

Efficiency Analysis of Traffic Management in Simpang Tiga Rawa Hingkek, Bogor

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Abstract: The intersection at Rawa Hingkek in Bogor Regency is a three-arm intersection without traffic signals. In 2021, a project aimed at enhancing traffic management at this intersection was implemented. The project aimed to alleviate congestion at intersections, utilizing the 1997 Indonesian Highway Capacity Manual (MKJI 1997) for analysis, including intersection capacity, queue length, and delays. Data collection primarily focused on the Rawa Hingkek Intersection, followed by processing and evaluation. Analysis results indicated that prior to the improvement project, the intersection experienced high congestion, with a Degree of Saturation (DS) of 1.73 and various delays, resulting in a Level of Service (LOS) of F. However, post-improvement, the congestion significantly decreased, as evidenced by a reduced DS of 1.17 and improved LOS to B. Thus, it can be concluded that the traffic management enhancement at Rawa Hingkek intersection successfully mitigated congestion.

Keywords: Traffic Management, Unsignalized, Intersection, Congestion.

INTRODUCTION

Transportation is one of the things that are important for humans in carrying out mobility in everyday life (Andika et al., 2022). Transportation is one of the means that can be a medium to connect people with certain goals (Tumlin, 2011). As the population increases, it is stated that world's population has reached around 7.94 billion people as of July 2022. So there would also be an increase in the amount of transportation in the world which is increasingly more and more both (Traveled, 2010) The countries with the most growth in registered cars since 1990 are China, India, and Indonesia with an average change of 18%, 9.8%, and 9.6%, respectively.

Indonesia is one of the countries with the most population. Indonesia is the fourth most populous country in the world (Djalante et al., 2020). This is in the position before Indonesia there are China, India, and the United States. In Indonesia, we are presently experiencing rapid population growth, causing an increase in human activities and needs (Mufhidin et al., 2022). It is not surprising that many vehicle companies compete to sell their products in Indonesia, which has many cities and regencies.

Bogor Regency, to be precise in the Cileungsi sub-district, has an area of 133,3 km². Bogor Regency has the largest population in Indonesia (Rifai & Farhan, 2021). The total population in the Bogor Regency in 2018 was 5,840,907 people consisting of 2,983,287 men and 2,857,629 women (Isradi et al., 2021). Compared to 2017, the Bogor Regency population has increased by an average of 2,20%. With the increasing flow of people and the density of the Cileungsi sub-district,

In connection with this, traffic problems often occur, especially in the intersection area which can be defined as a place where two or more road sections join so that it becomes a point prone to congestion (Jain et al., 2012). Congestion has become a common problem, and many ways have been developed to provide a solution (Kumarage, 2004; Lindley, 1987; Rifai et al., 2021; Rosenbloom, 1978).

In 2021, a project aimed at enhancing traffic management was implemented at the Rawa Hingkek intersection. A survey was conducted by the author at the Simpang Tiga Rawa Hingkek to address

congestion issues at this junction. The irregular traffic conditions at the intersection stem from drivers contending for limited road space. Peak traffic density persists during school drop-off and work commute hours, particularly in the surrounding residential and industrial areas.

The research focuses on addressing traffic congestion at the Rawa Hingkik intersection in Bogor Regency, aiming to enhance traffic management and alleviate peak-hour delays. By analyzing traffic patterns and surveying local conditions, the study seeks to improve commuter experience and safety, potentially serving as a model for managing similar congestion issues in urban areas. Successful implementation of solutions could not only reduce travel times and enhance accessibility for residents and businesses but also inform future urban planning and infrastructure projects, contributing to sustainable development and improved quality of life in Bogor Regency and beyond.

RESEARCH METHOD

To carry out the chosen approach, the researcher employed a quantitative survey technique involving direct interactions with fellow surveyors to gather essential data (Fellows & Liu, 2021; Fowler Jr, 2013; Gable, 1994). For the observational phase, various tools such as research forms, meters, smartphones, stationery, and laptops were utilized to streamline data collection and ensure accurate recording. The collected data encompass both secondary and primary sources. Subsequently, data analysis was conducted following the fundamental principles outlined in the 1997 Indonesian Road Capacity Manual.

Data

Primary data can be obtained by observing the research location, traffic survey data, geometric road data, side friction data. While secondary data can be obtained from authorized institutions and researchers, secondary data includes several data, namely location maps, environmental data, and data from the last five years. The research location can show in Figure 1.

