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PERFORMANCE OF THREE ARMS SIGNALIZED INTERSECTION AT SALABENDA IN BOGOR REGENCY

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ABSTRACT

The increase in urban transportation in the 2000s era was very high. The use of motorized vehicles during the pandemic has decreased slightly with the government's ban on traveling out of town, including the 2020 homecoming and 2021 homecoming. Most people who travel are in the city center, including the city of Bogor and Bogor district. The travel patterns are very diverse, but most use public transportation and private transportation in addition to freight transportation with a fairly high intensity, especially at night. The purpose of this study was to obtain the LoS value at the signalized intersection of the three arms of the Salabenda intersection. The three-arm Salabenda intersection is the border between Bogor regency and the city of Bogor, so this intersection is one of the busiest and most densely populated intersections beside the Ciawi intersection in the north. The Salabenda intersection has become more congested with the opening of the Section IIIA Toll Road so that the traffic load shifts from Jl. KH. Sholeh Iskandar to this toll road, so that the intersection will have a higher traffic intensity. From the three observations and data collection in the field, it can be seen that in the afternoon it has a very high LoS, namely E. Followed by a LoS D level in the afternoon and in the morning LoS is still in the form of C. So it is still safe to use in the morning with a recommended level. The LoS E condition is a condition where the intersection has a degree of saturation of 0.926, which is almost close to 1, exacerbated by high side resistance activity.

Keywords: signalized intersection; salabenda intersection; LoS; degree of saturation; capacity.

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INTRODUCTION

The urban transportation system in the early 2000s was very high. The spread of the journey of people and goods increases every year. The pandemic period at the beginning of 2020 more or less affected the population's travel patterns. However, this effect is not too significant when compared to the need to work and do business who always use a motorized vehicle. The use of motorized vehicles during the pandemic has decreased slightly with the government's ban on traveling out of town, including the 2020 homecoming and 2021 homecoming. Most people who travel are in the city center, including the city of Bogor and Bogor district. The travel patterns are very diverse, but most use public transportation and private transportation in addition to freight transportation with a fairly high intensity, especially at night. Geographically, the location of the city of Bogor and Bogor district is very strategic because it is close to DKI Jakarta, Bogor also acts as a buffer for Jakarta-Banten considering its role as a buffer, causing the main roads in this area to always be crowded with vehicles, both local residents and vehicles from outside. area.

Regional development is based on the concept of structuring activities and economic centers as an attraction for population movements in meeting their needs. The development of a well-controlled area is able to accommodate all the economic needs of the community, including transportation planning, economic development, urban planning and other integrated road accessibility (Ahmad HSP, et al, 2018; Akito K, et al, 2019; Ditha M, et al, 2020).

Transportation cannot be separated from motorized vehicles, road and bridge infrastructure and other supporting facilities. The concept of planning and improving roads, for example, it is necessary to repair both roads with road maintenance so that they are not damaged and are good for motorized vehicles. The geometry is not problematic and periodic maintenance is carried out every month to increase driving comfort. Road improvements support smooth transportation from the area of origin to urban areas or vice versa with structured and planned maintenance (Akhmad HFA, et al, 2015; Ihwan F & Eri SH, 2018; Saputro S & Eri SH, 2015).

The development of an increase in the economy is the attraction of the community to one or more objects of activity such as recreation areas, malls, places where large numbers of people gather will affect the pattern of travel using the mode of transportation. The pattern of travel of the population in the economic sector to improve the economy of both residents and motor vehicle operators.

Land transportation users who affect the real sector try to increase their roles and activities in each activity (Reno CDO, et al, 2020; Rustiadi E, 2001).

The concept of regional development based on spatial planning, by dividing the region into three types, namely growth centers, functional integration and decentralization. The concept of a growth center emphasizes the need to invest heavily in a growth center or region/city that already has good infrastructure. The development of the area around the growth center is expected to go through a trickle down effect. The concept of functional integration prioritizes integration that is created intentionally between various growth centers because of complementary functions. This concept places a city or region in a hierarchy as a service center relative to other cities or regions. The concept of decentralization is intended to prevent the outflow of funds and human resources (Rustiadi E & Junaidi J, 2011).

The concept of traffic engineering and transportation systems has been widely carried out in Indonesia. Traffic engineering is concerned with meeting the demands of using public roads for driving. Transportation system links are closely related to vehicle regulation in terms of traffic management (Hobbs, FD, 1995; Ofyar ZT, 2000). The purpose of this study was to obtain the LoS value at the signalized intersection of the three arms of the Salabenda intersection.

