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PERFORMANCE ANALYSIS OF SIGNALLED INTERSECTIONS ON MERANTI - SLAMET RIYADI ROAD, SAMARINDA CITY

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Abstract

Traffic bottlenecks are common in Samarinda, particularly during rush hour. This also occurred at the meranti road-slamet riyadi road crossing. Congestion at the Meranti Road-Slamet Riyadi Road crossroads is caused by numerous community activities like as educational institutions, stores, and services. So that events that produce congestion around the intersection occur during rush hours, causing delays in travel and community activities in the region. As a result, research is required to ascertain the operating parameters of the signalized crossings on Meranti Road and Slamet Riyadi Road in Samarinda City. Using MKJI 1997 and PTV Vissim methodologies, intersection performance analysis concluded. The highest degree of saturation value of 0.99 and the intersection delay of 35.32 seconds with service level D were found in the analysis results. In the meantime, service level C of Vissim's simulation yielded the highest delay of 27.67 seconds. Alternative 2, re-planning the signalized intersection geometry, is the recommended improvement alternative. As a result, the maximum degree of saturation is 0.82, and the average delay for all intersections is 20.14 seconds, with an intersection service level of C. According to the results of the intersection simulation using Vissim, the average intersection delay with service level B is 19.82 seconds.

Keywords: Intersection, Performance Analysis, PTV Vissim

INTRODUCTION

An intersection is a point where two roads come together. Because the crossroads is a spot where moving vehicles from different directions meet or change directions, various traffic barriers frequently occur at this point. Due to lower speed, greater delays, and vehicle queues, the intersection's poor performance will result in a variety of losses for road users, including increased vehicle operating expenses.

Samarinda city, like other cities in Indonesia, is plagued by transportation issues, one of which is the daily traffic jam. The crossroads is a frequent source of traffic congestion. Given the numerous community activities like as educational institutions, stores, and services, the three crossroads on meranti road - slamet riyadi road are particularly congested. During rush hour, traffic bottlenecks occur, causing delays in travel and community activities in the area.

As a result, the authors are interested in conducting research to identify the performance conditions of the three crossings on Meranti road - Slamet Riyadi road, Samarinda City, depending on the conditions that occur. Furthermore, it can identify appropriate alternative methods to improve the performance of the intersection.

LITERATURE REVIEW

Congestion

Munawar (2004) defined congestion as a circumstance or condition when there is excessive traffic, such as a traffic jam, due to the enormous number of cars. Large cities frequently experience congestion, particularly those without reliable or sufficient public transportation or where the requirement for highways is out of proportion to population density.

Intersection

According to Alamsyah (2008), "intersections are the most important part of the road network system, and the capacity of intersections can be controlled in general by controlling the volume of traffic in the road network system. An intersection is essentially a meeting point of two or more road networks."

Volumes of Traffic

Sukirman (1994) asserts that traffic volume depicts the quantity of cars passing through one observation location in a certain amount of time (days, hours, or minutes). The average daily traffic, planning hour volume, and capacity are the units of traffic volume that are frequently used in relation to establishing the number and width of lanes. The three different types of vehicles used in this calculation are as follows:

Light vehicles (LV), heavy vehicles (HV), and motorcycles (MC) are the three categories.

Signalized Intersection Performance

MKJI 1997 states that at signalized intersections, the flow of transport vehicles entering the intersection is alternatively structured to gain precedence by going first utilizing a traffic controller (traffic light). Capacity (C), degree of saturation (DS), and delay (D) are also performance parameters of signalized intersections.

MKJI 1997 measured the performance level of signalized junctions based on:

1. Que Length (QL)

   Que Length is The distance between the front of the leading vehicle and the back of the vehicle that is at the back of a queue due to traffic signals.

2. Number of stopped vehicles (NSV)

   The number of stopsped per vehicle is including repeated stops in the queue before passing through an intersection.

3. Delay (D)

   Delay is the amount of time it takes for the vehicle to move regularly. Delays at an intersection can be caused by two factors: traffic delays (DT) and geometry delays. (DG).

