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ROAD NETWORK SIMULATION MODEL ANALYSIS OF PAHLAWAN ROAD AREA WITH TRAFFIC MANAGEMENT AND ENGINEERING EFFORTS

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Abstract

During peak hour conditions, the traffic orderly area (KTL) in the existing Pahlawan Road area has not provided maximum results regarding performance and traffic order. The solution to the transportation problems that occur is to assess the performance of related sections and intersections and analyze the selection of traffic handling schemes to produce the most effective and efficient handling output. The purpose of this study is to determine the most optimal traffic engineering management recommendations for Pahlawan Road, Sidoarjo Regency. In data processing, researchers analyzed survey data, including the analysis of the traffic trip destination-origin matrix, vehicle free speed, vehicle behavior, and intersection control. The authors calibrated and validated the simulation model using the Vissim application, which represents the real situation in the field. Analysis of the traffic performance of the existing condition of the Pahlawan Road area road network revealed an average delay of 96.5 seconds, an average vehicle speed of 23.7 km/h, a total vehicle travel time of 1,691.6 hours, and a total vehicle delay of 725.2 hours, indicating poor road network performance. To improve the performance of the road network on the Pahlawan road section, the authors developed six road network simulation scenarios to derive the most optimal traffic engineering management recommendations for Pahlawan Road, Sidoarjo Regency.

Keywords: *Traffic Engineering Management, Vissim Application, Road Network Performance*

1. INTRODUCTION

Road traffic problems in this decade have increased due to the indiscipline of road users and the limited land to build or widen roads and the increasing growth in the number of vehicles accompanied by an increase in people's living standards (Ardiansyah et al., 2023). The rapid increase in the number of vehicles affects the increase in community movement in fulfilling their life needs. However, this is not balanced by the fulfillment of adequate road capacity so that it can cause traffic problems such as congestion. Congestion is a situation where vehicles experience a decrease in speed below normal conditions. Congestion is detrimental to road users because it creates obstacles and disrupts travel, causing longer travel times. The cause of congestion is usually caused by a decrease in road performance due to activities in an area that have not been properly regulated. Congestion is one of the problems that is often experienced by every city in the world. One of them is happening in Sidoarjo Regency, namely in the Pahlawan Road area (Ardiansyah et al., 2023).

Heterogeneous and irregular traffic conditions with both motorized and non-motorized vehicles competing with each other in one lane have the potential for traffic

accidents. Traffic accidents are events that are difficult to predict when and where they will occur. Traffic accidents have become a negative stigma of the rapid increase in transportation mobility. To reduce the risk of accidents and improve the comfort and safety of road users in the Pahlawan Road area of Sidoarjo Regency, appropriate and effective traffic engineering management is needed (Amirullah, 2015).

Another problem that needs to be considered in the Pahlawan Road area of Sidoarjo Regency is related to the placement and design of public transportation stops (Prasetyo et al., 2022). Improper placement and inadequate design of these facilities can cause disruption to traffic flow. In addition, motor vehicle parking spaces located on public roads also contribute to congestion. Suboptimal organization of parking spaces causes vehicles to stop or slow down abruptly, thus disrupting the smooth flow of traffic. Road crossings for pedestrians are also an important factor affecting traffic performance. Poorly located crosswalks and lack of safe crossing facilities can slow down vehicles and increase the risk of accidents. Good crosswalk management is necessary to ensure traffic safety and efficiency. Ineffective traffic signal timing under existing conditions also affects overall traffic performance. Poorly timed signals can cause long queues, vehicle buildup, and long waiting times for drivers. Therefore, there is a need for continuous evaluation and adjustment of the signal timing to match the dynamic traffic conditions.

Overall, the placement and design of public transport stops, on-street parking spaces, pedestrian crossings, and traffic signal timings on Jalan Pahlawan should be well managed to improve traffic performance on Jalan Pahlawan. The combination of these factors has a significant impact on traffic smoothness and safety, so special attention needs to be given to their planning and implementation.