The types of intersections vary from simple intersections which only consist of the confluence of two roads to complex intersections which consist of the confluence of several roads. The arrangement of intersections also varies, there are intersections that do not use the Traffic Signaling Tool (APILL) or also called unsignalized intersections, there are also intersections that are equipped with regulations using traffic lights. At intersections that use traffic light settings or signalized intersections, the flow and movement of vehicles is regulated by time controls that are arranged in isolation (M. Abdurrahman and Sukarno, 2018; Sofyan S, et al, 2014; Sony W and Rukman, 2019).

Transportation services, both passenger and freight transportation modes, affect the geometric condition of the road. Geometric roads and intersections that are not signaled will affect the length of the trip, the condition of the motor vehicle engine and the condition of the driver. The highway as motorized traffic is made so that drivers obey the rules on the highway. Keep each other's speed between one vehicle to another. So that the order in the road will be created (Juang A, et al, 2020; Syaiful S and Sri WM, 2019; Syaiful S and Yogi P, 2019; Syaiful S and Lasmana L, 2020; Syaiful S and Rendy A, 2021).

Travel in one route can be done if the traffic conditions are not too heavy. So that traffic flows smoothly without obstacles, especially at intersections. The influence of traffic flow is strongly supported by good road conditions and no damage (Syaiful S, Irbah AF, 2021; Syaiful S, et.al, 2021; Syaiful S, 2021).

Road capacity is the maximum flow of vehicles that pass through the road, under certain conditions. This depends on the number and width of traffic lanes and the number of disturbances to traffic flow. Ideal capacity conditions are determined, among others:

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a. Smooth, uninterrupted traffic flow, free from disturbances of vehicles and pedestrians,
b. Only passenger cars are there,
c. The standard width of the traffic lane is 3.65 meters,
d. There is no barrier to overtaking visibility.

The method of conducting the survey is by taking an inventory of the intersection locations for;

a. Knowing and identifying the research location, especially the intersection location/APILL and collecting field data as a complement to the secondary data that has been obtained,
b. It makes it easier to calculate the intersection capacity because for the inventory survey, measurements are made of the road geometry to obtain quantities as input data in the calculation of the intersection capacity.

Classified traffic volume survey at intersections

The survey conducted to enumerate the classified traffic volume at the intersection is carried out with the aim of collecting traffic volume data as a parameter of the intersection performance assessment process. It is necessary to enumerate the traffic volume at the intersection using a classified turning movement counting technique. The division of vehicle classification as follows:

a. Motorcycles, which include vehicles with 2 (two) or 3 (three) wheels, which include motorcycles and 3 (three) wheeled vehicles.
b. Light vehicles, which include motorized vehicles with 2 (two) axles with 4 (four) wheels and an axle distance of 2.0 – 3.0 meters, include passenger cars, oplets, microbuses, pick-ups and small trucks.
c. Heavy vehicles, which include motorized vehicles with more than 4 (four) wheels, which include buses, 2 axles trucks, 3 axles trucks, and combination trucks.

The traffic volume survey at the intersection is carried out for 1 (one) month during peak hours. This is done to determine the most optimal traffic light operating time interval. Traffic volume enumeration is carried out in a period of 15 minutes.

Passenger Car Unit (junior high school)

Road capacity is the maximum number of vehicles that can be accommodated by a road segment at a certain time period based on the geometry, pattern and composition of traffic flow/volume and factors around the road. The amount of conversion value for converting vehicle data into passenger car units (junior high school), Ministry of Public Works (1997). The conversion value of passenger car units (pcu) for roads and intersections is as shown in table 1 below.

Table 1. Passenger Car Unit for road sections

Type of vehicle	Conversion value (smp)
Light vehicle	1,00
Heavy vehicle	1,20
Motorcycle	0,25
Non-motorized vehicles	0,80

Departemen Pekerjaan Umum (1997)

Calculation of road capacity

According to the Ministry of Public Works (1997), the capacity of roads for inner-city roads is formulated as follows:

C = Co x Fw x Fks x Fsp x Fsf x Fcs

Where;

Co = base capacity

Fw = width of road benefit

Fks = shoulder of the road

Fsp = median

Fsf = friction factor

Fcs = total population of the city

Road service level (Level of Service = LoS)

Road sections can be assessed by knowing the level of service provided in the guidelines and based on the range of values for the V/C ratio of the roads shown in table 2 below.