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Signal Phase

A phase is a set of conditions that are applied to one or more flows that have the same traffic light designation. A phase with a good number of phases is one with a high capacity and a low average delay (Munawar, 2004). At intersections with traffic lights, many traffic flows can gain the right of way at the same time, while other flows are stopped. The traffic light phase is the time when one or more movements are given the green signal at the same time (Khisty, 2005). Inter-phase settings are configured with interrupt/pause time intervals to ensure a smooth transition between phases.

Capacity (C) and Degree of Saturation (DS)

The capacity of a signalized intersection is the intersection's maximum ability to service vehicles uniformly within a given time interval. The capacity of a signalized junction approach can be computed as follows:

$$C = S \, x \, g/c = S \times GR \qquad \ldots\ldots\ldots\ldots\ldots\ldots \text{(2.1)}$$

Where:

C = capacity (pcu/hour)

S = saturation current (pcu/hour)

g = green time (s)

c = adjusted cycle time (s)

GR = green ratio = g/c

Degree of saturation (DS) is the ratio between the current (Q) and the capacity (C), calculated as:

$$DS = Q/C \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2.2)}$$

Where:

Q = traffic flow (pcu/hour)

C = capacity (pcu/hour)

Level of Service

The level of signalized junction service is a measure of signalized intersection traffic performance that ranges from A (highest) to F (lowest) based on the intersection's average delay value per vehicle. Table 1 depicts the association between delays and service levels.

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Table 1: Level of Service

Level Of Service	Delay (Second)
A	≤ 5
B	5.1-15
C	15.1-25
D	25.1-40
E	40.1-60
F	≥ 60.1

PTV VISSIM Software

The Vissim software, according to Hutahaean (2021), is a simulation software used for traffic engineering, transportation planning, signal timing, and microscopic urban planning in multi-modal traffic flow that was visually translated and developed in 1992 by PTV Planning Transport Verkehr AG (PTV) in Karlshure, Germany.

Vissim Calibration and Validation

In Vissim, calibration is the process of establishing the proper parameter values so that the model can reproduce traffic under as comparable of conditions as feasible. By using prior research on calibration and validation using Vissim, the calibration procedure can be carried out depending on driving behavior.

By contrasting the outcomes of observations and simulations, validation on Vissim is a procedure for determining whether calibration is accurate. There are various parameters in the Vissim program that can be calibrated. Trial and error calibration was used to provide findings that were near to the observation data. The driver's behavior parameter value is altered in accordance with the assumed field conditions that apply. On the basis of the volume of traffic flows and traffic delays produced by a road network, the calibration and validation processes are carried out. Table 2 lists the parameters that were used for the calibration procedure.

Table 2. Calibration Parameters

Trial	Parameter	Before	After
Trial 1	*Desired position at free flow*	-	*midle*
	Overtake	-	*off*
Trial 2	*Desired position at free flow*	*midle*	*any*
	Overtake	*off*	*on*
Trial 3	*Average standstill distance*	0.5	0.6
Trial 4	*Additive part of safety distance*	2	1
	Multiplicative part of safety distance	3	2
Trial 5	*Additive part of safety distance*	1	0.8
	Multiplicative part of safety distance	2	1.5
Trial 6	*Multiplicative part of safety distance*	1.5	1

The optimum way for comparing input and output data, according to Gusavsson (2007), is to employ static Geoffrey E. Havers. (GEH). GEH is a Chi-squared modified statistical formula that combines the difference between relative and absolute values. Table 3 shows how the following GEH formula makes particular accommodations for the resulting error values.

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Table 3: Conclusion of GEH Calculation Results

GEH value	Conclusion
GEH<5.0	Accepted
5.0 ≤GEH ≤ 10	Possible bad model or bad data
GEH>10	Rejected

$$GEH = \sqrt{(q.simulation - q.observed)^2\ 0{,}5\ x\ (q.simulation5q.observed)} \ldots\ldots (2.3)$$

Information:

q: data on vehicle traffic volume (vehicles/hour)