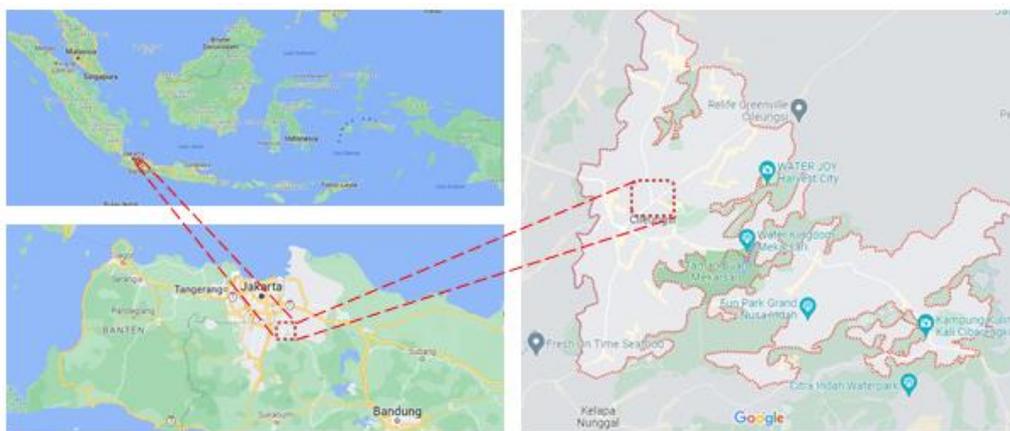


Figure 1. Location Maps (source: Google Maps)

In figure 2 the author has conducted a survey in the morning at the Simpang Tiga Rawa Hingkik.



Figure 2. Research Location of Intersection

Research Time

The study spanned three days: Monday (28th November 2022), Friday (2nd December 2022), and Sunday (4th December 2022), comprising two-hour sessions during peak periods. These sessions were held in the morning from 06:30 to 08:30, at noon from 11:30 to 13:30, and in the evening from 16:30 to 18:30.

Research Instruments

In this study, several proper research instruments were needed to facilitate researchers in collecting data. The research instruments, namely using form 1, meter, speed gun, smartphone, stationery, and laptop

RESULT AND DISCUSSION

Performance Road

The examination of roads focuses on the primary thoroughfare, Jalan Raya Narogong, employing standard methodologies outlined in the 1997 Indonesian Road Capacity Manual (MKJI 1997) for Urban Roads. The assessment of road statistics is conducted during the peak traffic hours on Friday from 06:30 to 07:30 WIB, when traffic flow is at its busiest.

Road Section Geometric Data

Geometric condition of the road section required for the calculation are as follows:

- Road Section Name : Narogong
- Highway Type of Road : 2/2 UD, 2 lines 2 undivided directions
- Width per lane : 3,9 meters
- City Size : Very Large (>3.0million people)
- Enviromental Type : Comercial, there are markets, shops, residential areas, etc
- Median : None
- Alignment Type : Flat
- Traffic Signs : No
- Road Markings : None

Every geometric road data can be seen in the table 1 and Figure 3 - 5.

Table 1. Geometrik road data

No	Explanation	Narogong Highway	
		Bogor Direction	Bekasi Direction
1	Road Type	2/2 UD (two lines, undivided)	2/2 UD (two lines, undivided)
2	Width Road	10,5m	7,8m