Table 2. Road Service Level (Level of Service)

Level of Service	Charakteristics	V/C limit ratio
A	a. Free flow with low traffic volume and high speed b. Very low traffic density with driver controllable speed based on maximum/minimum speed limits and road physical conditions, c. The driver can maintain his desired speed with little or no action.	0,00-0,20
B	a. Stable flow with moderate traffic volume and speed is easily limited by traffic conditions, b. Low traffic density traffic internal barriers have not affected the speed, c. The driver still has enough freedom to choose his desired speed and lane of the road.	0,20-0,44
C	a. Steady flow but vehicle speed and movement controlled by higher traffic volume, b. Moderate traffic density due to increased traffic internal drag, c. Drivers have limitations to choose the speed of changing lanes or overtaking.	0,45-0,74
D	a. The flow is approaching unstable with high traffic volume and speed is still tolerable but is very affected by changes in flow conditions, b. Moderate traffic density but fluctuations in traffic volume and temporary obstacles can cause large speed drops, c. The driver has very limited freedom in running the vehicle, comfort is low, but this condition can still be tolerated for a short time.	0,75-0,84
E	a. Flow is lower than service level D with traffic volume approaching road capacity and very low speed, b. High traffic density due to high traffic internal drag, c. Drivers start to feel traffic jams of short duration.	0,85-1,00
F	a. The flow is blocked and there is a long queue of vehicles, b. Very high traffic density and low volume and congestion for quite a long duration, c. In the queuing state, both speed and volume drop to 0.	> 1.00

Permenhub, (2006).

The indicators used in evaluating the performance of the APILL junction (Traffic Light) are:

Saturated current (S)

The saturation current (S) is expressed as the product of the basic saturation current (So) i.e. the saturation current at standard conditions, with an adjustment factor (F) for deviations from the actual conditions, from a set of predetermined ideal conditions.

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S = So x F1 x F2 x F3 x F4 x …..x Fn

While the basic saturation current is determined as a function of the effective approach width (We).

So = 600 x We

Further adjustments are made under the following conditions.

CS = city size in population

SF = side resistance class side resistance from the road environment and motorized vehicles.

G = slope in % up (+) or down (-)

P = parking, stopping line distance – first parked vehicle

RT = turning movement RT, % turn right LT, % turn left

The basic saturation flow is determined as a function of the effective width of the approach (We) and the right-turning traffic flow on that and on the opposite approach, because the influence of these factors is not linear. Then adjustments were made to the actual conditions, with respect to the size of the city, side barriers, slopes, and parking.

The adjustment factors use the provisions (Ministry of Public Works, 1997), while the city size adjustment factors (FCs) are shown in table 3 below.

Table 3. City size adjustment factors (FCs)

Population (million people)	**FcS**
> 3,00	1.05
1,00 - 3,00	1.00
0,5 - 1,00	0.94
0,1 - 0,5	0.83
< 0,1	0.82

For the adjustment factor for side resistance (FSf) using the standard at the Ministry of Public Works (1997) as follows.

Table 4. Side resistance adjustment factor (FSf)

Environment street	**Side obstacle**	**Fase type**	**Ratio for non-motorized vehicles**					
			0.00	0.05	0.10	0.15	0.20	0.25
Commercials (COM)	High	O	0.93	0.88	0.84	0.79	0.74	0.70
	High	P	0.93	0.91	0.88	0.87	0.85	0.81
	Medium	O	0.94	0.89	0.85	0.80	0.75	0.71
	Medium	P	0.94	0.92	0.89	0.88	0.86	0.82
	Low	O	0.95	0.90	0.86	0.81	0.76	0.72
	Low	P	0.95	0.93	0.90	0.89	0.87	0.83
Residence (RES)	High	O	0.96	0.91	0.86	0.81	0.78	0.72
	High	P	0.96	0.94	0.92	0.89	0.86	0.84
	Medium	O	0.97	0.92	0.87	0.82	0.79	0.73
	Medium	P	0.97	0.95	0.93	0.90	0.87	0.85
	Low	O	0.98	0.93	0.88	0.83	0.78	0.74

	Low	P	0.98	0.96	0.94	0.91	0.80	0.86
Access	High/medium/low	O	1.00	0.95	0.90	0.85	0.88	0.75
Limited (RA)	High/medium/low	P	1.00	0.98	0.95	0.93	0.90	0.88

Ministry of Public Works, 1997.

The slope adjustment factor (FG) uses the value according to the slope adjustment factor graph in Figure 1 below.

