LEADER
Civil Engineering and Architecture Journal

Civil Engineering and Architecture Journal Vol 2 No. 1 (2024) 3026-622X
DOI 10.37253/leader.v2i1.9506

ANALYSIS OF SIGNALIZED INTERSECTION PERFORMANCE: A CASE SIMPANG EMPAT SMPN 1 MAJALENGKA

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Keywords:

Signalized Intersection,
Road Performance,
Traffic Flow

ABSTRACT

Economic and health aspects are most significantly affected by traffic congestion due to delays in the execution of daily tasks, causing a huge waste of time, effort, and focus, as well as other additional costs. Like the intersection at SMPN 1 Majalengka or what is usually called the Abok intersection, which is one of the access roads to the economic center, the traffic problem that often occurs at the intersection at SMPN 1 Majalengka is congestion, especially at rush hour. traffic flow is increasing. denser than at other times. The aims of this research is to analyze the traffic engineering that occurs at the signalized intersection of SMPN 1 Majalengka which can cause congestion so that in the future this research will look for solutions to be more careful in traffic engineering. The research methodology used in this research is a qualitative method. This research was conducted at the Abok signalized intersection which is located near SMPN 1 Majalengka, Majalengka Regency. Based on the table above, it can be seen that the degree of saturation in the four directions has a value of 0.88. It can be concluded that the degree of saturation in all four directions is the same, namely 0.88 and according to MKJI 1997 this figure is included in the creeping dense category. The resulting degree of saturation is quite high, causing the service level value to creep up. This result will increase the risk of traffic jams at the intersection. So attention is needed in carrying out good traffic management.

1. Introduction

Vehicle traffic is the root of many problems, namely congestion, crashes, and pollution(Marzoug, Lakouari, Pérez Cruz, & Vega Gómez, 2022). A signalized intersection is an intersection that has traffic lights that are used to facilitate traffic flow(EG, B, & Purwanto, 2018). Many people use the signalized intersection method abroad, especially in developed countries like Japan. Of course, this method can engineer traffic to avoid or minimize traffic jams. Where congestion is not only a problem in Indonesia but also occurs in several other countries.

Indonesia is a vast country with a dense population of 268,583,016 people (Haryati & Najid, 2021). Of course, very rapid population growth will increase the number of vehicles, thereby triggering several problems that arise in traffic. Indonesia has many complex issues that still need to be resolved, one of which is the performance of interchanges in Indonesia. According to MKJI 1997, *intersection performance* is defined as a quantitative description of the operational status of intersections and intersection facilities, usually expressed regarding road capacity, vehicle speed, and cross-traffic behavior(Ulfah & Purwanti, 2019). As a result of low intersection performance, the smooth flow of traffic on urban roads is primarily hampered.

Road intersections are an essential component of the urban traffic nerwork(Pathivada & Perumal, 2019). The congestion problem is not a problem that only occurs in big cities. However, this problem often occurs in small towns. The transport permeability and capacity of city streets will depend

primarily on the geometric characteristics of the street, the cycle time of the controlled intersection, and the traffic composition of vehicles (Abdurakhmanov, 2022). Traffic management at intersections is vital in managing intersection traffic, especially with the increasing development of small cities, especially in West Java. So, this can trigger an increase in traffic volume on that road.

Signalized intersections are indispensable parts of urban traffic networks(Zheng & Liu, 2017). Economic and health aspects are most significantly affected by traffic congestion due to delays in the execution of daily tasks, causing a huge waste of time, effort, and focus, as well as other additional costs (Alsaawy, Alshanqiti, Bhat, & Bahbouh, 2022). Like the intersection at SMPN 1 Majalengka or what is usually called the Abok intersection, which is one of the access roads to the economic center, the traffic problem that often occurs at the intersection at SMPN 1 Majalengka is congestion, especially during rush hour. Traffic flow is increasing. Denser than at other times. Other problems at intersections are traffic conflicts due to uneven road widths, undisciplined drivers, and inappropriate traffic lights, which can cause travel time delays at intersections and traffic queues(Nina, Hidayat, & Kurnia, 2019). Especially during the day, which is the time when SMPN 1 Majalengka students go home.
With this research, traffic engineering efforts will be carried out to make overcoming problems that are, are, or will occur easier. This research aims to analyze the traffic engineering at the signalized intersection of SMPN 1 Majalengka, which can cause congestion in the future; this research will look for solutions to be more careful in traffic engineering.

