impacts during the construction process such as increased delays, queue lengths, decreased speed, and changes in traffic flow patterns. Traffic performance evaluation is limited to the parameters of traffic volume, delay, degree of saturation (DS), and service level (LOS) according to PKJI 2023. In addition, mitigation analysis is only focused on strategies that can be implemented during the construction period, not long-term post-construction recommendations. The data used in this study are secondary data from PT Armada and the Ministry of Public Works, as well as data on existing conditions in the field during the research period. This research is expected to provide academic benefits in the form of increasing knowledge and insight into traffic impact analysis, especially in the construction of underpasses; practical benefits in the form of input for related agencies in evaluating the effectiveness of the construction of the *TNI* Headquarters special lane underpass; and social benefits in the form of an overview to the community about the impact of the underpass construction on traffic conditions.

METHOD

Research Stages

This research was carried out through stages that are systematically and structured to obtain accurate results and in accordance with the research objectives that have been formulated. The preparation of systematic research stages is needed so that the research process can run in a directed, logical, and scientifically accountable manner. This research stage includes problem identification activities, literature studies, determination of research locations, data collection, data processing and analysis, and evaluation of research results. Such a phased approach is commonly used in transportation and traffic engineering research to ensure that any analytical decision is based on relevant data and theoretical foundations (Creswell & Creswell, 2018; Sugiyono, 2019).

Data Collection

Data collection is an important stage in this study because the data obtained becomes the basis for the processing and analysis of traffic performance. The data collected must be able to represent the existing traffic conditions at the research site and support the analysis of the impact of the construction of the underpass as a special access route for the *TNI* Headquarters. Data collection is carried out through field surveys and tracing of supporting data from relevant agencies so that the data obtained is comprehensive and can be accounted for scientifically (Creswell & Creswell, 2018).

Data Processing

Data processing is an advanced stage after all primary and secondary data are collected. This stage aims to convert raw data from field survey results into processed data that is ready to be used in traffic performance analysis. The data processing process is carried out systematically so that the calculation results obtained are accurate, consistent, and in accordance with the research objectives (Creswell & Creswell, 2018).

Primary data in the form of traffic volume, vehicle composition, road geometric data, and peak traffic time were recapitulated and grouped based on the direction of movement and type of vehicle. The volume of vehicles that are still in the vehicle unit per hour is then converted into a passenger car unit (smp/hour) using the Passenger Car Equivalent (EMP) value in accordance with the provisions of the 2023 Indonesian Road Capacity Guidelines (PKJI) (Directorate General of Highways, 2023).

Furthermore, road geometric data is used to determine the basic capacity of roads and intersections, which are then adjusted to adjustment factors, such as lane width and environmental conditions. The results of this data processing are the basis for calculating traffic performance parameters, including degree of saturation (DJ), average delay, queue length, and level of road service (Level of Service / LOS) (Tamin, 2017).

Analysis of Traffic Impact During Underpass Construction

Analysis of the impact of traffic during the construction of the underpass was carried out to determine the influence of the construction activities of the *TNI* Headquarters special line underpass on traffic performance at the research site. This analysis is focused on comparing traffic conditions before construction and during construction, because construction activities have the potential to cause narrowing of road bodies, increased side obstacles, and changes in traffic flow patterns (Tamin, 2017; Khisty & Lall, 2018).

The analysis was carried out using a quantitative method based on the 2023 Indonesian Road Capacity Guidelines (PKJI), with the parameters analyzed including traffic volume, road capacity, degree of saturation (DJ), and road service level (LOS) (Directorate General of Highways, 2023).

RESULTS AND DISCUSSION

Data Presentation and Calculation of Survey Results

1. Data Presentation

Traffic data was obtained through a vehicle enumeration survey during the period **07.00–17.00 WIB.** This data includes various types of vehicles that cross the research roads.

Table 1. Daily Traffic Volume

Vehicle Type	Number (Vehicles)
Motorcycles	8682
Sedan/Jeep	2919
Oplet/Minibus	2105
Pick Up/Micro Truck	1179
Small Bus	22
Big Bus	16
2-Axis Truck (4 wheels)	18
2-Axle Truck (6 wheels)	12
3 Axis Truck	13
Others	0

Source: Calculation Results 2026

2. Road Geometry

The geometric condition of the road is one of the important factors that affect traffic capacity and performance. The road section studied consists of two segments with different cross-sectional types.

The first segment is a 4/2 UD type road with a larger capacity, while the second segment is a 2/2 UD type road with a smaller capacity.