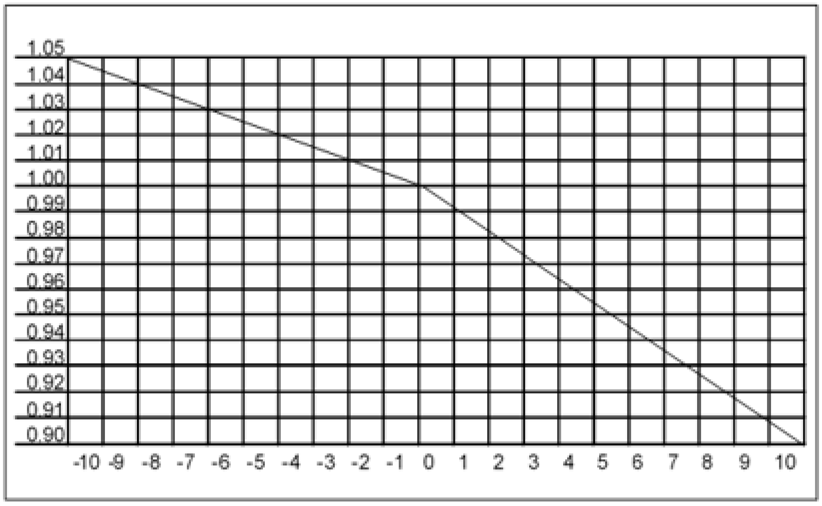

Figure 1. Graph of slope adjustment factor (FG). Source: MKJI, 1997

Left turn adjustment factor (FLT)

The left turn adjustment factor (FLT) can be found using the formula:

FLT = 1 - PLT x 0.16

Where;

PLT = the ratio between the number of motorized vehicles turning left and the total number of motorized vehicles passing through the intersection approach.

Right turn adjustment factor (FRT)

The right turn adjustment factor can be found using the formula.

FRT = 1 + PRT x 0.26

Where;

PRT = ratio between the number of motorized vehicles turning right and the total number of motorized vehicles passing the approach

Parking adjustment factor (FP)

The parking adjustment factor can be found using the formula

FP = [LP/3 – (WA – 2) x (Lp/3 – g)/WA]/g

Where;

FP = distance between the stop line and the first parked vehicle(m)

WA = approach width (m)

g = green time on approach (normal value 26 seconds)

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Cycle time (c)

In determining the cycle time in conditions with constant control, it is carried out based on the Webster method (1966) to minimize the total delay at an intersection.

c = (1.5 x LTI + 5) / (1 - FRcrit)

Where;

c = signal cycle time (seconds)

LTI = amount of lost time per cycle (seconds)

FR = current divided by saturation current (Q/S)

FR_{crit} = the highest FR value of all departing approaches in a signal phase

(FR_{crit}) = current ratio simpan

The cycle time is less than this value, so there is a serious risk of oversaturation at the intersection. Cycle times that are too long will cause the average delay to increase. If the value of (FR_{crit}) is close to or more than 1 then the intersection is supersaturated and the formula will result in a very high or negative cycle time.

Green time (gi)

The performance of a signalized intersection is generally more sensitive to errors in green time distribution than to too long cycle times.

Gi = (c – LTI) x FR_{crit} / (FR_{crit})

Where;

g = green time display in phase i (seconds)

Capacity (C)

The capacity of the signalized intersection approach can be expressed as follows.

C = S x g/c

Where;

C = capacity (pcu/hour)

S = saturated current (pcu/hour green)

g = green time (seconds)

c = cycle time (seconds)

Degree of saturation (DS)

The degree of saturation is obtained from the equation below.

DS = Q/C

Where;

Q = traffic flow on approach

C = crossing capacity

Queue (NQ)

The average number of smp queues at the start of the green signal (NQ) is calculated as the number of smps remaining from the previous green phase (N_{Q1}) plus the number of smps arriving during the red phase (N_{Q2})

NQ = N_{Q1} + N_{Q2}

Where;

N_{Q1} = 0.25 x C x [(DS – 1) + (DS – 1)2 + 8 x (DS – 0.5)/C]

If DS > 0.5; other than that N_{Q1} = 0

N_{Q1} = c x [(1– GR/1 – GR x DS)] x [Q/3600]

Where;

N_{Q1} = number of junior high schools left behind from the previous green phase

N_{Q2} = number of junior high school students who came during the red phase

DS = degree of saturation

GR = green ratio

c = cycle time (seconds)

C = capacity (pcu/hour) = saturation current times green ratio (S x GR)

Q = traffic flow on that approach

Queue length (QL) is obtained by multiplying (NQ) with the average area used per junior high school (20m^2) and dividing by the entry width.

$$Q_L = NQ_{MAX} \times \frac{20}{W_{IN}}$$

Where;

Q_L = queue length

NQ_{MAX} = product of NQ with the average area used

W_{IN} = entry width

Stopping rate (NS)