The Jalan Pahlawan area is a very busy area. Around the road there are a lot of trip generators and pulls such as settlements, shopping centers, health facilities, sports facilities, and access to toll roads (Tamin, 2000). This makes the volume of vehicles passing through the sections and intersections on Jalan Pahlawan very high, especially during peak time. The increase in the volume of vehicles passing through the sections and intersections on Jalan Pahlawan resulted in the creation of a fairly long queue of vehicles at the intersection in the Jalan Pahlawan area of Sidoarjo Regency, especially at level crossings which are also located in the Jalan Pahlawan area (Maulana, 2020; Rusmandani et al., 2021; Setiawan, 2017).

The Jalan Pahlawan area plays an important role in serving and passing a large enough traffic flow, therefore to realize, support and maintain security, safety, order, and smooth traffic in the Jalan Pahlawan area and to realize the program of the Sidoarjo Regency Government which makes the Jalan Pahlawan area a Traffic Orderly Area (KTL), an analysis of the performance of sections and intersections in the Jalan Pahlawan area is needed to obtain effective and efficient solutions in its application.

Jalan Jati Raya and Jalan Pahlawan are connected by the Sidoarjo Toll Gate. The distance between the Sidoarjo Toll Gate location and the arterial road, Jati Raya Road, is very close (+ 130 meters). This causes problems because when the volume of traffic entering the Sidoarjo Toll Road is high (Pamungkas et al., 2022) and the payment process at the toll gate takes a relatively long time, causing a long queue on the Toll Exit Road to reach Jalan Jati Raya. This results in congestion on Jalan Jati Raya (west approach of Pancasila Monument Roundabout) and Jalan Pahlawan (east approach of Pancasila

Monument Roundabout). If the arrangement of vehicle movements that will enter the Sidoarjo Toll gate is not good, it could result in GridLock or queues of vehicles blocking the entire road network at the intersection so that traffic in all directions stops completely at the Pancasila Monument Roundabout, Jalan Jati Raya and Jalan Pahlawan.

This study aims to analyze traffic engineering management on Jalan Pahlawan, Sidoarjo Regency, in order to provide the right solution to overcome traffic problems in the area. Through in-depth analysis, it is expected to find effective strategies that can be applied to improve traffic performance, reduce congestion, and improve road user safety (Anwar, 2022). The results of this study are also expected to be taken into consideration for the Sidoarjo Regency Government and related stakeholders in making better policies in managing transportation in this region.

2. RESEARCH METHODS

2.1. Research Design

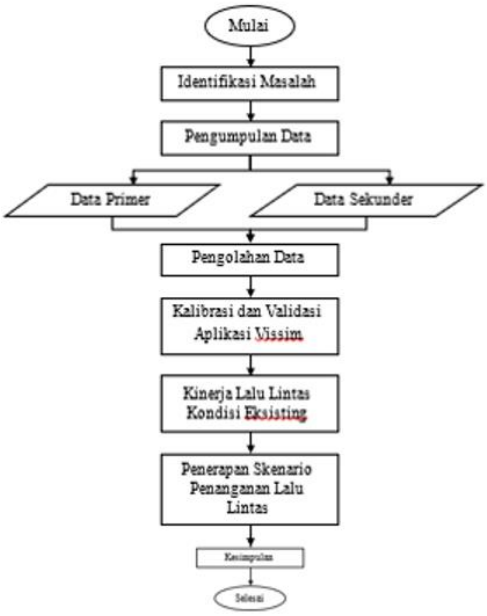


Figure 1. Research Flow Chart

The chart outlines a systematic approach to analyzing and simulating traffic conditions using VISSIM software. The process begins by identifying specific traffic-related problems or issues. Once identified, data is collected, which includes both primary data gathered for the project and secondary data sourced from external records. This data is then processed to extract meaningful insights.

Next, the VISSIM model is calibrated and validated to accurately reflect real-world traffic conditions. With a calibrated model, current traffic performance can be analyzed to identify bottlenecks and congestion points. To address these issues, various traffic management scenarios are simulated to evaluate their potential impact on traffic flow. Based on the simulation results, conclusions and recommendations are drawn, ultimately leading to the implementation of effective traffic improvement measures.

2.2. Data Collection

Data collection is carried out in two ways, namely primary data and secondary data, primary data is obtained from direct survey results in the field by directly calculating and measuring, while secondary data is obtained from certain agencies or institutions related to supporting research.

