LEADER
Civil Engineering and Architecture Journal

Civil Engineering and Architecture Journal Vol 2 No. 1 (2024) 3026-622X
DOI 10.37253/leader.v2i1.9531

IMPACT OF SIDE BARRIER ON ROAD SERVICE LEVELS CASE STUDY: INTERSECTION UNSIGNALIZED RAJAGALUH

Rio Refelino Ginting[1], Indrastuti[2]
[1]Civil Engineering, Faculty of Engineering, Universitas Majalengka
[2]Faculty of Civil Engineering & Planning, Universitas Internasional Batam, Indonesia
Emai korespondensil: riorefelinoginting77@gmail.com

ARTICLE INFO

Keywords:

Intersection,
Traffic Volume,
Side Barries

ABSTRACT

Majalengka is one of the cities in West Java impacted by the rapid growth of private vehicle numbers. One place in Majalengka that often experiences traffic congestion is the intersection of three markets and the terminal in Rajagaluh. This road connects to Cirebon and tourist areas in the Sindangwangi District. This happens for several reasons, including the significant number of side obstacles along the road around the intersection. Side obstacles at this intersection include street vendors, parked/stopped vehicles, and pedestrians. This research aims to determine the road service level through field surveys at the junction of the three markets and the Rajagaluh terminal. The research methodology employed in this study is qualitative. The use of this qualitative method is interrelated, involving data collection, data grouping, data validation, and finally, data analysis, allowing the emergence of new theories and insights. This research was conducted at the unsignalized intersection near Rajagaluh Market and Terminal in Majalengka Regency. This unsignalized intersection is a junction for inter-district routes located near the terminal and market. Based on the table above, it is found that in the northbound direction, the level of road service is average during the morning and afternoon, while it is classified as high during the evening. In the westbound direction, the level of road service is mild during the morning and afternoon, and during the evening, it is classified as high. The road service level in the eastbound direction is similar, average during the morning and afternoon, and increased during the evening. Therefore, according to the author, the government must improve to anticipate the high traffic volume that will lead to congestion in the future. Based on the study, side obstacles are still relatively low to average. However, this does not mean it will be a benchmark in the future. It is possible that in the coming years, these side obstacles will increase, leading to congestion.

1. Introduction

A city is a center of settlement and activities for the population, with its administrative boundaries regulated by laws and regulations, as well as aggregations that exhibit the characteristics and specificities of urban life. Cities serve various functions, such as residential areas, trade, education, employment, and more. Development in cities are often oriented to the system of transportation with motorized vehicles (Johanes, Dermawan, Isradi, & Rifai, 2022). Over time, many cities are actively constructing infrastructure, especially near city centers. One such infrastructure includes food centers, etc., which also impact the density of the roads. Additionally, the development of recreational or tourist infrastructure in various areas certainly affects traffic flow.

Indonesia is a vast country with a dense population of 268,583,016 people (Haryati & Najid, 2021). The rapid increase in the number of vehicle owners, both motorcycles and cars, can undoubtedly impact the traffic volume on the roads. Consequently, the capacity of a highway will significantly increase. However, the increase in traffic volume must be accompanied by road geometry that can accommodate the traffic volume. If the geometry of a road does not adjust traffic volume, congestion, and traffic hours are unavoidable. Vehicle traffic is considered to be the root of many problems, namely congestion, crashes and pollution (Marzoug, Lakouari, Pérez Cruz, & Vega Gómez, 2022). This is especially true in areas near shopping centers or markets where there are likely to be many obstacles, such as street vendors on the sidewalks, reducing the road capacity.

It's not only in large cities that are affected by the overwhelming number of private vehicles. In fact, small towns, especially in West Java, are also affected. Majalengka is one of the cities in West Java that is impacted by the rapid growth of private vehicle numbers. The road was a means of land transport is very important to the social relations and economic goods and services, and with a population that is increasing in every year to year, increasing the number of vehicles passing on the road that there is, therefore, in need planning a safe way according to the function, volume, and nature of traffic (Abiansyah & Rifai, 2020). Indeed, the infrastructure of a road must be improved promptly to anticipate congested traffic. One of the problems is traffic congestion, which is a factor inhibiting the smooth flow of the traffic on the highway (Winaya, 2020). There should also be regulations regarding side obstacles around the road section, reducing the road capacity. Moreover, in Majalengka, there is a rapid growth of tourist areas in several districts. This must be considered, especially supporting such tourist areas with smooth and optimal access roads.