That is the average number of stops a vehicle (including repeated stops in the queue) before passing through a queue, is calculated as follows:

NS = 0.9 x [(NQ/Qxc))] x 3600

Where;

NS = stop number

NQ = average number of junior high school queues at the beginning of the green signal

Q = traffic flow on that approach

c = cycle time (seconds)

Number of vehicles stopped (NSV)

To calculate the number of vehicles stopped, the formula is used:

NSV = NS x Q

Where;

NSV = number of vehicles stopped

NS = stop number

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Q = total volume of each approach

Stopped vehicle ratio (PSV)

That is, the ratio of vehicles that must be stopped due to a red signal before passing an intersection, is calculated as:

PSV = min(NS, 1)

Where;

NS = is the stop number of an approach.

Delay (D = Delay)

Delays at an intersection can occur for two reasons:

a. Traffic delay (DT) due to traffic interaction with other Movements at an intersection

b. Geometrical delay (DG) due to deceleration and acceleration when turning at an intersection and/or stopped at a red light.

The average delay for an approximation j is calculated as:

Dj = DTj + DGj

Where;

Dj = average delay for approach j (sec/pcu)

DTj = average traffic delay for approach j (sec/pcu)

DGj = mean geometric delay for approach j (sec/pcu)

The average traffic delay on an approach j can be determined from the following formula:

$$DT = c \times \frac{0{,}5 \times (1 - GR)^2}{(1 - GR \times DS)} + \frac{NQ1 \times 3600}{C}$$

Where;

DTj = average traffic delay on approach j (sec/pcu)

GR = green ratio (g/c)

DS = degree of saturation

C = capacity (pcu/hour)

NQ1 = number of junior high schools left behind from the previous green phase.

The mean geometric delay in an approximation j can be determined from the following formula:

DGj = (1 – Psv) x PT x 6 + (Psv x 4)

Where;

DGj = mean geometric delay on approach j (sec/pcu)

PSV = ratio of vehicles stopped on an approach

PT = ratio of vehicles turning on an approach

The normal value of 6 seconds for vehicles turning non-stop and 4 seconds for those stopping is based on the assumptions: 1) speed = 40 km/hour; 20 non-stop turning speed = 10 km/h 3) acceleration and deceleration = 1.5 m/s2 4) the vehicle stops slowing down to minimize delay so that it only causes acceleration delay (Ministry of Public Works, 1997; Suwardjoko PW, 2002).

RESEARCH METHOD

The research was conducted at the Salabenda three-arm signaled intersection in Kemang District, Bogor Regency. This intersection started to get busy after the opening of the Yasmin-Semplak Section IIIA Toll road opened in early 2021. The Salabenda intersection underwent a very fast existing change and from early 2020 it was still under repair, so the performance of the intersection was not too heavy. With the operation of the Section IIIA Toll Road, the performance of the intersection has changed and is very congested. The following shows the condition of the intersection in Figure 2, and Figure 3 illustrates a signalized intersection and Figure 3 shows a research flow chart for this intersection.

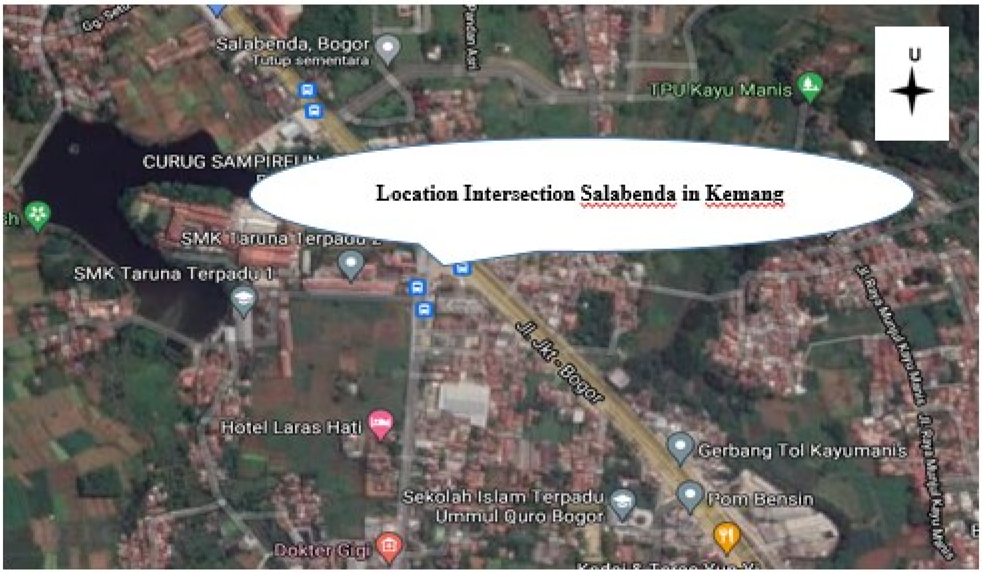

Figure 2. The research location of the three-arm signalized intersection Salabenda intersection