2.3. Data Processing

After all the data is collected, the next stage is data processing or data analysis to obtain traffic performance in existing conditions in the study area. In this study, the authors used segment and intersection performance analysis. The results of the analysis will be processed so as to obtain the results of traffic performance on the analyzed sections and intersections.

a. Simulation Model Calibration and Validation

The performance of the sections and intersections that have been analyzed and the results obtained are then calibrated and validated so that the model in the Vissim application can be used and can represent the real situation in the field.

b. Implementation of Traffic Engineering Management handling scenarios

Several traffic management and engineering scenarios were carried out in the Vissim application and then re-simulated so as to determine the impact of the scenarios carried out so as to improve the traffic performance of the Jalan Pahlawan network (Mellyarti & Zulkifli, 2020).

c. Recommendations and Suggestions

After all stages have been carried out, the last stage is the recommendation for the best problem solving handling which can later be used as a consideration in determining policies to overcome problems.

2.4. Data Analysis Technique

The stages carried out include data analysis of survey results in the form of analysis of the origin destination matrix of traffic trips, vehicle free speed, vehicle behavior and intersection control. Based on the results of data analysis, a simulation model is then made with the Vissim application to determine the performance of the study area road network traffic in existing conditions, the results of the existing conditions are then calibrated and validated so that the model used can represent real conditions in the field and after traffic management and engineering efforts (in this case several scenarios are carried out) (Prihiyandhoko, 2023; Yatmar et al., 2021). In this study, the traffic performance analysis of the study area road network was carried out under the busiest hour conditions. To determine the traffic performance of the study area road network, it is necessary to calculate travel time and vehicle speed due to obstruction of vehicle travel due to control of signalized intersections, roundabouts and other factors, as well as calculating the average vehicle delay on the road network.

The tool or method used to calculate the traffic performance of the study area road network is to use the Vissim simulation program (Hutahaean & Susilo, 2021). This is

because the study of the traffic performance of the study area road network is not limited to motorized vehicles, but also non-motorized vehicles, namely cyclists and pedestrians.

3. RESULTS AND DISCUSSION

3.1. Research Results

3.1.1. Road Network Simulation Model of Pahlawan Road Area Scenario 1

The traffic performance of the Jalan Pahlawan area road network is influenced by the effectiveness of the toll gate payment system performance (Rakha et al., 1996). Motor vehicle drivers entering the toll gate make payments by tapping the card at the toll gate. In connection with the relatively high number of vehicles entering the toll gate with varying card tapping times and the location of the toll gate close to Jalan Jati Raya has an impact on vehicle queues in front of the toll gate and Jalan Jati Raya. Traffic management and engineering efforts proposed in Scenario 1 are to speed up the card tapping time at the toll gate with the SLFF concept payment system. In this case, the card tapping time at the toll gate is faster than with the existing system (Existing Conditions), because the vehicle does not need tapping but only reduces the speed of the vehicle when entering the toll gate. The cumulative distribution of card tapping time at the toll gate is assumed to be between four to six seconds.

The results of the traffic performance analysis of the Jalan Pahlawan area road network Scenario 1. The average vehicle delay that occurs on the Jalan Pahlawan area road network is 95.0 seconds with a total vehicle delay of 713.5 hours. The average vehicle speed that occurs on the Jalan Pahlawan area road network is 23.9 km / h with a total vehicle travel time of 1,679.8 hours. Vehicle travel time in the four segments analyzed from the Scenario 1 simulation model.



Figure 2. Scenario 1 of the Road Network Simulation Model Pahlawan Road area

Table 1. Network Traffic Performance Parameters of Road Network Simulation Model

Network Traffic Performance Parameters	Value	Unit
Average vehicle delay	95,0	seconds
Average vehicle speed	23,9	km/h
Total vehicle travel time	1.679,8	hour
Total vehicle delay	713,5	hour