One place in Majalengka that often experiences traffic congestion is the intersection of three markets and the terminal in Rajagaluh. This road connects to Cirebon and tourist areas in the Sindangwangi District. This happens due to several reasons, one of which is the significant number of side obstacles along the road around the intersection. Side obstacles at this intersection include street vendors, parked/stopped vehicles, and pedestrians. Barrier is a type of obstruction that tries to keep vehicles within their road lanes and prevent them from collision with obstacles or other vehicles (Jaysingpure & Bijwe, 2022).The government must make improvements to reduce congestion in this intersection. Furthermore, the government should consider traffic lights to minimize encounters with cars from opposite directions at this intersection. Signalized intersections also performance a role in regulating urban traffic flow, increasing energy consumption and slowing vehicle traffic (Dong, et al., 2022).

Additionally, the existence of Daily Traffic Volume data, which is used as the result of a survey regarding the traffic volume at the intersection of the three markets and the Rajagaluh terminal, should be taken into account. The Majalengka Regency government should consider this to ensure that no party is adversely affected. This research aims to determine the road service level through field surveys at the intersection of the three markets and the Rajagaluh terminal. It can also serve as a reference for improvements by the government of Majalengka.

2. Literature Review

2.1 Intersection

An intersection is a point where two or more road segments meet. Road intersections are an important component of the urban traffic network (Pathivada & Perumal, 2019). Many issues arise at these road intersections, such as queues, traffic congestion, and accidents, all of which lead to congestion at the intersection. The most dangerous highways because of the complicated traffic conflict movements and frequent stop and go traffic are Intersections (Yuan & Abdel-Aty, 2019). Intersection one of the most

important part of the highway because most of the efficiency, traffic capacity, speed, operating costs, travel time, security and comfort will depend on the planning of the intersection (Fajar & Yasruddin, 2021). Intersections come in various types, including three-way, four-way, and even five-way intersections. Additionally, intersections can be signalized or unsignalized, and these designations result from multiple considerations.

Unsignalized intersections are the most widely used type of intersections in the road network (Pitlova, 2019) Signalized intersections are usually located in areas near the city center. The decision to signalize an intersection is often based on the results of a survey conducted by an institution that directly studies a particular intersection to calculate the traffic volume at that location. Traffic congestion forecasting is heavily dependent on sensors and other equipment to acquire relevant data, such as traffic speed, weather and accident data, etc (Kashyap, Devarakonda, Nayak K, KV, & Bhat, 2022). If an intersection has a relatively low traffic volume, it may not require traffic lights. Conversely, suppose an intersection has a relatively high traffic volume. In that case, traffic lights are needed to reduce the risk of conflicts between road segments, which can lead to congestion or even accidents, making it a signalized intersection.

The number of vehicles compared to the width and size of roads in Indonesia, which are not evenly distributed, and the use of signalized intersections or roundabouts that are not good cause terrible traffic jams (Immanuel, Rifai, & Prasetijo, 2022). However, it's not uncommon for various cities or districts to have intersections that escape the attention of the local government. This is often due to high traffic volume and frequent interactions between vehicles from different road segments. One of the contributing factors is the absence of traffic lights to regulate traffic at the intersection. Therefore, the government needs to evaluate whether traffic lights are required at such intersections to minimize conflicts between vehicles from different road segments due to the high traffic volume.
Thus, issues at intersections must be a focal point for local governments to establish effective traffic management. Typically, intersections with four to six arms tend to require traffic lights. In contrast, three-way intersections rarely have traffic lights unless they experience high traffic volume, leading to congestion at the intersection. Intersections are planned as conflict points in urban traffic networks and play an important role in optimizing traffic mobility (Chen, Wang, Xu, Wang, & Li, 2021)