The width of the column on the road section is 4 meters, so based on PKJI it is included in the category of column width ≥ 3.50 meters.

Table 2. Road Geometric Data

Segments	Road Type	Length (m)	Column Width (m)
1	4/2 UD	420,52	4
2	2/2 UD	214,94	4

Source: Calculation Results 2026

The difference in capacity between these segments has the potential to cause **a bottleneck**, which is a condition where traffic flow is hampered due to narrowing road capacity.

3. Calculation of Traffic Volume

Traffic volume is calculated to determine the amount of traffic flow that passes through the road in a certain unit of time. In this analysis, the volume of vehicles is converted into passenger car units (SMP) using the Passenger Car Equivalency (EMP) value.

a. Morning Peak Hours (07:00 - 09:00 WIB)

Based on survey data, the number of vehicles in the morning period is classified into:

SM = 2995

KR = 1946

KB = 16

Furthermore, the conversion was carried out into junior high school units:

KR = 1946 × 1.00 = 1946 smp/h

KB = 16 × 1.30 = 20.8 smp/h

SM = 2995 × 0.40 = 1198 cm/h

So that the total traffic volume is obtained:

Q = 3164.8 smp/hour

b. Afternoon Peak Hours (15:00 - 17:00 WIB)

In the afternoon period, the number of vehicles is:

SM = 2293

KR = 1637

KB = 16

Convert to junior high school:

KR = 1637 smp/h

KB = 20.8 smp/h

SM = 917.2 smp/h

Q = 2575 smp/h

4. Recapitulation of Highest Traffic Volume (Peak Hours)

Based on the results of processing traffic volume data that has been converted into passenger car units (smp/hour), it can be determined the time period with the highest vehicle flow on the Independence Pioneer Road section.

The next step is to identify the peak time, which is presented in Table 3 below.

Table 3 Recap of the Highest Traffic Volume on Jl. Terusan Hankam Headquarters

Directions	Day	Time (Hours)	Maximum Volume (smp/h)
TNI Headquarters Cilangkap - Junction of Hankam Headquarters Canal	Monday, 13 October 2025	07:00 - 09:00	4957
TNI Headquarters Cilangkap - Junction of Hankam Headquarters Canal	Monday, 13 October 2025	15:00 - 17:00	3946

Source: Calculation Results 2026

5. Road Section Capacity Calculation

Road capacity is the maximum number of vehicles that can be served by a road section or intersection in certain traffic conditions. As can be seen on Table 3, it was obtained that the highest traffic flow occurred on Monday in the range of 07:00 to 09:00 WIB and 15:00 to 17:00 WIB, with a value of 4957 smp/hour in the morning and 3946 smp/hour in the afternoon.

Furthermore, this value is used as a basis for determining the capacity of the road section.

Table 4. Capacity of the Hankam Headquarters Canal Road Section

Segments	Street Name	Directions	Co	FCw	FCsf	FCe	C smp/hour
1	Copyright © 2019 Hankam Headquarters Canal. All Rights Reserved.	*TNI* Headquarters Cilangkap - Junction of Hankam Headquarters Canal	3600	1,05	1,00	1,00	3780
2	Copyright © 2019 Hankam	*TNI* Headquarters Cilangkap -	2800	1,05	1,00	1,00	2940

	Headquarters Canal. All Rights Reserved.	Junction of Hankam Headquarters Canal	

Source : Calculation Results 2026

From the calculations in Table 4.5, it was obtained that the capacity of the Hankam Headquarters Canal Road section was 3780 smp/hour. In the morning and 2940 smp/hour in the afternoon.

The capacity value is then used for traffic performance analysis, especially in determining the level of road service (Level of Service / LOS) in the next discussion.

6. Service Level Calculation (LOS)

The level of service or Level of Service (LOS) is an indicator used to assess the performance of a road section in serving the flow of vehicles. This assessment is influenced by several factors such as the level of capacity utilization, vehicle speed, current density, and disturbances that occur along the road.

LOS also reflects the quality of road operations felt by users, including smooth travel, travel time, obstacles experienced, freedom of maneuver, and driving comfort. In addition, this condition also has an impact on the efficiency of vehicle operational costs.

Table 5. Degree of Saturation (DS) and Level of Service

Time	Segments	DS	Conditions	THE
Morning	4/2 UD	0,84	Near-unstable current, speed decreases, density increases	D
Morning	2/2 UD	1,08	Blocked current, congestion or long queues	F
Afternoon	4/2 UD	0,68	The flow is still stable, but the vehicle's movement space is limited	C
Afternoon	2/2 UD	0,88	Unstable current, road capacity is almost reached	E

Source : Calculation Results 2026

Based on Table 4.6, it can be seen that traffic conditions on the Hankam Headquarters Canal Road section vary in service levels in each segment and observation time.