Source: Analysis Results, 2024

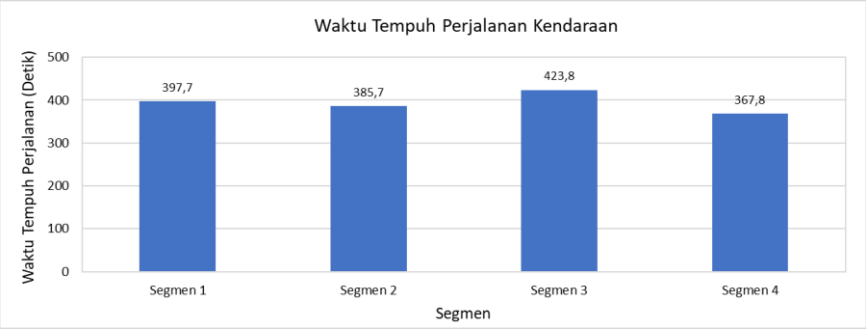


Figure 3. Travel Time in Four Segments Analyzed (Scenario 1)

3.1.2. Road Network Simulation Model of Pahlawan Road Area Scenario 2

Traffic management and engineering carried out in Scenario 2 is to speed up the process of vehicles entering the toll gate without going through the card tapping process at the toll gate. In this case, it is assumed that the toll card payment process uses the MLFF system where vehicles enter the toll gate without tapping the card and do not reduce vehicle speed when entering the toll gate.



Figure 4. Scenario 2 of the Road Network Simulation Model of Pahlawan Street Area

The results of the analysis of the traffic performance of the Jalan Pahlawan area road network Scenario 2. The average vehicle delay that occurs on the Jalan Pahlawan area road network is 87.5 seconds with a total vehicle delay of 659.9 hours. The average vehicle speed that occurs on the Jalan Pahlawan area road network is 24.7 km / hour with a total vehicle travel time of 1,620.5 hours.

Table 2. Network Traffic Performance Parameters of Road Network Simulation Model

Network Traffic Performance Parameters	Value	Unit
Average vehicle delay	87,5	seconds
Average vehicle speed	24,7	km/h
Total vehicle travel time	1.620,5	hour
Total vehicle delay	659,9	hour

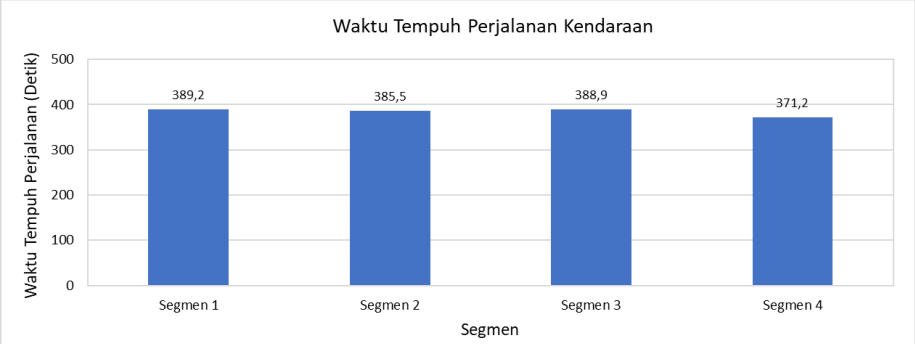
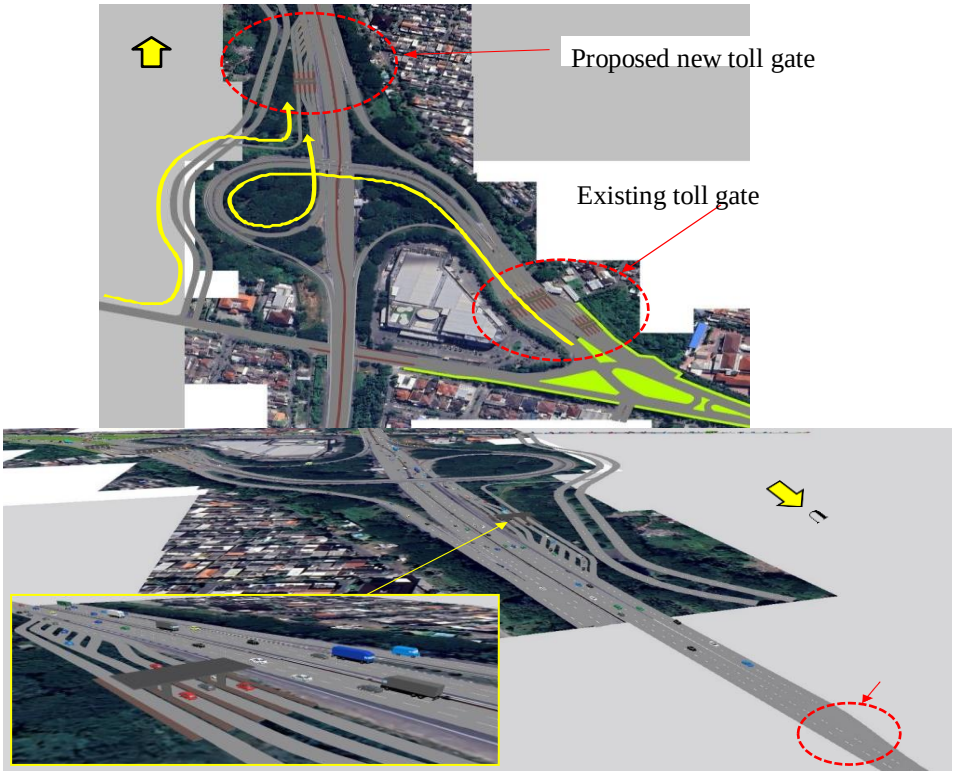