Research Flowchart

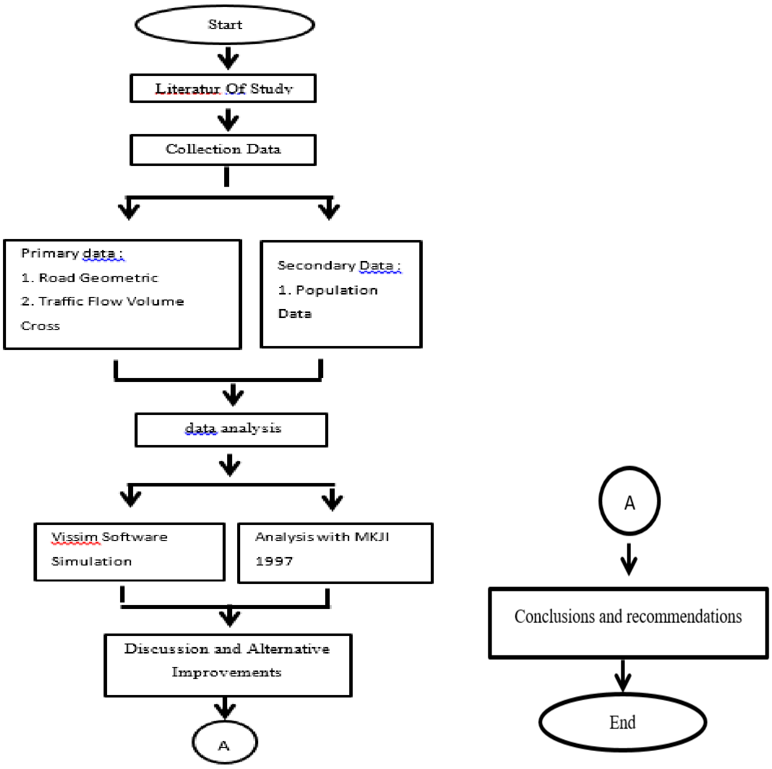

Figure 1: Research Flowchart

Data Analysis Techniques

Primary data from field results are utilized as material for calculations based on the 1997 Indonesian Road Capacity Manual. These computations' results will be used to assess performance at signalized junctions to be reviewed, such as capacity (C), degree of saturation (DS), and delay. (D). Following an analysis of the intersection's performance, a traffic simulation is performed using the vissim tool. When running a simulation using the vissim application, certain parameters must be selected and inputted in order for the simulation to operate. The following parameters must be determined and entered:

1. Provide background information in the form of a map of the location of the road to be researched.
2. Use the link option to create a road network.
3. Determine the vehicle type in 2D/3D models, then add and modify vehicle types in Vehicle Types and Vehicle Classes.
4. Input the speed of each vehicle on the Desired Speed Distribution
5. Inputting traffic volume on Vehicle Inputs
6. Plan travel routes based on Static Vehicle Routing Decisions
7. Input the vehicle composition in Vehicle Compositions
8. Plan and install traffic signals at signalized intersections.
9. Set conflict areas on the Conflict Areas menu
10. Set the parameter value of the driver's behavior in driving behavior
11. Calibration and validation should be done using the trial and error method to obtain results that are near to the observation data.
12. Run the simulation

RESULT AND ANALYSIS

Total population

According to the Central Bureau of Statistics for the City of Samarinda, the city's population in 2020 will be 827,994 people. According to the Official Statistical News of the Results of the 2020 Population Census of Samarinda City, page 1, the population growth rate in Samarinda was 1.26% each year from 2010 to 2020. The following equation can be used to project Samarinda City's population for the coming year.

$P(t) = Po(1+i)^t$

$P(t) = 827.994 \text{ x } (1 + 1.26\%)^2$

$= 848.991$ Person

Where:

i = growth rate (%)

P t = amount of data for year t

P o = amount of data for the initial year

t = period between the initial year and year t (in years)

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Using the above equation and demographic estimates for 2020, Samarinda City's anticipated population in 2022 is 848.991 person.

Geometric Data and Intersection Environment

The geometric data for the intersection was gathered through direct observation and measurement at the research site, namely the intersection of Jalan Slamet Riyadi and Jalan Meranti. The table below shows the findings of geometric and environmental observations and measurements.