2.2 Traffic Volume

Traffic volume is the number of vehicles that pass through a road segment. Traffic volume indicates the number of cars passing through a specific observation point within a unit of time (day, hour, minute). Standard traffic volume units used to determine the number and width of lanes include average daily traffic, planning hour volume, and capacity. The types of vehicles in these calculations are classified into three categories. From the AADT data, it can be concluded that road utilization is planned and prioritized for road improvements that are needed and appropriate, and for planning new road construction projects there are sources of information (Baffoe-Twum, Asa, & Awuku, 2022).

The first type of vehicle is Light Vehicles (LV), an index for motorized vehicles with four wheels (passenger cars). The second type is Heavy Vehicles (HV), an index for motorized cars with more than four wheels (buses, two-axle trucks, three-axle trucks, and compatible combinations). The third type is Motorcycles (MC), an index for motorized vehicles with two wheels. Development is a form so that the Indonesian state can be more advanced, in addition to being more advanced, development will also increase the productivity of the economy in a country or region. Regional development has also led to

the addition and expansion of social facilities and infrastructure as well as transportation to serve the needs of its population (Rifai, Surgiarti, Isradi, & Mufhidin, 2021)

With the current development, the rapid growth of vehicles in Indonesia has become apparent. The impact of this rapid increase in vehicle ownership has led to a drastic rise in traffic volume. Smooth traffic flow is of course created by good traffic engineering or management. Accurate traffic forecasts are an effective reference for implementing traffic management strategies, planning itineraries, and assessing public transport risks (Zhou, Chen, & Lin, 2022).One way to avoid congestion due to this issue is to adjust the traffic volume to the available road capacity. This approach helps minimize traffic problems caused by a drastic increase in the number of vehicles.

2.3 Side Barries

Side road obstacles refer to the effects of roadside activities on traffic (Ministry of Public Works, 2014). Community activity centers such as offices, shopping centers, industries, entertainment, and educational facilities become tourist destinations and contribute to roadside obstacles. Obstacles include the use of road edges for parking, pedestrian use of the road frame, vehicles entering and exiting markets, and loading and unloading of goods on the road frame. Generally, on-street parking is closer to the final destination as it is distributed everywhere in a city, while the locations of off-street parking are more fixed, and drivers may need to park further away from, and walk to, their final destination (Wu & Ma, 2022). Pedestrians engaging in buying and selling activities along the road and road frame create conflicts with motorized vehicles.

Roadside obstacles are commonly observed in cities throughout Indonesia. Handling and addressing these issues are significant tasks for the government to prevent traffic problems. Indeed, the rapid increase in private ownership in Majalengka can also have negative impacts, affecting the quality of parking services in Majalengka. As a result, parking space capacity will decrease, potentially increasing on-street parking in Majalengka. Currently, on-street parking is becoming more prevalent in Majalengka. Not all on-street parking in Majalengka has received permission from the police to use the road as a parking space. Still, some groups utilize the road as a parking space without obtaining permission from the police or the transportation department of the Majalengka Regency. Infrastructure development, such as widening roads and bridges, and the creation of culverts, can lead to a reduction in the number or width of roads (Wahyudi, Rifai, & Prasetijo, 2022)

On-street parking yang ada di Majalengka jelas membuat kemacetan di Majalengka semakin tampak. A relevant fraction of road congestions in crowded urban areas is due to drivers looking for parking space, with heavy environmental and economic consequences**Invalid source specified.**. On-street parking, especially near the Rajagaluh market and terminal, often experiences congestion during busy hours. This optimization process involves extracting information about the future state of every parking area**Invalid source specified.**