Figure 5. Travel Time in Four Analyzed Segment (Scenario 2)

3.1.3. Road Network Simulation Model of Pahlawan Road Area Scenario 3

Traffic management and engineering carried out in Scenario 3 is to create a new toll gate located west of the toll road to the North, where access to the new toll gate is through the existing toll gate and Jalan Kahuripan Raya. The purpose of creating this new toll gate is to minimize the problem of traffic congestion in front of the existing toll gate, Pancasila Monument Roundabout and surrounding roads by providing vehicle access from the west of Jalan Jati Raya to the northbound toll road via Jalan Kahuripan Raya and replacing the function of the existing toll gate (deactivating) for vehicles heading to the northbound toll road. Scenario 3 is a road network simulation model of the Existing Pahlawan Road area with the addition of a new toll gate.



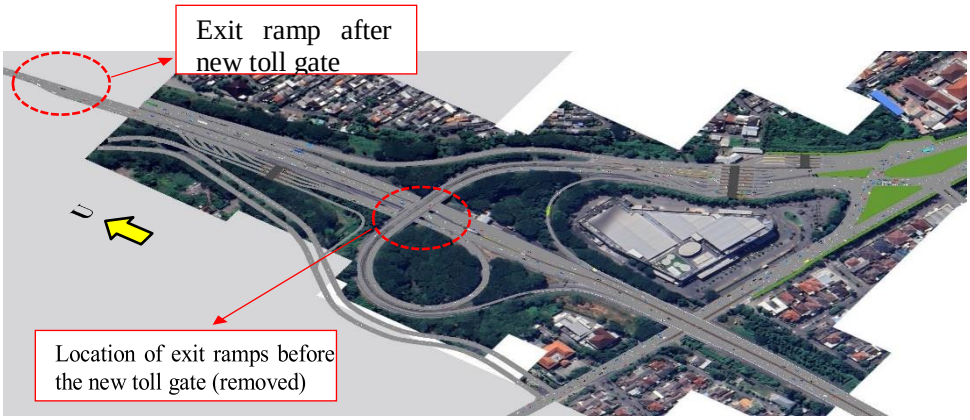


Figure 6. Location of the proposed new toll gate

The average vehicle delay that occurs on the Jalan Pahlawan area road network is 84.3 seconds with a total vehicle delay of 635.6 hours. The average vehicle speed that occurs on the Jalan Pahlawan area road network is 25.9 km / hour with a total vehicle travel time of 1,635.4 hours.

Table 3. Network Traffic Performance Parameters of Road Network Simulation Model

Network Traffic Performance Parameters	Value	Unit
Average vehicle delay	84,3	seconds
Average vehicle speed	25,9	km/h
Total vehicle travel time	1.635,4	hour
Total vehicle delay	635,6	hour