In the morning period, the 4/2 UD segment was at service level D, which indicates that the flow condition began to be unstable with a decrease in vehicle speed. Meanwhile, the 2/2 UD segment has a DS value of 1.08 which is included in the service level F, thus indicating congestion conditions with a fairly long queue of vehicles.

In the afternoon period, traffic conditions tend to be better than in the morning. The 4/2 UD segment is at service level C, which is still relatively stable even though vehicle movement space is starting to be limited. Meanwhile, the 2/2 UD segment is at service level E, which shows that the traffic flow is close to the maximum capacity of the road.

Overall, the 2/2 UD segment is the most critical part of the road because it has the lowest level of service, especially during the morning rush hour.

Analysis and Discussion

1. Traffic Volume Analysis

Based on the results of the survey and calculations that have been carried out, the traffic volume on the Hankam Headquarters Canal Road section shows a significant difference between the morning and evening periods. The highest volume occurred in the morning period of 3164.8 smp/hour, while in the afternoon period it was 2575 smp/hour.

The high volume of vehicles in the morning is influenced by routine community activities such as trips to work and school. In addition, the research location on the route to the *TNI* Headquarters area (*TNI* Headquarters) also contributed to the increase in vehicle volume.

The mobilization of vehicles related to the operational activities of the *TNI* Headquarters, such as official vehicles, personnel vehicles, and logistics vehicles, tends to increase at certain hours, especially in the morning. This causes an increase in traffic load that is centralized at certain times, thereby significantly increasing the volume of vehicles.

In addition, the existence of access in and out of the *TNI* Headquarters area also has the potential to cause disruptions to the smooth flow of traffic, such as vehicles that slow down the speed to enter or exit the area, as well as security activities that can affect the movement of vehicles around them.

The composition of vehicles dominated by motorcycles and light vehicles shows the characteristics of urban traffic, but with the additional load from operational vehicles in the *TNI* Headquarters area, traffic conditions become more complex.

2. Service Level Analysis (LOS)

The level of service (LOS) is used to assess the performance of a road section based on the ratio between traffic volume (Q) and road capacity (C), expressed in degree of saturation (DS). The DS value indicates the operational condition of traffic, whether it is still stable, close to saturation, or has experienced congestion.

Based on the calculation results, in the morning period the 4/2 UD segment had a DS value of 0.84 which was included in the D service level, which indicates that the current condition began to be unstable with a decrease in speed and an increase in density. Meanwhile, the 2/2 UD segment has a DS value of 1.08 which is included in the service level F, which indicates congestion with long queues of vehicles. In the afternoon period, traffic conditions were relatively better, where the 4/2 UD segment was at service level C (DS = 0.68) and the 2/2 UD segment at service level E (DS = 0.88), indicating that the traffic flow was close to capacity.

Overall, the 2/2 UD segment is the most critical part of the road because it has the highest DS value, especially during the morning rush hour. This condition is caused by the difference in capacity between the 4/2 UD and 2/2 UD segments which causes bottlenecks, as well as being influenced by mobilization activities towards the *TNI* Headquarters area and the presence of vehicle access and exit that increases traffic barriers.

3. Alternative Solutions

Based on the results of the analysis that has been carried out, traffic problems on the Hankam Headquarters Canal Road section are not only influenced by the high volume of vehicles, but also by the geometric condition of the road, mobilization activities to the *TNI* Headquarters area, and the impact of underpass construction construction.

During the construction period of the underpass, there was a narrowing of traffic space which resulted in a decrease in road capacity. In addition, the existence of several entrances and exits to the *TNI* Headquarters area also affects the performance of road sections.

However, based on field conditions, not all access has a negative impact. Of the three existing accesses, only one main access is a traffic nuisance point, because it has a high intensity of vehicles in and out and is directly connected to the main road. Meanwhile, the other two accesses have the potential to be used as an alternative to vehicle flow distribution, so that they can reduce the load on the main access.