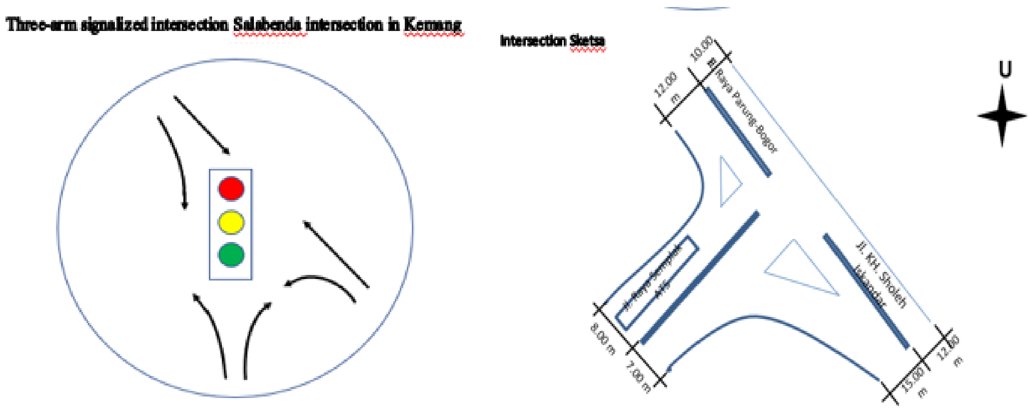

Figure 3. The three-arm signaled intersection of Salabenda and the sketch of the Salabenda intersection

Signaled/APILL intersection performance Kinerja

In analyzing the performance of the APILL (traffic light) intersection, this study carried out the stages of the study as shown in the flow chart in Figure 4 below.

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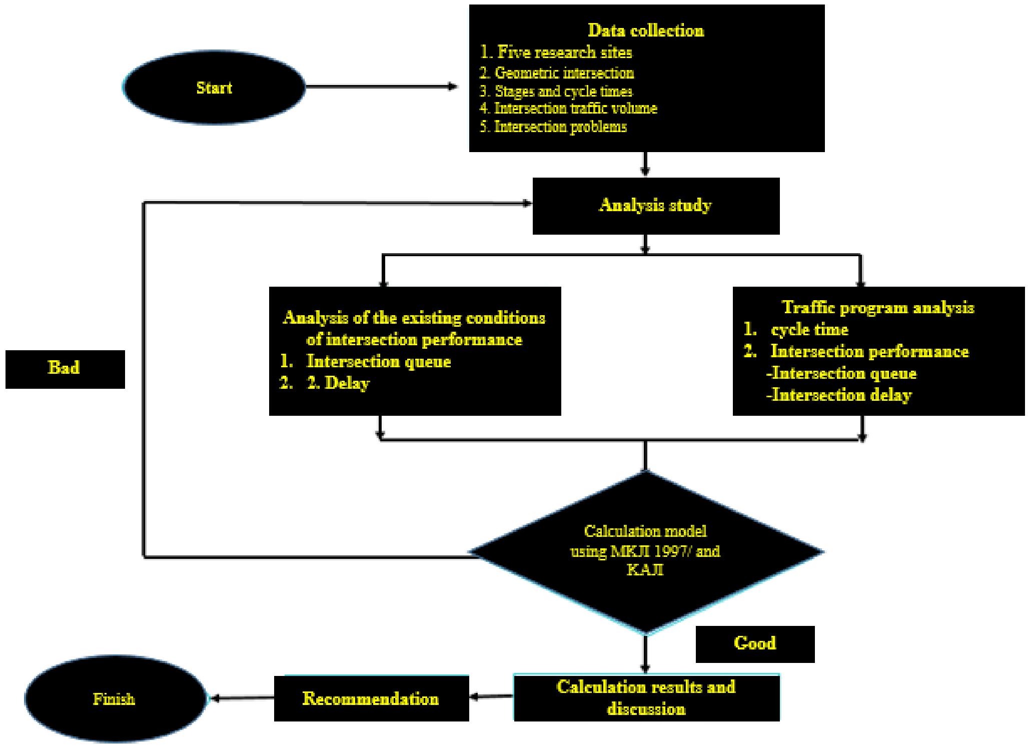