2. Literature Review

2.1 Signalized Intersection

The most dangerous highways because of the complicated traffic conflict movements and frequent stop and go traffic are Intersections (Yuan & Abdel-Aty, 2018). Currently, people's need for traffic activities is very high because it is a tool for work and other activities. The scale of installing traffic lights in urban areas is enormous because other methods of traffic management are not possible (Novikov, Novikov, & Shevtsova, 2018). Therefore, currently there are many signalized intersections in urban environments which aim to minimize traffic congestion. Signalized intersections regulate traffic flow in urban areas, increasing energy consumption and delaying vehicular traffic (Dong, et al., 2022).
In various regions in Indonesia, traffic lights can also have a negative impact on traffic activities that occur in urban areas. Traffic lights are designed for safe traffic management, but inefficient operation of traffic lights can exacerbate traffic jams, increasing fuel consumption and vehicle emissions (Dong, Liu, & Yin, 2022). So every traffic light must have good traffic management. To ensure the safety of vehicle traffic and the smooth flow of traffic, controlling and managing traffic signs at intersections is a challenge in the traffic system (Tomar, Sreedevi, & Pandey, 2022)
This cause of congestion must be evaluated, including improving the traffic capacity of intersections by widening the critical approaches and reducing the car travel demand by adding an exclusive lane to the existing road (Sun, Lin, Jiao, & Lu, 2020). Intersections also significantly affect the safety and capacity of the road network (Firmansyah, Rifai, & Taufik, 2022). 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). At these road intersections, the factors causing congestion are large traffic volumes, driver indiscipline, road access to economic centers, and inappropriate traffic lights which can cause travel time delays at intersections and traffic queues. In overcoming traffic jams, it is necessary to pay attention to the lanes at intersections to optimize vehicle movement at intersections during green time..

2.2 Road Performance

Road performance is the ability of a section to serve the traffic flow that occurs on that road section. Road performance is greatly influenced by traffic flow on a particular road section (Rahayu, Rifai, & Akhir, 2022). Road performance is determined by road capacity, degree of saturation, average speed, travel time. Road performance is closely related to the level of service of a road, because it greatly influences the level of service of a road. The level of service itself is the quality of road services provided to motorists.

Road performance is influenced by several factors, one of which can be influenced by development projects along the road so that it can affect road performance on that road section. Poor road performance can result in serious traffic jams. The most negative impact on road users are time loss, energy wastage, health problems due to vehicle pollution, to stress and a decrease in people's productivity in their activities (Isradi M. , Mufhidin, Dermawan, Rifai, & Prasetijo, 2022).

Congestion is common at intersections and roads connecting main roads with city centers, shopping malls, and community enablement (Sarbaini, 2022). 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). Moreover, there are many four-wheeled vehicles that pass on this road, ranging from light vehicles such as minibuses to heavy vehicles such as buses.

2.3 Traffic Flow

Arus lalu lintas sendiri dapat dipengaruhi oleh kapasitas jalan dan keadaan geometric jalan. The transport permeability and capacity of city streetswill depend primarily on the geometric characteristics of the street, the cycle time of the controlled intersection, and also on the traffic composition of vehicles (Abdurakhmanov, 2022). 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).

Recording traffic flow is usually done by calculating the average daily traffic (LHR). Average daily traffic is obtained by calculating the volume of vehicles crossing a road. Usually the recording time is during peak hours, namely in the morning, afternoon and evening. From the AADT data, road utilization is concluded; planning and prioritization are carried out for necessary and appropriate road improvements, and there are sources of information for planning new road construction (Baffoe-Twum, Asa, & Awuku, 2022).

3. Method

The research methodology used in this research is a qualitative method. The purpose of descriptive research selection is for the author to collect data randomly, be illustrative, and interpret existing problems factually and in detail according to the data obtained (Ma'aruf, Eprilianto, & Megawati, 2021). Using qualitative methods, data collection, data grouping, data validation, and this interconnected data analysis can allow new theories and insights to emerge. So, the qualitative method is a research method carried out directly. Thus, this qualitative research method requires data, both primary and secondary.

This research was conducted at the Abok signalized intersection, which is located near SMPN 1 Majalengka, Majalengka Regency. This signalized intersection is in an urban area close to the city centre. The research location can be seen in Figure 1. Before conducting a survey, you must know the data needed for this research. The data required in research are primary and secondary data.