Table 4: Geometric and Environmental Data of the Intersection

Approach	Environment	Side Barriers	Median	Direct Left Turn	Approach Width		
					WA	WM	WK
North	Commercial	Low	Yes	No	9.8	3.55	6.95
South	Commercial	Low	Yes	No	6.95	6.95	9.8
West	Commercial	Medium	NO	No	8.5	4.25	4.25

Composition of Signalized Intersection Traffic Flow at Peak Hours

Composition of Signalized Intersection Traffic Flow at Peak Hours, Presented in the following table:

Table 5: Composition of Traffic Flow and Signalized Intersections

Road	Direction	MC	LV	HV	UM
Meranti (West)	LT	133	37	1	6
	RT	575	178	10	2
Slamet Riyadi (South)	LT	330	106	7	0
	ST	2587	994	47	7
Slamet Riyadi (North)	RT	880	181	9	0
	ST	3417	1365	65	5

Analysis with MKJI 1997 and Vissim

Analysis of Existing Signalized Intersection Conditions with MKJI 1997, Presented in the following table:

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Table 6: Cycle Time

Code	Phase	Light On Time				Cycle Time
		Red	Yellow	All Red	Green	
North	1	91	3	2	23	119
South	2	50	3	1	65	119
West	3	97	3	2	17	119

The intersection's performance was evaluated under current conditions during peak hours (16.00 - 17.00 WITA). Table 8 shows the findings of the analysis.

Table 7: Performance of Existing Signalized Intersections

Approach	Capacity (pcu/hour)	DS	Queue Lengh (m)	Delay (sec/pcu)	Level Of Servive
North	379	0.97	147.9	122.0	D
South	1967	0.89	200.6	33.7	
West	373	0.99	135.1	142.8	
			Average	35.32	

Analysis of Existing Signalized Intersection Conditions with Vissim Simulation

Analysis of Existing Signalized Intersection Conditions with Vissim Simulation, Presented in the following table:

Table 8: Simulation of Existing Signalized Intersections

Intersection Approach	Direction	Queue Length (m)	Delay (Second)	Level Of Service
Meranti (West)	LT	191.669741	260.4509	F
	RT	128.823675	260.4509	F
Slamet Riyadi (South)	LT	24.97971	205.4302	C
	ST	27.567376	205.4302	C
Slamet Riyadi (North)	ST	10.016748	188.2071	B
	RT	78.872957	188.2071	E
Intersection		**27.66679**	**260.451**	**C**

MKJI 1997 and PTV Vissim computations were used to analyze the performance of existing junctions. The highest degree of saturation value obtained from the analysis was 0.99 (exceeding the safe value of DS of 0.85), and the intersection delay was 35.32 seconds with service level D. Meanwhile, the simulation results provided by Vissim yielded the maximum delay of 27.67 seconds with service level C.

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This implies that the performance of the three intersections on Slamet Riyadi road - Meranti road is poor, and repairs are actually recommended.

Repair Alternatives

The researchers made two alternative improvements to be reviewed in order to improve the performance of the slamet riyadi road - meranti road intersection in serving the traffic flow that passes through it, namely:

1. Planning for changing the signal time phase according to the 1997 Indonesian Highway Capacity Manual.
2. Changing the geometric intersection at the intersection of Slamet Riyadi road and Meranti road, as well as signal timing, in accordance with the 1997 Indonesian Road Capacity Manual, to improve the performance of signalized intersections.

Alternative Repair 1

Analysis of Alternative Signalized Intersection Conditions Repair 1 with MKJI 1997, Presented in the following table:

Table 9: Alternative Repair Cycle Time 1

Code	Phase	Light On Time				Cycle Time
		Red	Yellow	All Red	Green	
North	1	76	3	2	20	101
South	2	45	3	1	52	101
West	3	81	3	2	15	101

Table 10: Performance of Improved Alternative Intersection 1

Approach	Capacity (pcu/hour)	DS	Queue Lengh (m)	Delay (sec/pcu)	Level Of Servive
North	388	0.95	124.5	97.7	D
South	1854	0.95	204.9	42.1	
West	388	0.96	105.9	103.2	
			Average	33.4	

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Analysis of Signalized Intersection Conditions for Improvement Alternative 1 with Vissim Simulation