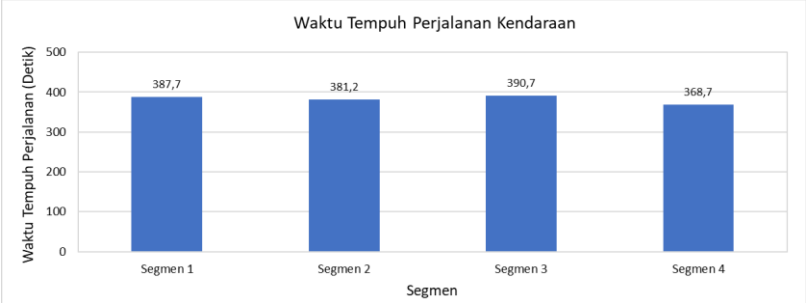


Figure 7. Travel Time in Four Segments Analyzed (Scenario 3)

3.1.4. Road Network Simulation Model of Pahlawan Road Area Scenario 4

Traffic management and engineering carried out in Scenario 4 is to change the geometrics of the GOR Gelora Delta Roundabout in the Existing Conditions into underpass infrastructure and a signalized intersection on it. Figure 8 depicts a simulation model of the GOR Gelora Delta Roundabout underpass along with a signalized intersection using APILL. The design of Intersection 4 GOR Gelora Delta with underpass infrastructure shows the timing of the APILL of Intersection 4 GOR Gelora Delta.



Figure 8. Scenario 4 Network Simulation Model Roads of Pahlawan Road Area

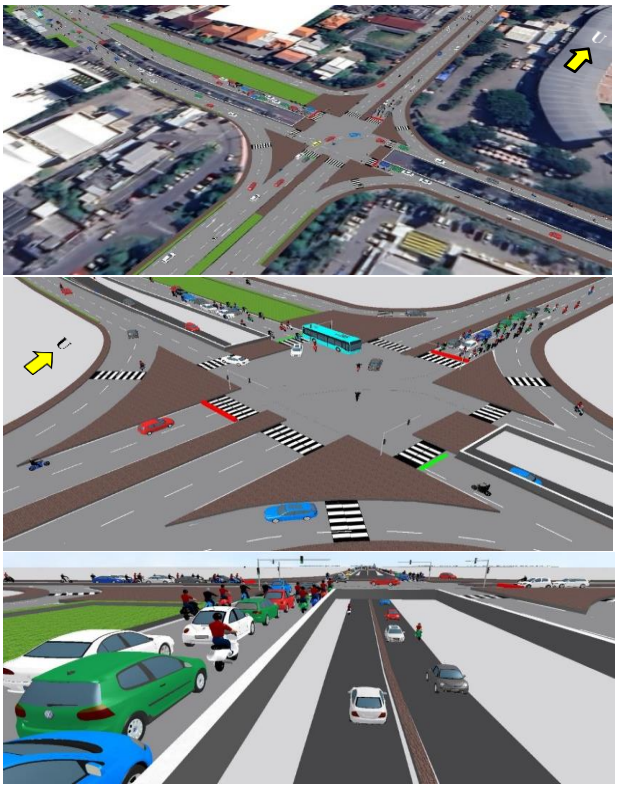
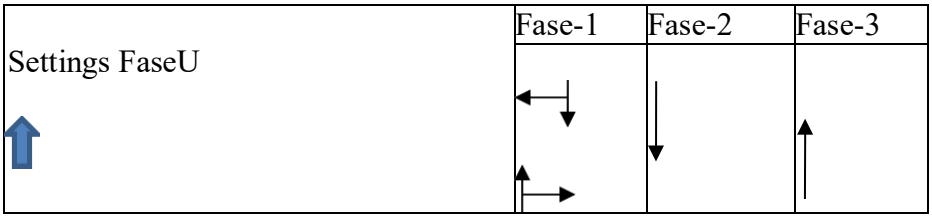


Figure 9. Design of Intersection 4 of Gelora Sports Hall Delta with Underpass Infrastructure

Table 4. Traffic signal timing of Intersection 4 GOR Gelora Delta

Approach	Time			
	Cycle (seconds)	Green (seconds)	Yellow (seconds)	All-Red (seconds)
Jl. Pahlawan (West) SG1	100	23	3	2
Jl. Pahlawan (East) SG3		23	3	2
Jl. Raya Taman PinangIndah (South) SG4		21	3	2
Jl. Raya Ponti (North) SG2		41	3	2