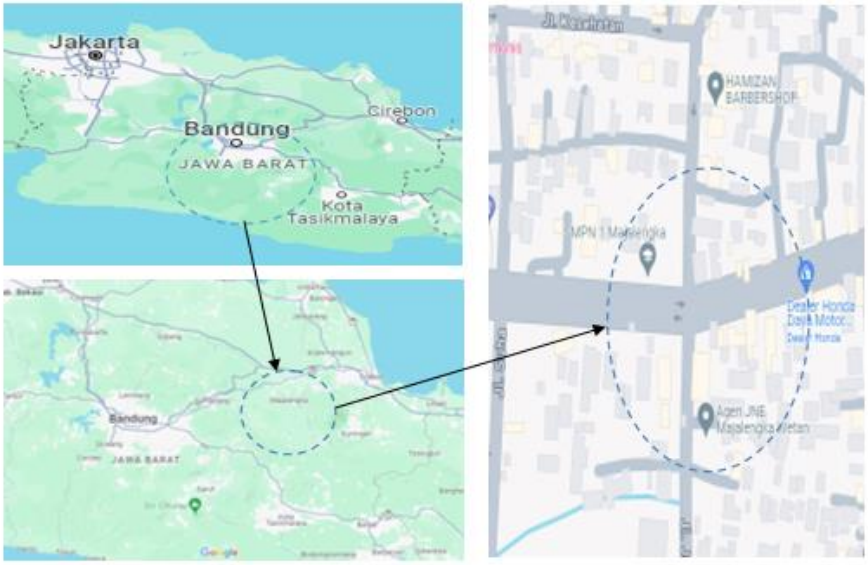

Figure 1. Research Location

The field survey will produce primary data. The primary data used in this research is traffic volume data. Where primary data is data obtained or paid directly through field surveys. Of course, in the data collection process, we must know the data collection instruments to produce correct data before the data is processed.

Traffic surveys are carried out for one day during every morning, afternoon, and evening rush hour using a traffic counter application. After obtaining traffic volume data, the data will be processed using the MKJI 1997 method, with the expected output in this research being to produce the performance of the signalized intersection.

4. Result and Discussion

Data calculations also require primary data for this research. This rimer data was obtained from research results and is accurate data. The Indonesian Highway Manual Capacity (IHCM 1997) method is used in the calculation process.

4.1 Road Geometric

The road geometry in this study was obtained by conducting a direct survey at the intersection with a Cigasong signal. In these four directions, two median directions are the same size, namely 2 meters. The east and west road types use the 4/2 UD road type, while the north and south use the 2/2 UD road type. The four directions have dimensions; the north and south directions each have a width of 7 meters, while the east direction is the same as the west direction, namely 14 meters with a median width of 1 meter. The results of the road geometry survey are in Figure 2.

The type of these four approaches is the Protected type, which has a Wltor of 2 each for the north and east directions. Meanwhile, for the south and west directions, there are 3.

Table 1. Geometric Recapitulation

Direction	Wltor	Wa	We
North	3	7,5	4,5
South	2	7	5
East	2	7	5
West	3	7,5	4,5

4.2 Traffic Volume

The traffic volume depends on the results of peak traffic surveys in the morning, afternoon and evening on weekends. The survey results show that the peak flow occurs during the afternoon rush hour, namely 16:30-17:30. See attachment 1 for traffic volume data.

Table 2. Traffic Volume

Light Vehicles (LV)			Heavy Vehicles (HV)			Motorcye (MC)			Motor Vehicle			Rasio Berbelok	
protected emp=1,0			protected emp=1,3			protected emp=0,25			TOTAL				
Challenged emp=1,0			Challenged emp=1,3			Challenged emp=0,25			MV				
Vehicles/ Hour	PCU/Hour		Vehicles/ Hour	PCU/Hour		Vehicles/ Hour	PCU/Hour		Vehicles/ Hour	PCU/Hour		PLT	PRT
	protected	Challenged		protected	Challenged		protected	Challenged		protected	Challenged	(%)	(%)
127		127	11		14.3	223		55.75	361		197.05	28	
75		75	23		29.9	342		85.5	440		190.4		
32		32	8		10.4	423		105.75	463		148.15		37
234		**234**	**42**		**54.6**	**988**		**247**	**1264**		**535.6**		
79		79	47		61.1	170		42.5	296		182.6	26	
96		96	63		81.9	331		82.75	490		260.65		
64		64	13		16.9	278		69.5	355		150.4		31
239		**239**	**123**		**159.9**	**779**		**194.8**	**1141**		**593.65**		
84		84	8		10.4	253		63.25	345		157.65	23	
102		102	17		22.1	498		124.5	617		248.6		
149		149	33		42.9	328		82	510		273.9		35
335		**335**	**58**		**75.4**	**1079**		**269.8**	**1472**		**680.15**		
56		56	32		41.6	219		54.75	307		152.35	25	
62		62	19		24.7	390		97.5	471		184.2		
68		68	43		55.9	353		88.25	464		212.15		37
186		**186**	**94**		**122.2**	**962**		**240.5**	**1242**		**548.7**		

4.3 Intersection Traffic

Data obtained from the results of traffic volume calculations:

Table 3. Traffic Flow

Direction	pcu/hour
North	535,6
South	593,65
East	680,15
West	548,7

From the table above, it can be seen that traffic flow in the North direction is 535.6 pcu/hour; in the South direction, it is 593.65 pcu/hour; in the West direction, it is 548.7 pcu/hour. Therefore, the most minor traffic flow occurs in the north direction or on Health Road. Meanwhile, the peak flow at the eastbound intersection or Jalan K.H Abdul Halim is 680.19 pcu/hour.