In addition, the existence of intersection three in the 4/2 UD segment and intersection four in the 2/2 UD segment is also a factor that increases traffic barriers, especially during peak hours. Based on these conditions, some alternative solutions that can be applied are as follows:

a. Optimizing Access to the *TNI* Headquarters Area

Access management needs to be carried out with a traffic flow distribution approach, namely:

1) Reduce reliance on one key access that causes congestion
2) Diverting part of vehicle flow to the other two accesses
3) Set access functions (e.g.: one dedicated in, one dedicated out)

With this strategy, the traffic load can be spread more evenly, reducing the accumulation of vehicles at one point.

b. Traffic Management During Underpass Construction

During the construction of the underpass, temporary traffic arrangements are required, including:

1) Implementation of alternative routes (traffic diversion)
2) Clear placement of project signs and barriers
3) Arrangements by officers during peak hours

This step aims to minimize the impact of road narrowing on traffic flow.

c. Junction Handling

Junction 3 (Segment 4/2 UD)

1) Vehicle flow priority setting
2) Clearer signage installation
3) Peak Hour Surveillance

Junction 4 (Segment 2/2 UD)

1) Installation of traffic lights
2) Optimal signal phase setting
3) Engineering alternatives such as small roundabouts

This handling aims to reduce vehicle movement conflicts that occur at intersections.

d. Road Capacity Increase

To overcome bottlenecks in the 2/2 UD segment, it is necessary to increase road capacity through:

1) Widening to 4/2 UD
2) Addition of columns at specific points

e. Underpass Function Optimization

The underpass that is being built is a long-term solution that is very effective in reducing traffic conflicts, especially for vehicles heading to the *TNI* Headquarters area.

With the operation of the underpass:

1) Vehicle flow can be separated
2) Conflicts at intersections reduced
3) Road capacity increased

CONCLUSION

Based on the results of the analysis, it can be concluded that traffic performance on the Hankam Headquarters Canal Road section experienced problems, especially during the morning peak hours, with the highest traffic volume reaching 3164.8 smp/hour, while in the afternoon period it was 2575 smp/hour. The level of road service in the morning showed quite congested conditions, namely the 4/2 UD segment was in LOS D with a DS of 0.84, while the 2/2 UD segment was in LOS F with a DS of 1.08 which indicated congestion. In the afternoon, traffic conditions were relatively better, with the 4/2 UD segment being at LOS C and the 2/2 UD segment being at LOS E, although it still showed near-capacity. The main problem on this road section is caused by the difference in capacity between the 4/2 UD and 2/2 UD segments which causes bottlenecks, coupled with the high mobilization of vehicles to the *TNI* Headquarters area, especially during peak hours. Of the three accesses to the area, only one main access is a congestion point, while the other two accesses have not been optimally utilized. In addition, congestion is also affected by the mobility of vehicles in underpass construction projects and the narrowing of traffic lanes which reduces the effective capacity of the road. Based on these findings, several handling efforts are needed to improve the performance of the Hankam Headquarters Canal Road section. Optimizing access to the *TNI* Headquarters area needs to be done by reducing the burden on the main access and utilizing the other two accesses as alternative routes for vehicle distribution. In addition, construction project vehicles need to be regulated through restrictions on operating hours outside peak hours as well as vehicle entry and exit arrangements so as not to disrupt the main traffic flow. During the construction period, traffic management also needs to be strengthened through the arrangement of temporary lanes, the installation of clear project signs and dividers, and the placement of officers during peak hours. Handling intersections, both intersections and intersections, is also important to be done through flow priority management, installation of traffic lights, and traffic engineering to minimize vehicle conflicts. After the construction of the underpass is completed, the facility needs to be optimized to be able to reduce traffic flow conflicts on the surface and increase the overall road capacity.

REFERENCE

Almatar, K. M. (2024). Increasing electric vehicles infrastructure in urban areas for efficiently employing renewable energy. *Environment, Development and Sustainability, 26*(10), 26183–26204.

Amri, M. A., Jinca, M. Y., & Ramli, M. I. (2025). Traffic performance analysis on urban road sections using the 2023 Indonesian Road Capacity Guidelines (PKJI): A case study of Maros Regency. *International Journal of Engineering Trends and Technology, 73*(10),