Figure 4. Flowchart of intersection performance evaluation

RESULTS AND DISCUSSION

There are three arms in the assessment of the analysis of intersection performance, namely;

North : Arm Jl Raya Parung-Jl. KH. Sholeh Iskandar

South : Arm Jl. KH. Sholeh Iskandar-Jl. Raya Parung

West : Arm Jl. Raya Semplak-ATS

The volume of LV, HV, MC and UM motor vehicles in the direction of Parung-Jl. KH. Sholeh Iskandar and the direction of Jl. KH. Sholeh Iskandar-Parung. The calculation period for the afternoon peak hour is shown in table 5 and table 6 below.

Table 5. The peak hour period in the afternoon in the direction of Parung-Jl. KH. Sholeh Iskandar straight ahead

Period	LV	HV	MC	UM
17.00 - 17.15	743	55	1767	0
17.15 - 17.30	795	48	1762	0
17.30 - 17.45	838	49	1836	0
17.45 - 18.00	874	49	1841	0

Table 6. Peak hours in the afternoon in the direction of Parung-ATS, turn right with APILL

Period	LV	HV	MC	UM
17.00 - 17.15	678	56	991	0
17.15 - 17.30	716	60	1121	0
17.30 - 17.45	736	69	1321	0
17.45 - 18.00	771	61	1399	0

Volume of motorized vehicles LV, HV, MC and UM direction Jl. KH. Sholeh Iskandar-Parung and Jl. KH. Sholeh Iskandar-ATS. The calculation period for the afternoon peak hour is shown in table 7 and table 8 below.

Table 7. Peak hours in the afternoon towards Jl. KH. Sholeh Iskandar-Parung straight with APILL

Period	LV	HV	MC	UM
17.00 - 17.15	820	3	1697	0
17.15 - 17.30	785	4	1711	0
17.30 - 17.45	833	4	1750	0
17.45 - 18.00	811	3	1753	0

Table 8. Peak hours in the afternoon towards Jl. KH. Sholeh Iskandar-ATS turn left with LTOR

Period	LV	HV	MC	UM
17.00 - 17.15	122	0	410	0
17.15 - 17.30	127	0	418	0
17.30 - 17.45	143	0	450	0
17.45 - 18.00	162	0	436	0

Volume of motorized vehicles LV, HV, MC and UM direction ATS-Jl. KH. Sholeh Iskandar and ATS-PArung. The calculation period for the afternoon peak hour is shown in table 9 and table 10 below.

Table 9. Peak hour period in the afternoon direction ATS-Jl. KH. Sholeh Iskandar turn right with APILL

Period	LV	HV	MC	UM
17.00 - 17.15	185	9	429	0
17.15 - 17.30	195	9	422	1
17.30 - 17.45	212	7	410	1
17.45 - 18.00	210	10	418	1

Table 10. Peak hour period in the afternoon direction ATS-PArung turn left with LTOR

Period	LV	HV	MC	UM
17.00 - 17.15	297	18	453	1
17.15 - 17.30	302	19	434	1
17.30 - 17.45	290	16	417	1
17.45 - 18.00	257	13	388	0

Furthermore, data on the volume of motorized vehicles and non-motorized vehicles are grouped into North, South and West units (for the three arms of the Salabenda signalized intersection), as shown in table 11, table 12 and table 13 below.

Table 11. Volume of northern motor vehicles

Direction/Type of vehicle	LV	HV	MC	UM
LT				
ST	874	49	1841	0
RT	771	61	1399	0
LTOR				

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Table 12. Volume of southern motor vehicles

Direction/Type of vehicle	LV	HV	MC	UM
LT				
ST	833	4	1750	0
RT				
LTOR	162	0	436	0

Table 13. Volume of Western motorized vehicles

Direction/Type of vehicle	LV	HV	MC	UM
LT	257	13	388	0
ST				
RT	210	10	418	1
LTOR				

Results and discussion of calculations using the 1997 MKJI program KAJI

This calculation uses the KAJI program from SIG I to SIG V. The data entered is data on the volume of motorized vehicle traffic LV, HV, MC and UM. The results obtained are capacity, degree of saturation, delay and level of service/LoS of motorized vehicles. The following shows the calculation results in table 14 below.