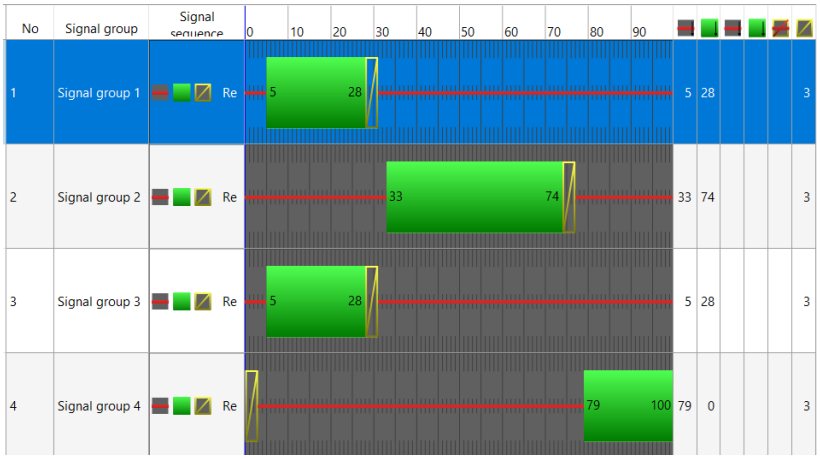


Figure 10. Timing of traffic signals at Intersection 4 GOR Gelora Delta

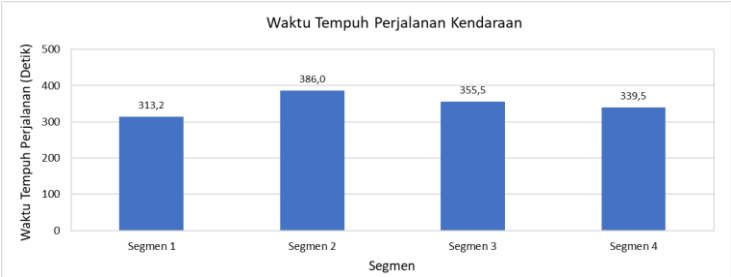
The results of the traffic performance analysis of the Jalan Pahlawan Scenario 4 area road network can be seen in Table 5. The average vehicle delay that occurs on the Jalan Pahlawan area road network is 100.9 seconds with a total vehicle delay of 755.8 hours. The average vehicle speed that occurs on the Jalan Pahlawan area road network is 22.7 km / hour with a total vehicle travel time of 1,677.4 hours.

Table 5. Network Traffic Performance Parameters of Network Simulation Model

Network Traffic Performance Parameters	Value	Unit
Average vehicle delay	100,9	seconds
Average vehicle speed	22,7	km/h
Total vehicle travel time	1.677,4	Hour
Total vehicle delay	755,8	hour

Source: 2024 Analysis Results

The travel time of vehicles in the four segments analyzed from the Scenario 4 simulation model can be seen in Figure 11.



Source: Analysis Results, 2024

Figure 11. Travel Time in Four Segments analyzed (Scenario 4)

3.1.5. Road Network Simulation Model of Pahlawan Road Area Scenario 5

Traffic management and engineering carried out in Scenario 5 is to speed up the payment system process at the toll gate as in Scenario 1 (SLFF concept) and change the geometry of the GOR Gelora Delta Roundabout into underpass infrastructure and a signalized intersection above it. Simulation model of Intersection 4 GOR Gelora Delta with underpass infrastructure and intersection control using APILL. The average vehicle delay that occurs on the Jalan Pahlawan area road network is 88.4 seconds with a total vehicle delay of 664.1 hours. The average vehicle speed that occurs on the Jalan Pahlawan area road network is 24.2 km / hour with a total vehicle travel time of 1,596.8 hours.

Table 6. Network Traffic Performance Parameters of Network Simulation Model

Network Traffic Performance Parameters	Value	Unit
Average vehicle delay	88,4	seconds
Average vehicle speed	24,2	km/h
Total vehicle travel time	1.596,8	Hour
Total vehicle delay	664,1	hour

Source: Analysis Results, 2024

Vehicle travel time in the four segments analyzed from the Scenario 5 simulation model.