3	Width Road Shoulder	1m	1m
4	Median	None	None
5	Road Condition	Flat	Flat
6	Pavement Type	Asphalt	Asphalt

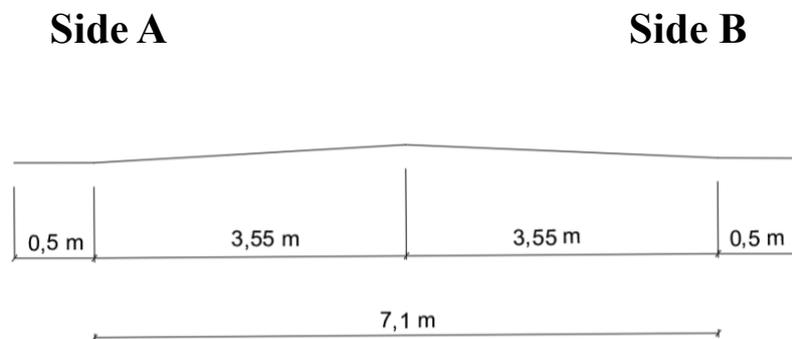


Figure 3. Front View of the Jalan Cileungsi Setu Raya Narogong Bekasi Direction

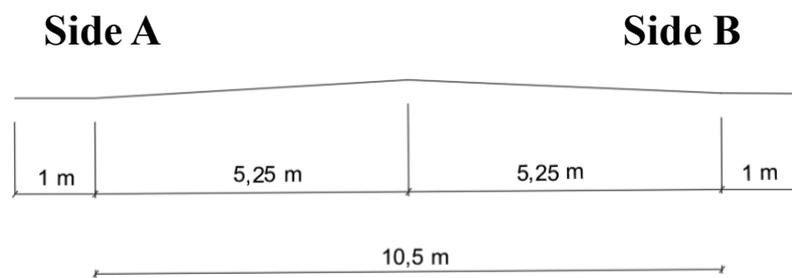


Figure 4. Front View of the Jalan Raya Narogong Bogor Direction

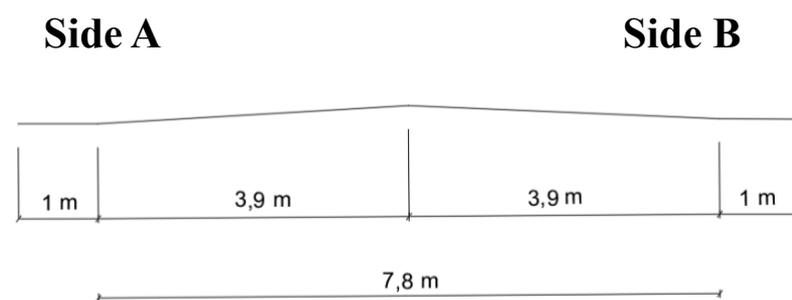


Figure 5. Front View of the Jalan Raya Narogong Bekasi Direction

Road Traffic Volume Data

Traffic data for road section analysis were collected through direct surveys over three days at the research site: Monday (28 November 2022), Friday (2 December 2022), and Sunday (4 December 2022). Analysis of the survey findings revealed that the Narogong Highway section experienced its peak traffic volume on the morning of Friday, 2 December 2022, as depicted in Table 2.

Parking Volume

Table 2. Traffic Volume based on Friday on Narogong Highway
Jumat, 2 Desember 2022
Narogong Highway Bogor Direction

Time	LV (emp 1,0)		HV (emp 1,3)		MC (emp 0,5)		Total	
	vehicle/hour	pcu/hour	vehicle/hour	pcu/hour	vehicle/hour	Smp/Jam	vehicle/hour	pcu/hour
06.30-07.30	489	489	163	211,9	1843	921,5	2495	1622,4
07.30-08.30	362	362	99	128,7	1692	846	2153	1336,7
11.30-12.30	329	329	351	456,3	1307	653,5	1987	1438,8
12.30-13.30	450	450	201	261,3	1658	829	2309	1540,3
16.30-17.30	490	490	168	218,4	1731	865,5	2389	1573,9
17.30-18.30	209	209	101	131,3	1682	841	1992	1181,3
Narogong Highway Bogor Direction								
06.30-07.30	476	476	180	234	2151	1075,5	2807	1785,5
07.30-08.30	317	317	106	137,8	1626	813	2049	1267,8
11.30-12.30	321	321	239	310,7	1207	603,5	1767	1235,2
12.30-13.30	222	222	139	180,7	1004	502	1365	904,7
16.30-17.30	406	406	109	141,7	1562	781	2077	1328,7
17.30-18.30	318	318	91	118,3	1792	896	2201	1332,3

Calculation of Road Performance

1. Actual Speed of Roads

A survey to determine the speed of vehicles on Jalan Cileungsi Setu and Jalan Raya Narogong was conducted using a speed gun. This survey was performed over a 200-meter stretch, which constituted a section of the research survey location. Researchers collected three samples of each vehicle type, including light vehicles, heavy vehicles, and motorcycles. Table 3 displays the recorded vehicle speeds on Jalan Raya Narogong.