Analysis of Signalized Intersection Conditions for Improvement Alternative 1 with Vissim Simulation, Presented in the following table:

Table 11: Vissim Simulation of Improvement Alternative Intersections 1

Intersection Approach	Direction	Queue Length (m)	Delay (Second)	Level Of Service
Meranti (West)	LT	262.655767	122.9706	LOS_F
	RT	262.655767	24.75955	LOS_F
Slamet Riyadi (South)	LT	137.054272	20.64771	LOS_C
	ST	137.054272	21.26389	LOS_C
Slamet Riyadi (North)	ST	168.769768	9.624503	LOS_A
	RT	168.769768	77.6665	LOS_E
Intersection		**262.65577**	**24.7596**	**LOS_C**

MKJI 1997 and PTV Vissim calculations were used to analyze the performance of the intersection conditions of Alternative repair 1. The highest degree of saturation value obtained from the analysis was 0.96 (exceeding the safe value of DS of 0.85), and the intersection delay with service level D was 33.40 seconds. Meanwhile, for the simulation results using Vissim, the longest delay was recorded of 24.76 seconds with service level C.

This implies that the three crossings on Slamet Riyadi Road - Meranti Road perform poorly, and it is actually recommended to enhance the geometric intersection.

Alternative Repair 2

Geometric Signalized Intersection Repair Alternative 2, Presented in the following table:

Table 12: Geometric Intersection Alternative 2

Approach	Environment	Side Barriers	Median	Direct Left Turn	Approach Width		
					WA	WM	WK
North	Commercial	Low	Yes	No	11	4.25	7.5
South	Commercial	Low	Yes	No	7.5	7.5	10
West	Commercial	Medium	NO	No	10	5.75	4.25

Analysis of Alternative Signalized Intersection Conditions Repair 2 with MKJI 1997

Analysis of Alternative Signalized Intersection Conditions Repair 2 with MKJI 1997, Presented in the following table:

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Table 13: Alternative Repair Cycle Time 2

Code	Phase	Light On Time				Cycle Time
		Red	Yellow	All Red	Green	
North	1	78	3	1	20	102
South	2	42	3	1	56	102
West	3	84	3	2	13	102

Table 14: Performance of Improved Alternative Intersection 2

Approach	Capacity (pcu/hour)	DS	Queue Lengh (m)	Delay (sec/pcu)	Level Of Servive
North	460	0.8	78.6	54.6	C
South	2134	0.82	144.4	25.0	
West	450	0.82	60.5	61.5	
			Average	**20.14**	

Analysis of Signalized Intersection Conditions for Improvement Alternative 2 with Vissim Simulation

Analysis of Signalized Intersection Conditions for Improvement Alternative 2 with Vissim Simulation, Presented in the following table:

Table 15: Vissim Simulation of Improvement Alternative Intersections 2

Intersection Approach	Direction	Queue Length (m)	Delay (Second)	Level Of Service
Meranti (West)	LT	125.380947	7.924847	LOS_A
	RT	125.380947	45.2285	LOS_D
Slamet Riyadi (South)	LT	131.019384	168.8509	LOS_F
	ST	131.019384	124.0214	LOS_F
Slamet Riyadi (North)	ST	104.763086	15.14399	LOS_B
	RT	104.763086	15.92636	LOS_B
Intersection		**131.01938**	**19.8206**	**LOS_B**

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An examination of the intersection condition's performance MKJI 1997 and PTV Vissim calculations were used for alternative repair 2. According to the analysis results, the highest degree of saturation value is 0.82 (not exceeding the safe value of DS, which is 0.85), and the intersection delay with service level C is 20.14 seconds. According to the Vissim simulation results, the longest delay is 19.82 seconds with service level B.

It is recommended in enhancement alternative 2 to improve the performance of the signalized intersection of Slamet Riyadi Road - Meranti Road geometric intersection.

Intersection Improvement Condition Performance Comparison

The value of the intersection performance parameters is obtained as a reference in developing alternative improvements that can be selected as recommendations for intersection repairs based on the results of the analysis of two alternative improvements at the intersection. Table 16 and Figure 2 show a comparison of intersection performance in current and repaired situations using MKJI 1997 and Vissim based on the delay value.