4.4 Saturation Current

Saturation current is the fundamental saturation current (So), namely the saturation current under normal conditions multiplied by an adjustment factor (F) for deviations from actual conditions. Table 3 shows the calculated saturation current.

Table 4. Saturation Current (pcu/green time)

Direction	So	Fcs	Fsf	Fg	Fp	Frt	Flt	S
North	4497	1	0,91	1	0,82	1	1	3355,661
South	4198	1	0,91	1	0,77	1	1	2941,539
East	4198	1	0,91	1	0,75	1	1	2865,135
West	4497	1	0,91	1	0,79	1	1	3232,893

The results in Table 3 are the results of saturated current calculations. In the north direction, there were 335,661; in the south direction, there were 2,941,539; in the east direction, there were 2,865,135; and in the west direction, there were 3,232,893. So, the most considerable saturation current is obtained, namely 3355.661 in the north direction. Meanwhile, the most minor saturated current is east at 2865.13.

4.5 Saturation Current Ratio

The formula for the saturation current ratio is FR=Q/S. The results of the saturation current ratio are in table 4.

Table 5. Saturation Current Ratio

Direction	Q	S	FR	∑Fr
North	535,6	3355,661	0,159611	0,76854
South	593,65	2941,539	0,201816	
East	680,15	2865,135	0,237388	
West	548,7	3232,893	0,169724	

Based on the table above, the saturation current ratio is 0.159611 in the north direction, 0.201816 in the south direction, 0.237388 in the east direction, and 0.169724 in the west direction. So, the overall saturation current ratio of the four directions is 0.76854. The east direction has the most significant saturation current ratio of 0.237488.

4.6 Cycle Time

After getting some of the data above, calculate the cycle time (S). The results of these calculations are in the calculations below.

c=(1,5 x 16+5)/ (1-0,768)

c=125 det

4.7 Green Time

Formula to calculate your own Green Time:

g= (c-LTI) x (FR/∑FR)

Thus, the results of these calculations are in table 5.

Table 6. Green Time

Direction	G	
North	23	det
South	29	det
East	34	det
West	24	det

It can be seen in Table 5, which is the green time in each direction. Green time for northbound is 23 seconds, southbound is 29 seconds, eastbound is 34 seconds, and westbound is 24 seconds. Thus, the longest and fastest green times are from the east and north, with 34 seconds and 23 seconds, respectively.

4.8 Road Capacity

The road capacity that can accommodate the highest vehicle volume is in the east direction, namely 771.71104 pcu/hour. After following the steps above, road capacity data is obtained in Table 6.

Table 7. Road Capacity

Direction	C
North	607,70195
South	673,56641
East	771,71104
West	622,56544

Based on the table above, it produces road capacities in all four directions. Northbound capacity is 607.70195 pcu/hour, southbound is 673.56641, eastbound is 771.71104, and westbound is 622.56544. The largest road capacity is in the east, 771.71104 pcu/hour. Meanwhile, the smallest road capacity is in the north direction at 607.70195.

4.9 Degree of Saturation and Level of Services

The calculation results for the degree of saturation in the west, south, north and east directions are 0.8, and the value for the level of road service is in the form of creepage density. This result certainly increases the risk of congestion at peak flows. They are contained in Table 7.

Table 8. Degree of Saturation and Level of Services

Direction	C	DS	LOS
Norh	607,70195	0,8813531	Padat Merayap
South	673,56641	0,8813533	Padat Merayap
East	771,71104	0,8813532	Padat Merayap
West	622,56544	0,8813531	Padat Merayap

Based on the table above, it can be seen that the degree of saturation in the four directions has a value of 0.88. It can be concluded that the degree of saturation in all four directions is the same, namely 0.88, and according to MKJI 1997, this figure is included in the creeping dense category.

5 Conclusion

This research concludes that the peak traffic flow at this intersection is on weekends during the afternoon rush hour, precisely at 16.30-17.30. The degree of saturation for each direction is 0.88. The road capacity to accommodate traffic volumes in each direction is 607.7 pcu/hour in the north, 673.5 pcu/hour in the south, 771.7 pcu/hour in the east, and 622.5 pcu/hour in the west. The resulting degree of saturation is relatively high, causing the service level value to creep up. This result will increase the risk of traffic jams at the intersection. So, attention is needed to carry out good traffic management.

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