Table 3. Sample Vehicle Speed

Road Section	Actual speed in the morning			Actual speed in the noon			Actual speed in the evening		
	(Km/hour)			(Km/hour)			(Km/hour)		
	LV	HV	MC	LV	HV	MC	LV	HV	MC
Jalan Cileungsi Setu	20	20	27	35	32	40	24	21	28
	22	21	32	36	33	35	26	22	31
	24	24	31	33	30	33	28	19	25
Average	22	21,67	30	34,67	31,67	36	26	20,67	28
Jalan Raya Narogong	31	35	25	34	31	38	32	31	35
	32	36	30	29	33	36	34	26	33
Arah Bogor	29	32	28	27	29	34	30	22	31
Average	30,7	34,3	27,7	30	31	36	32	26,3	33

Jalan Raya	36	36	41	36	40	42	32	29	33
Narogong	34	33	39	40	37	44	34	30	36
Arah Bekasi	39	35	38	33	36	40	36	27	30
Average	36,3	34,7	39,3	36,3	37,7	42	34	28,7	33

2. Capacity

Capacity refers to the continuous movement of traffic along a specific section of the road within specified circumstances, typically measured in vehicles per hour or passenger car units per hour (MKJI 1997). The fundamental formula for assessing capacity on urban roads is provided in table 4.

$$C = C0 \times FCW \times FCSP \times FCSF \times FCCS$$

$$C = 2900 \times 1.12 \times 1 \times 0.92 \times 1.05$$

$$C = 3137,57 \text{ pcu/ hour}$$

Table 4. Capacity Recapitulation

Road Section	Based Capacity and Adjustment Factor					C
	C0	FCW	FCSP	FCSF	FCCS	Pcu/hour
Cileungsi Setu Road	2900	1,03	1	0,89	1,05	2791,35
Narogong Highway Bogor Direction	2900	1,31	1	0,92	1,05	3669,8
Narogong Highway Bekasi Direction	2900	1,31	1	0,92	1,05	3669,8

3. Degree of Saturation

The main determinant of road service level, indicating whether there's a capacity issue, is the saturation degree. It's defined as the ratio of traffic flow to capacity and can be calculated using the provided formula, as shown in table 5.

$$DS = Q / C$$

$$DS = 1785,5 / 3137,57$$

$$DS = 0,57$$

Table 5. Degree of Saturation Recapitulation

Road Section	Total Vehicle Flow. (Q)	Road Capacity (C)	Degree of Saturation DS = Q / C
Cileungsi Setu Road	1575,9	2791,35	0,55
Narogong Highway Bogor Direction	1766,3	3669,8	0,48
Narogong Highway Bekasi Direction	1785,5	3669,8	0,49

4. Level of Service

The Indonesian Road Capacity Manual (MKJI. 1997) defines a road segment's level of service (LOS) as a qualitative measure that reflects the driver's perception of the quality of driving a vehicle. Service level value refers to DS. The level of road service can be seen in Table 6.

Table 6. Service Level (LOS) Recapitulation

Road Section	Degree of Saturation DS = Q / C	Level Of Service (LOS)
Cileungsi Setu Road	0,55	C

Narogong Highway	0,56	C
Bogor Direction		
Narogong Highway	0,57	C
Bekasi Direction		

Performance of Unsignalized Intersection

Analyses are conducted at the junctions of Jalan Cileungsi Setu and Jalan Raya Narogong. The analysis employs primary data encompassing geometric, environmental, and traffic data, alongside side friction and vehicle speed data collected through on-site observations and surveys. Additionally, secondary data from pertinent agencies are also utilized.

Geometric Data

The point where Jalan Cileungsi Setu meets Jalan Raya Narogong is categorized as a type 322 intersection, indicating three arms with two lanes on the smaller road and two lanes on the primary road. Details regarding the intersection's geometric attributes are provided in Table 7, while Figure 6 offers a visual representation. Geometric data encompassing various aspects of the intersection is outlined.

Table 7. Existing Geometric Data of Intersection

No	Explanation	Road of Cileungsi Setu	Narogong Highway Bogor Direction	Narogong Highway Bekasi Direction
1	Road Type	2/2 UD (two lines, undivided)	2/2 UD (two lines, undivided)	2/2 UD (two lines, undivided)
2	Width Road	7,1m	10,5m	7,8m
3	Widht Per Lane	3,55m	5,25m	5,25m
4	Width Road Shoulder	0,5m	1m	1m
6	Road Condition	Flat	Flat	Flat
7	Pavement Type	Asphalt	Asphalt	Asphalt