Table 16: Comparison of Intersection Delays

Condition	MKJI		Vissim	
	Delay (sec/pcu)	Level Of Service	Delay (sec/pcu)	Level Of Service
Exist	35.2	D	27.67	LOS_C
Alternative 1	33.4	D	24.76	LOS_C
Alternative 2	20.14	C	19.82	LOS_B

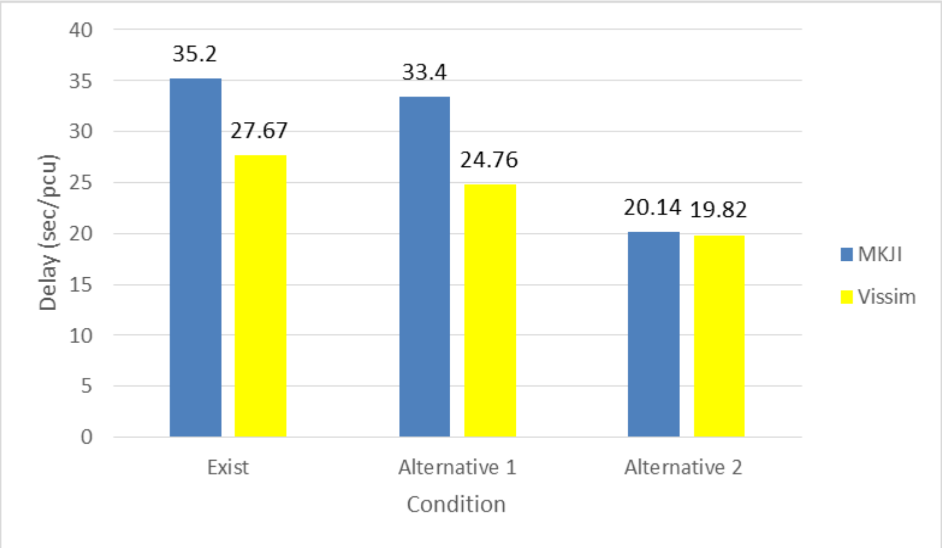

Figure 2: Comparison of Intersection Delays

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CONCLUSION

The following conclusions can be obtained based on the results of the performance analysis of the intersection meranti road - slamet riyadi road in Samarinda City: 1) The highest volume of traffic flow during peak hours occurs on Wednesday, 13 July 2022 at 16.00-17.00 with a volume of 4626.1 pcu/hour, on Saturday, 16 July 2022 peak hours occur at 16.00-17.00 with a volume of 4329 smp/hour, on Monday, 18 July 2022 peak hours occur at 16.30-17.30 with a volume of 4590.2 pcu/hour, and on Sunday, 24 July 2022 peak hours occur at 16.15-17.15 with a volume of 3993.7 pcu /hour; 2) Analysis of the performance of the intersection of Slamet riyadi Road - Ir. Meranti Road in the existing conditions revealed poor results, with a capacity of 379 pcu/hour with a saturation degree of 0.97 in the north approach, 1967 pcu/hour with a saturation degree of 0.89 in the south approach, and 373 pcu/hour with a saturation degree of 0.99 in the west approach. As a result, with service level D, the intersection delay is 35.32 seconds/pcu. While used Vissim to simulate the signalized intersection of Slamet Riyadi Road - Meranti Road, the highest queue length was obtained at the northern approach of 260.45 m, the southern approach of 188.20 m, and the west approach of 205.43 m. With the level of service C, the average delay at the intersection is 27.67 seconds; and 3) Alternative 2 is the recommended improvement choice, which is to re-plan the signalized intersection geometry; the degree of saturation value reached at the intersection is 0.82. The degree of saturation value does not exceed the safe level of saturation advised by MKJI 1997, which is 0.85. Because the junction delay value is 20.14 seconds/pcu, the service level of intersection C is. The simulation modeling of the signalized intersection of Slamet Riyadi Road - Meranti Road in the existing conditions using Vissim resulted an intersection delay of 19.82 seconds with a level of service B.

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