Table 14. Performance results of the three-arm Salabenda signaled intersection

No	Intersection Period	Cross arm	Capacity smp/hours	Degree of saturation	Queue length	Delay sec/smp	LoS
1	Morning	NORTH	1131	0,703	33	19	C
	Morning	SOUTH	1496	0,703	40	17	C
	Morning	WEST	1005	0,703	57	16	C
2	Afternoon	NORTH	2334	0,807	89	21	D
	Afternoon	SOUTH	1449	0,807	62	26	D
	Afternoon	WEST	634	0,807	67	33	D
3	Night	NORTH	2630	0,926	273	53	E
	Night	SOUTH	1552	0,926	173	70	E
	Night	WEST	711	0,926	179	84	E

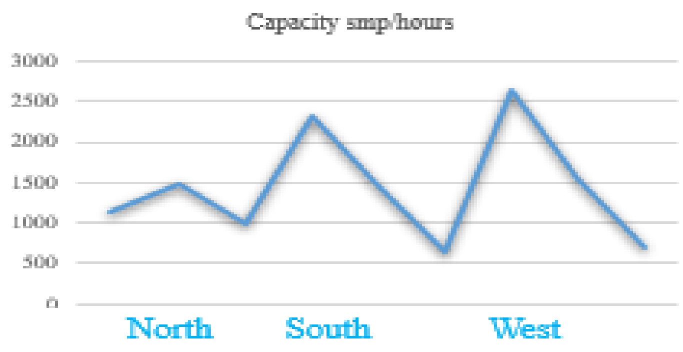

Figure 5. The level of the intersection capacity of the arms at the Salebenda intersection

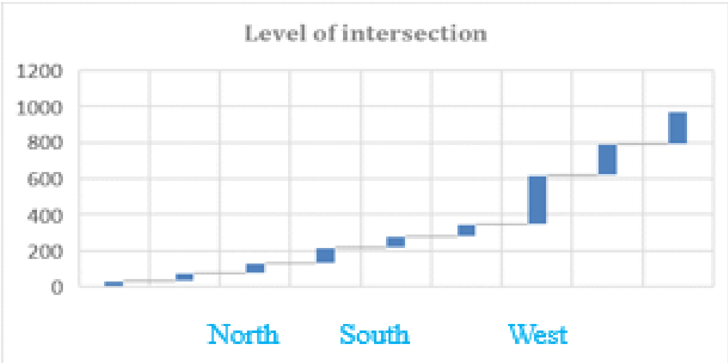

Figure 6. The level of the queue length of the intersection on the arm at the Salebenda intersection

Figure 7. The level of delay on the arm at the Salebenda intersection

Discussion of the results of data processing that in the afternoon the three-arm signaled intersection Salabenda intersection has shown LoS E performance, meaning that the traffic flow is low with traffic volume approaching very low road capacity, high traffic density due to high internal traffic barriers. and the driver has started to feel the traffic jam and stops at this condition. For the condition of the Salabenda intersection during the day, it can be identified that the flow is approaching unstable, the traffic density is moderate and the driver still has very limited freedom in running his vehicle. But different in the morning LoS is C, meaning that the flow of motorized traffic is stable but the speed of vehicle movement is controlled by traffic volume, traffic density is moderate and drivers still have limitations to choose the speed of changing lanes or taking the lead. From the three observations above, the condition of the three-arm signalized intersection of the Salabenda intersection is still able to accommodate the flow of vehicles, but along with the operation of the Section IIIA Toll Road to the Salabenda intersection, the intersection will receive a larger number of vehicles than before the operation of the toll road. The most appropriate step is to increase the number of lanes from 2 to four and minimize side obstacles in the form of public transportation vehicles 06 parked on the shoulder of the road, as well as parking for shopping vehicles at every stall or supermarket on this route. Parking tightening must be done immediately so that accidents can be minimized. The following is an illustration between the morning, afternoon and evening for each activity at the three-arm signaled intersection of the Salabenda intersection.

CONCLUSION

The three-arm Salabenda intersection is the border between Bogor regency and the city of Bogor, so this intersection is one of the busiest and most densely populated intersections besides Ciawi intersection in the north. The Salabenda intersection has become more congested with the opening of the Section IIIA Toll Road so that the traffic load shifts from Jl. KH. Sholeh Iskandar to this toll road, so that the intersection will have a higher traffic intensity. From the three observations and data collection in the field, it can be seen that in the afternoon it has a very high LoS, namely E. Followed by a LoS D level in the afternoon and in the morning LoS is still in the form of C. So it is still safe to use in the morning with a recommended level. The LoS E condition is a condition where the intersection has a degree of saturation of 0.926 which is almost close to 1, which is exacerbated by the high side resistance activity. Meanwhile, the delay reached 84 vehicles/junior high school in the afternoon so that traffic jams became more pronounced at the intersection of the three arms of Salabenda.

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