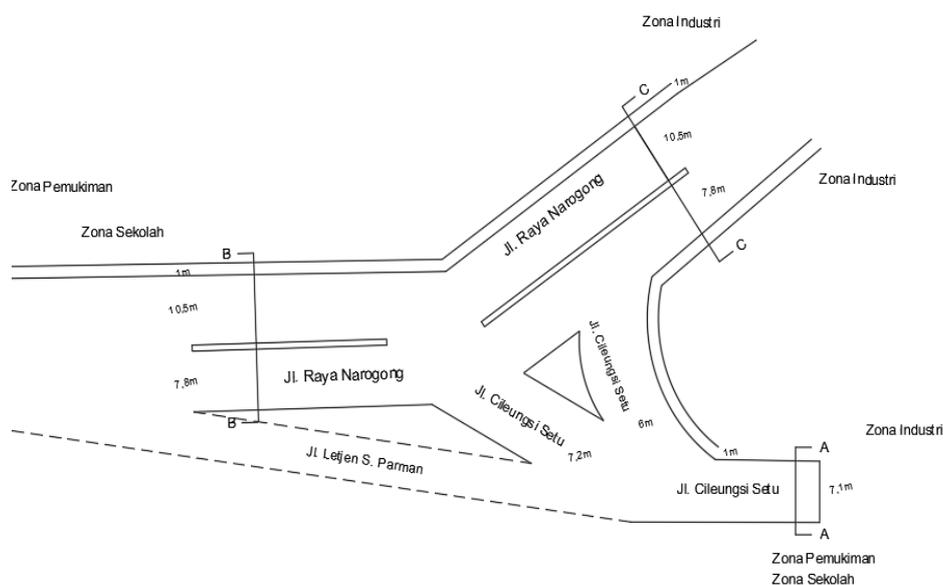


Figure 6. Ilustrstion of Unmarked Intersection Rawa Hingik

Intersection Traffic Data

The survey at the intersection was carried out over a span of 2 hours across three days - Monday, Friday, and Sunday - covering morning, noon, and evening periods. The summary of survey findings is presented in Table 8, while the graphical representations can be found in the accompanying figures.

Table 8. Recapitulation of Intersection Survey Result Monday, Friday, Sunday

Time	Monday, 28 November 2022	Friday, 2 December 2022	Sunday, 4 December 2022
	Total (pcu/hour)	Total (pcu/hour)	Total (pcu/hour)
06.30-07.30	4637,9	4983,8	2945,2
07.30-08.30	3502,7	3695,4	3181,4
11.30-12.30	3292,8	3401,1	4017,7
12.30-13.30	2962,3	3084,7	3942,6
16.30-17.30	3829,6	4034,4	4432,3
17.30-18.30	3705,1	3799,8	4459,7

The highest traffic congestion is observed on Sundays, particularly during peak hours from 5:30 to 6:30 PM, registering a total of 5119.5 vehicles per hour. This information serves as a basis for conducting an analysis on unsignalized intersections. Detailed findings from the intersection survey are presented in Table 9.

Table 9. The result of Intersection Survey for Friday, 2 December 2022 at 06.30-07.30

Approach	Direction	Vehicle Type				Total Vehicle Per Hour
		MC	HV	LV	UM	
Road Cileungsi	LT	-	-	-	-	-
Setu	ST	991	18	189	2	1200
Narogong	RT	1178	10	266	6	1460
Highway Direction Bogor	LT	882	56	233	6	1177
Narogong	ST	961	107	256	0	1324
Highway Direction Bekasi	RT	-	-	-	-	-
	LT	1016	107	244	11	1378
	ST	-	-	-	-	-
	RT	1135	73	232	4	1444

7983

Results of the Calculation of the Unsignalized Intersection

1. Total Capacity of Unsignalized Intersection

The survey at the intersection involved assessing the overall capacity of all arms by multiplying the baseline capacity (C0), representing ideal conditions, with adjustment factors (F) to accommodate field conditions. This calculation, detailed in table 10, determined the total capacity of the intersection. The survey spanned 2 hours across 3 days: Monday, Friday, and Sunday, covering morning, noon, and evening times. The summary of survey findings is presented in Table 8.

$$C = C0 \times FW \times FM \times FCCS \times FRSU \times FLT \times FRT \times FMI$$

$$C = 3200 \times 1,03 \times 1,00 \times 1,01 \times 0,94 \times 1,37 \times 0,76 \times 0,88$$

$$C = 2867,75 \text{ pcu / hou}$$

Table 10. Capacity for the Intersection of Jalan Cileungsi Setu and Jalan Raya Narogong