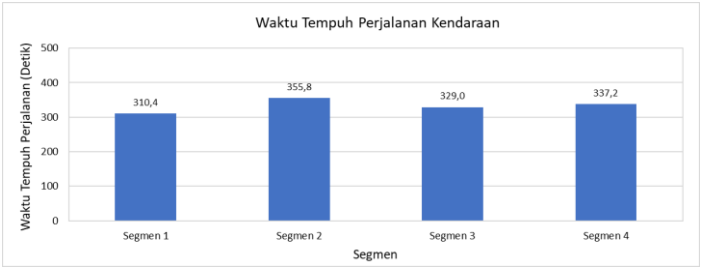


Figure 12. Travel time in the four segments analyzed (Scenario 5)

3.1.6. Road Network Simulation Model of Pahlawan Road Area Scenario 6

Traffic management and engineering carried out in Scenario 6 is to speed up the payment system process at the toll gate as in Scenario 2 (MLFF concept) and change the geometry of the GOR Gelora Delta Roundabout into underpass infrastructure and a signalized intersection on it. Figure 9 to Figure 10 show the simulation model of Intersection 4 GOR Gelora Delta with underpass infrastructure along with intersection control using APILL (Traffic Signaling Devices).

The results of the analysis of the traffic performance of the Pahlawan Road area road network Scenario 6 can be seen in Table 7. The average vehicle delay that occurs on the Jalan Pahlawan area road network is 82.9 seconds with a total vehicle delay of 622.0 hours. The average vehicle speed that occurs on the Jalan Pahlawan area road network is 24.8 km / hour with a total vehicle travel time of 1,554.9 hours.

Table 7. Network Traffic Performance Parameters Network Simulation Model

Network Traffic Performance Parameters	Value	Unit
Average vehicle delay	82,9	seconds
Average vehicle speed	24,8	km/h
Total vehicle travel time	1.554,9	Hour
Total vehicle delay	622,0	hour

Vehicle travel time in the four segments analyzed from the Scenario 6 simulation model.

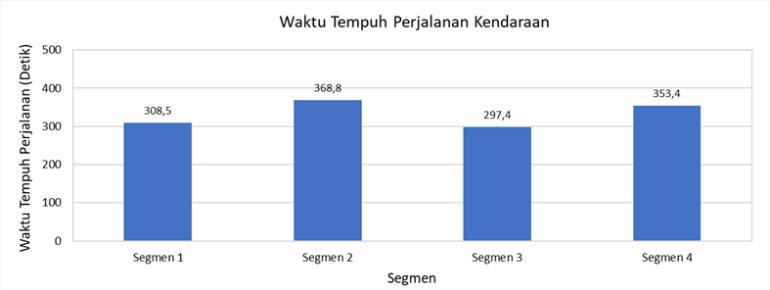


Figure 13. Travel time in the four segments analyzed (Scenario 6)

4. CONCLUSION

From the results of the comparison of the traffic performance of the Jalan Pahlawan area road network between existing conditions and the conditions of implementing traffic management and engineering efforts (scenarios), several important points can be drawn. In the modeling simulation conducted for 1 hour, the average vehicle delay on Jalan Pahlawan was 96.5 seconds, with travel time in the four segments analyzed ranging from

353 to 425 seconds. The traffic engineering management effort on Pahlawan Road in Sidoarjo Regency consists of six scenarios.

Scenario 1 involves the implementation of the SLFF system at the toll entrance gate, while scenario 2 implements the MLFF system at the toll gate. Scenario 3 involves the creation of a new toll gate through the Kahuripan Road access. Scenario 4 involves changing the geometry of the Gelora Delta GOR Roundabout into an underpass infrastructure with a signalized intersection on top. Scenario 5 is a combination of scenario 1 and scenario 4, while scenario 6 is a combination of scenario 2 and scenario 4.

Suggestions that can be given by the author for research on Traffic Engineering Management Analysis of Pahlawan Road Provincial Road 35.070.11k Sidoarjo Regency are as follows. This research is expected to be taken into consideration for relevant stakeholders in each scenario so that the traffic performance that has been modeled can be applied to actual traffic. To improve the smoothness and safety of traffic flow on Jalan Pahlawan, especially at level crossings located on Jalan Pahlawan, researchers suggest building an underpass in the area. For further research, it is expected to examine the proposed impact and influence of the construction of an underpass on the level crossing of Jalan Pahlawan.

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