3. Method

The research methodology employed in this study is qualitative. The research methodology used in this research is a qualitative method. The purpose of descriptive research selection allows the author to collect data randomly, make descriptive, and interpret existing problems factually and in detail according to the data obtained (Ma'aruf, Eprilianto, & Megawati, 2021). The use of this qualitative method is interrelated, involving data collection, data grouping, data validation, and finally, data analysis, allowing the emergence of new theories and insights. Thus, it can be concluded that the

qualitative method is a research method conducted directly. Therefore, this qualitative research method requires both primary and secondary data.
This research was conducted at the unsignalized intersection near Rajagaluh Market and Terminal in Majalengka Regency. This unsignalized intersection serves as a junction for inter-district routes and is located in close proximity to the terminal and market. The research location can be seen in Figure 1. Before conducting the survey, it is necessary to understand the required data for this research prior to the field visit. The needed data includes both primary and secondary data.

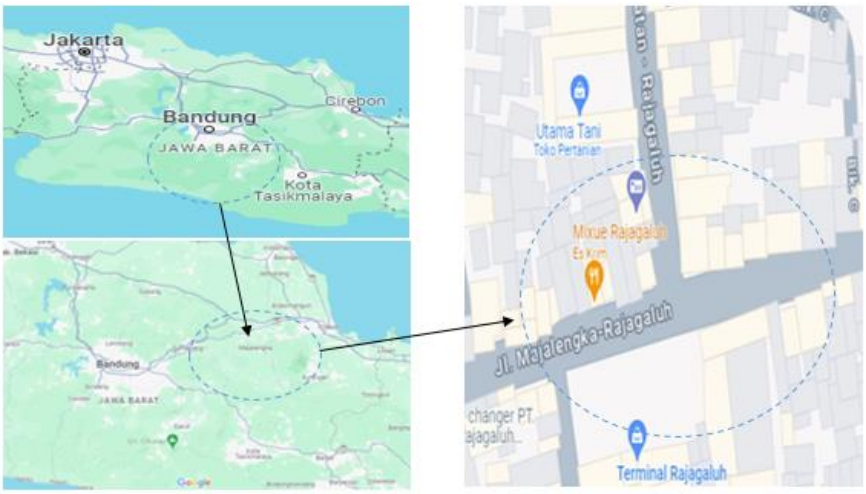

Figure 1. Research location

The field survey will generate primary data, with the primary data used in this research being traffic volume data. Primary data is information obtained or directly generated through field surveys. In the data collection process, it is essential to know the data collection instruments to ensure the production of accurate data before processing the data.

The traffic survey is conducted throughout one day during busy morning, afternoon, and evening hours using a traffic counter application. After obtaining the traffic volume data, the next step is to process it using the MKJI 1997 method. The expected output of this research is to assess the performance of this signalized intersection.

4. Result and Discussion

4.1 Traffic Volume

The volume of traffic depends on the results of peak morning, afternoon, and evening weeVehicles traffic surveys. According to the survey results, the peak flow occurs during the busy evening hours, specifically from 16:30 to 17:30. The table below shows the calculations of LHR (Daily Traffic Volume) or Traffic Volume at this intersection.

Table 1. Daily Traffic Volume (West Direction)

No	Period	HV(emp=1,3)	LV (emp=1)	Motor cycle (emp = 0,25)	Vehicles	pcu	4x15 minute (pcu/hour)
1	07:00-07:15	55	103	245	403	235,75	975,65
2	07:15-07:30	47	100	276	423	230,1	
3	07:30-07:45	48	114	315	477	255,15	
4	07:45-08:00	63	114	235	412	254,65	
5	13:00-13:15	24	90	165	279	162,45	987,65
6	13:15-13:30	39	134	278	451	254,2	
7	13:30-13:45	41	148	349	538	288,55	
8	13:45-14:00	34	173	261	468	282,45	
9	16:30-16:45	19	169	349	537	280,95	1232,3
10	16:45-17:00	27	167	379	573	296,85	
11	17:00-17:15	39	180	406	625	332,2	
12	17:15-17:30	36	175	402	613	322,3	

The table above shows that the traffic flow on the westbound road in the morning is 975.65 pcu/hour, in the afternoon is 987.65 pcu/hour, and in the evening is 1232.3 pcu/hour. Therefore, on this road, the heaviest traffic occurs in the evening, specifically from 16:30 to 17:30, from Majalengka towards Sindangwangi/Cirebon.