Basic		Capacity Adjustment					Capacit y	
Capacit y	width approac h	Median road main	Size	Side	Turn Left	Turn Right	Ratio Minor	C
(CO)	average (FW)	(FM)	(FCCS)	Obstacl e	(FLT)	(FRT)	Total FMI	pcu/ho ur
3200	1,03	1,00	1,01	0,94	1,37	0,76	0,88	2867,75

2. Degree of Saturation

The saturation level, a crucial measure in assessing the efficiency of intersections and road segments (MKJI 1997), is determined by the ratio between traffic flow and capacity. Table 11 provides an overview of the saturation levels for various intersections and traffic patterns.

$DS = Q_{smp} / C$
 $DS = 4983,8 / 2867,75$
 $DS = 1,73$

Table 11. Traffic Behavior at the Intersection of Jalan Cileungsi Setu and Jalan Raya Narogong

Traffic Flow (Q) pcu/hour	Degree of Saturation (DS)	Delay Traffic Intersection (DTI)	Delay Traffic JL. Utama (DTMA)	Delay Traffic JL. Minor (DTMI)	Delay Geometric Intersection (DG)	Delay Intersection (D)	ppportunity Queue (QP%)
4983	1,73	11,81	14,7	5,59	4	9,59	$\frac{131,75\% - 292,38\%}{}$

3. Service Level

There are several ways to determine the service level value, one of which is the intersection service level can be seen from how long the delay occurs at the intersection. The value of the delay obtained is 9,59 sec/pcu. Then it is known that the LOS result is B, which means the intersection conditions are at moderate traffic levels.

Analysis Comparison Data Existing with Previous Researchers

Volume (Q), capacity (C), and various traffic behavior metrics including degree of saturation (DS), intersection traffic delays (DTI), main road traffic delays (DTMA), minor road traffic delays (DTMI), geometric intersection delay (DG), intersection delay (D), and queuing opportunity (QP) constitute the data under comparison. The outcomes of this comparison are presented in Table 12.

Table 12. Comparison Result

Traffic Flow (Q) Vehicle/hour	Traffic Flow (Q) pcu/hour	Degree of Saturation (DS)	Delay Traffic Interse ction (DTI)	Delay Traffic JL. Utama (DTMA)	Delay Traffic JL. Minor (DTMI)	Delay Geom -etric Interse ction (DG)	Delay Interse- ction (D)	ppportunity Queue (QP%)
Existing 7954	4983	1,73	11,82	14,7	5,59	4	9,59	$\frac{131,75\% - 292,38\%}{}$

Previous	7867	5119,5	1,17	30,1	18,35	52,96	4	34,1	55,63% - 112,47%
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CONCLUSION

From the results of field surveys and the results of data analysis calculations that have been carried out, The following conclusions can be drawn: On Jalan Cileungsi Setu, the peak traffic flow occurs on Monday morning at 06.30-07.30, where the performance of the section has a vehicle volume of 2724 vehicles/hour or 1545.2 pcu /hour, DS value = 0.55, speed value km/hour and having a service level based on Q/C has an C grade. Based on the Jalan Raya Narogong section in the direction of Bogor, the peak traffic flow occurs on Sundays at 12.30-13.30, where the performance of the section has a vehicle volume of 2580 vehicles/hour or 1766.3 pcu/hour, DS value = 0.48, speed value km/hour and has a level of service based on Q/C has an C value. The peak traffic flow occurs on Friday at 06.30-07.30, where the performance of the section has a vehicle volume of 2807 vehicles/hour or 1785.5 pcu/hour, DS value = 0.49, speed value km/hour and has a level of service based on Q/C has an C value. The highest traffic volume value on Friday morning (06.30-07.30) on 2 December 2022 of 7954 vehicles/hour or 4983.8 pcu/hour, with a capacity (C) of 2421.78 pcu/hour, degree of saturation (DS) of 1,73 and an intersection delay of 9,59 sec/pcu with this intersection service level included in the LOS B category. The intersection performance at the Rawa Hingkik Simpang Tiga has a LOS B value, which means that improvements to traffic management are effective in reducing congestion. In calculating intersection capacity data in previous studies, where there was a calculation error in the equation for determining the proper turn ratio (FRT), incorrect intersection capacity results were obtained. This capacity's value is essential in determining the degree of saturation (DS).

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