107–115. https://doi.org/10.14445/22315381/IJETT-V73I10P107
Anggana, S. Y. (2025). *Territorial defense management: An effective military strategy in the contemporary era.*
Ariansyah, M., Miftahuddin, & Riyanto, B. (2017). Analisis dampak lalu lintas pembangunan underpass Kentungan. *Jurnal Teknik Sipil Universitas Muhammadiyah Yogyakarta, 2*(1), 1–9. http://repository.umy.ac.id/handle/123456789/34656
Bucsky, P., & Juhász, M. (2022). Long-term evidence on induced traffic: A case study on the relationship between road traffic and capacity of Budapest bridges. *Transportation Research Part A: Policy and Practice, 157*, 244–257.
Fattah, M. A., Morshed, S. R., & Kafy, A.-A. (2022). Insights into the socio-economic impacts of traffic congestion in the port and industrial areas of Chittagong city, Bangladesh. *Transportation Engineering, 9*, 100122.
Fazahudiya, K., Dewanti, & Irawan, M. Z. (2024). *Evaluasi Pedoman Kapasitas Jalan Indonesia (PKJI) 2023 dalam menghitung panjang antrean simpang bersinyal* [Tesis magister, Universitas Gadjah Mada]. https://etd.repository.ugm.ac.id/penelitian/detail/238286
Filippi, F. (2022). A paradigm shift for a transition to sustainable urban transport. *Sustainability, 14*(5), 2853.
Geremew, G. (2026). Modeling and analyzing the impact of on-street parking on traffic flow: A study of the main highway in Debre Markos Town, Ethiopia. *Transportation, 53*(2), 783–817.
Iqbal, M. A., Budiarto, A., & Sari, D. (2020). A survey of road traffic congestion measures towards a sustainable and resilient transportation system. *Sustainability, 12*(11), 4660. https://doi.org/10.3390/su12114660
Kurnia, A., Triadmojo, S., & Wahyudi, D. (2026). Evaluasi kapasitas ruas jalan terhadap kinerja pelayanan jalan berdasarkan PKJI 2023: Studi kasus ruas Jalan P. Diponegoro Kota Tarakan. *Civil Engineering Scientific Journal, 5*(1), 1–10. https://doi.org/10.35334/cesj.v5i1.7345
Mashhadi, A. H., Rashidi, A., & Markovic, N. (2024). Decision support for improved construction traffic management and planning. *Sustainable Cities and Society, 107*, 105432. https://doi.org/10.1016/j.scs.2024.105432
Ministry of Public Works and Public Housing. (2023). *Pedoman Kapasitas Jalan Indonesia (PKJI) 2023.* Direktorat Jenderal Bina Marga. https://binamarga.pu.go.id/uploads/files/1942/09pbm2023-pedoman-kapasitas-jalan-indonesia-.pdf
Padma, S., Velmurugan, S., Kalsi, N., Ravinder, K., Erramapalli, M., & Kannan, S. (2020). Traffic impact assessment for sustainable development in urban areas. *Transportation Research Procedia, 48*, 3173–3187. https://doi.org/10.1016/j.trpro.2020.08.085
Rodríguez-Sánchez, A., Santiago, J. L., Vivanco, M. G., Sanchez, B., Rivas, E., Martilli, A., & Martín, F. (2024). How do meteorological conditions impact the effectiveness of various traffic measures on NOx concentrations in a real hot-spot? *Science of the Total Environment, 954*, 176667.
Sarjito, A., & Sutawidjaya, A. H. (2024). Indonesia's national defense resilience during Covid-19: Key lessons. *Journal of Ecohumanism, 3*(4), 2913–2926.
Shawly, H. (2022). Evaluating compact city model implementation as a sustainable urban development tool to control urban sprawl in the city of Jeddah. *Sustainability, 14*(20), 13218.
Sudarya, A. (2022). Personnel management of the Indonesian National Army Air Force (TNI-AU) in preparing to implement network centric warfare. *Atestasi: Jurnal Ilmiah Akuntansi, 5*(2), 693–709.

Tamin, O. Z. (2021). *Perencanaan, pemodelan, dan rekayasa transportasi: Teori, contoh soal, dan aplikasi* (3rd ed.). Institut Teknologi Bandung Press.

Wibowo, R., Santosa, W., & Haryanto, I. (2024). Evaluasi kinerja lalu lintas sebelum dan setelah pembangunan underpass Dewi Sartika Kota Depok dengan metode simulasi Vissim. *Jurnal Teknik Sipil, 3*(1), 1–12. https://www.researchgate.net/publication/388333730

Xiao, H., Zhou, Z., Liu, J., & Zhu, H. (2018). The planning and construction of a large underpass crossing urban expressway in Shanghai: An exemplary solution to the traffic congestions at dead end roads. *Tunnelling and Underground Space Technology, 80*, 567–575. https://doi.org/10.1016/j.tust.2018.07.020

Yao, Z., Li, S., & Chen, H. (2024). The effectiveness of route guidance for expressway reconstruction and expansion projects. *Case Studies on Transport Policy, 17*, 101222. https://doi.org/10.1016/j.cstp.2024.101222