Table 2. Daily Traffic Volume (East Direction)

No	Period	HV(emp=1,3)	LV (emp=1)	Motor cycle (emp = 0,25)	Vehicles	pcu	4x15 minute (pcu/hour)
1	07:00-07:15	58	108	238	404	242,9	986,65
2	07:15-	47	100	267	414	227,85	

	07:30						
3	07:30-07:45	43	115	311	469	248,65	
4	07:45-08:00	65	123	239	427	267,25	
5	13:00-13:15	29	91	178	298	173,2	997,1
6	13:15-13:30	40	137	269	446	256,25	
7	13:30-13:45	44	145	334	523	285,7	
8	13:45-14:00	44	164	243	451	281,95	
9	16:30-16:45	15	178	357	550	286,75	1224,2
10	16:45-17:00	29	152	361	542	279,95	
11	17:00-17:15	43	171	411	625	329,65	
12	17:15-17:30	37	179	403	619	327,85	

As seen in the table above, the traffic flow on the westbound road in the morning is 986.65 pcu/hour, in the afternoon is 997.1 pcu/hour, and in the evening is 1224.2 pcu/hour. Therefore, on this road, the heaviest traffic occurs in the evening, specifically from 16:30 to 17:30, from Sindangwangi/Cirebon towards Majalengka.

Table 3. Daily Traffic Volume (North Direction)

No	Period	HV(emp=1,3)	LV (emp=1)	Motorcycle (emp=0,25)	Vehicles	pcu	4x15 minute (pcu/hour)
1	07:00-07:15	56	104	223	383	232,55	944,65
2	07:15-07:30	43	94	254	391	213,4	
3	07:30-07:45	45	102	301	448	235,75	
4	07:45-08:00	69	118	221	408	262,95	
5	13:00-13:15	30	87	165	282	167,25	986,65
6	13:15-13:30	41	129	243	413	243,05	
7	13:30-13:45	47	148	315	510	287,85	
8	13:45-14:00	45	174	224	443	288,5	
9	16:30-16:45	19	186	359	564	300,45	1180,85
10	16:45-17:00	23	153	345	521	269,15	

11	17:00-17:15	42	163	400	605	317,6	
12	17:15-17:30	33	154	387	574	293,65	

As seen in the table above, the traffic flow on the westbound road in the morning is 944.65 pcu/hour, in the afternoon is 986.65 pcu/hour, and in the evening is 1180.85 pcu/hour. Therefore, on this road, the heaviest traffic occurs in the evening, specifically from 16:30 to 17:30, from Leuwimunding towards Majalengka.

4.2 Degree of Saturation

To find the degree of saturation, several supporting data are needed.

$$DS = Q/C$$

Q = Traffic Flow (pcu/hour) C = Kapasitas

The equation for road capacity is as follows:

$$C = C_O \times FC_W \times FC_{SP} \times FC_{SF} \times FC_{CS}$$

Where :

C = Capacity (pcu/hour)

CO = Basic Capacity (pcu/hour)

FCW = Road width adjustment factor

FCSP = Direction separation adjustment factor (only for undivided roads)

FC SF = Side friction and shoulder adjustment factor

FCCS = City size adjustment factor

The requirements for each data are in Chapter 3. The essential capacity (C0) of each road segment in this intersection has the same value, 2900, as indicated in Table 5. This corresponds to 2/2 UD. The value of the adjustment factor for lane width (FCw) for these three road segments is one because each segment in this intersection has the same total width of 7 meters. Furthermore, the direction separator for the three road segments in this intersection is 50-50, so the value for the direction separator adjustment factor is 1.

The next coefficient to be determined is the value of the Adjustment Factor for Side Friction and Shoulder/Curb. It is known that the three road segments in this intersection have a shoulder width of less than 0.5 meters. It has a low-side friction class for the northbound direction, while it has a medium-side friction class for the eastbound and westbound directions. Thus, the obtained value for the side friction adjustment factor (Fpsf), according to Table 8, is 0.92 for the northbound direction and 0.89 for the eastbound and westbound directions. The adjustment factor for the city size in Majalengka is one because the population in Majalengka regency is estimated to be 1,328,894 people by 2023. After obtaining these values, the capacity is calculated as follows.

Table 4. Road Capacity

Direction	Co	FCw	FCsp	FCsf	FCcs	Capacity

North	2900	1	1	0,92	1	2668
East	2900	1	1	0,89	1	2581
West	2900	1	1	0,89	1	2581

Based on Table 13, the largest capacity at the Rajagaluh Market and Terminal intersection occurs in the northbound direction, or from Leuwimunding, with a road capacity value of 2668 smp/hour. After knowing the capacity values for each road, we can calculate the degree of saturation and the road service level values as follows.

Table 5. DOS and LOS

Direction	Period	Q (pcu/hour)	C (pcu/hour)	DOS	LOS
North	07:00-08:00	944.65	2668	0.35	Se
	13:00-14:00	986.65	2668	0.37	Average
	16:30-17:30	1180.85	2668	0.44	High
West	07:00-08:00	975.65	2581	0.38	Average
	13:00-14:00	987.65	2581	0.38	Average
	16:30-17:30	1232.3	2581	0.48	High
East	07:00-08:00	986.65	2581	0.38	Average
	13:00-14:00	997.1	2581	0.39	Average
	16:30-17:30	1224.2	2581	0.47	High

Based on the table above, it is found that in the northbound direction, the level of road service is average during the morning and afternoon, while it is classified as high during the evening. In the westbound direction, during the morning and afternoon, the level of road service is average, and during the evening, it is classified as high. The road service level in the eastbound direction is similar, being average during the morning and afternoon and high during the evening.

4.3 Side Barries

After the field survey, it was found that side obstacles occurred on each road section, with details as follows: the northern road section or towards Leuwimunding is 210 meters long. For the western direction or towards Majalengka, it is 450 meters, while for the eastern direction or towards Sindangwangi/Cirebon, it is 450 meters. The results of the side obstacle research can be seen in the table below.

Table 6. Side Barrier

Direction	PED	PSV	EEV	SMV	PKL	Frequency Weight	CLASS
North	103	117	107	102	23	295,7	Low
East	118	124	118	112	29	324,9	Average
West	127	133	115	114	47	346,1	Average

Based on the table above, it was found that the northern direction has a low level of side obstacles. Meanwhile, in the eastern and western directions, the level of side obstacles is average.

5. Conclusion

Based on the calculations above, it is found that the level of service on each road segment at the intersection of the three terminals and markets in Rajagaluh is mostly between average to high. Therefore, according to the author, the government must improve to anticipate the high traffic volume that will lead to congestion in the future. Based on the study, side obstacles are still relatively low to average. However, this does not mean it will be a benchmark in the future. It is possible that in the coming years, these side obstacles will increase, leading to congestion.

References

Abiansyah, L., & Rifai, A. (2020). Analysis Traffic Volume of Rigid Pavement Damage on Roads Badami Karawang. *Journal of World Conference, 2 (2). pp*, 190-199.

Baffoe-Twum, E., Asa, E., & Awuku, B. (2022). Estimation of annual average daily traffic (AADT) data for low-volume roads: a systematic literature review and meta-analysis. , 13. *Emerald Open Research, 4*, 13.

Chen, C., Wang, J., Xu, Q., Wang, J., & Li, K. (2021). Mixed platoon control of automated and human-driven vehicles at a signalized intersection: dynamical analysis and optimal control. *Transportation Research Part C: Emerging Technologies, 127*, 103138.

Dong, H., Zhuang, W., Chen, B., Lu, Y., Liu, S., Xu, L., & Yin, G. (2022). Predictive energy-efficient driving strategy design of connected electric vehicle among multiple signalized intersections. *Transportation Research Part C: Emerging Technologies*, 1.

Fajar, A., & Yasruddin, Y. (2021). PERFORMANCE ANALYSIS OF UNSIGNALIZED INTERSECTION ON PERJUANGAN AND VETERAN STREET MARTAPURA BANJAR DISTRICT. *CERUCUK, 4(1)*, 33-60.

Haryati, S., & Najid, N. (2021). ANALISIS KAPASITAS DAN KINERJA LALU LINTAS PADA RUAS JALAN JENDERAL SUDIRMAN JAKARTA. *JMTS: Jurnal Mitra Teknik Sipil, 4(1)*, 95-108.

Immanuel, Y., Rifai, A. I., & Prasetijo, J. (2022). The Road Performance Analysis of the Tuah Madani Roundabout, Batam-Indonesia. *Indonesian Journal of Multidisciplinary Science, 1(1)*, 27-36.

Jaysingpure, K. P., & Bijwe, A. R. (2022). Highway Safety Using Rolling Barrier. *International Journal of Research in Engineering and Science (IJRES), 10(3)*, 04-09.

Johanes, A., Dermawan, W. B., Isradi, M., & Rifai, A. I. (2022). Analysis of the Satisfaction Level of Sidewalk Users:(Case Study on Jl Jendral Ahmad Yani Bekasi). *ADRI International Journal of Engineering and Natural Science, 7(1)*, 74-82.

Kashyap, A. A., Devarakonda, A., Nayak K, S. R., KV, S., & Bhat, S. J. (2022). Traffic flow prediction models–A review of deep learning techniques. *Cogent Engineering, 9(1)*, 2010510.

Ma'aruf, M., Eprilianto, D., & Megawati, S. (2021). Collaborative Governance in Handling Traffic Problems in the City of Surabaya. *Proceedings of the 1st Tidar International Conference onAdvancing Local Wisdom Towards Global Megatrends, TIC 2020, 21-22 October 2020, Magelang, Jawa Tengah, Indonesia*, 3.

Marzoug, R., Lakouari, N., Pérez Cruz, J., & Vega Gómez, C. (2022). Model Cellular Automata untuk Analisis dan Optimalisasi Emisi Lalu Lintas di Simpang Bersinyal. *Keberlanjutan , 14 (21)*, 14048.

Pathivada, B., & Perumal, V. (2019). Analyzing dilemma driver behavior at signalized intersection under mixed traffic conditions. *Transportation research part F: traffic psychology and behaviour, 60*, 111-120.

Pitlova, A. K. (2019). CRITICAL GAPS AT UNSIGNALIZED INTERSECTIONS WITH BENDING RIGHT-OF-WAY. *COMMUNICATIONS*, 20.

Rifai, A. I., Surgiarti, Y. A., Isradi, M., & Mufhidin, A. (2021). Analysis of Road Performance and the impact of Development in Pasar Minggu, Jakarta: Case Study of Jalan Lenteng Agung-Tanjung Barat. *ADRI International Journal of Civil Engineering, 6(1)*, 68-74.

Wahyudi, M. A., Rifai, A. I., & Prasetijo, J. (2022). Analysis of the Effectiveness of Traffic Flow Diversion on Road Performance: A Case of Jalan Gajah Mada Development Project, Batam. *Indonesian Journal of Multidisciplinary Science, 1(1)*, 92-102.

Winaya, A. (2020). On-Street Parking and Traffic Flow Performance at Kapasan Shopping Area Surabaya. . *JACEE (Journal of Advanced Civil and Environmental Engineering), 3(1)*, 9-16.

Wu, F., & Ma, W. (2022). Clustering Analysis of the Spatio-Temporal On-Street Parking Occupancy Data: A Case Study in Hong Kong. *Sustainability, 14(13)*, 7957.

Yuan, J., & Abdel-Aty, M. (2019). Approach-level real-time crash risk analysis for signalized intersections. *Accident Analysis & Prevention, 119*, 2.

Zhou, Q., Chen, N., & Lin, S. (2022). FASTNN: A Deep Learning Approach for Traffic Flow Prediction Considering Spatiotemporal Features. *Sensors, 22(18)*, 6921.