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Analysis of Capacity, Speed, and Degree of Saturation of Intersections and Roads

Muhammad Isradi[a]*, Hermanto Dwiatmoko[b], Muhammad Ikhsan Setiawan[c], Dadang Supriyatno[d]

[a]*Faculty of Engineering, University of Mercu Buana, Jakarta, Indonesia, isradi@mercubuana.ac.id*
[b]*Faculty of Engineering, University of Mercu Buana, Jakarta, Indonesia, hermanto.dwiatmoko@mercubuana.ac.id*
[c]*Faculty of Engineering, University of Narotama, Surabaya, Indonesia, ikhsan.setiawan@narotama.ac.id*
[d]*Faculty of Engineering, State University of Surabaya, Surabaya, Indonesia, dadangsupriyatno@unesa.ac.id*

Abstract

No traffic-signal intersection located on Jalan Serang and Jalan Curug, Tangerang Regency often causes traffic congestion. Many side barriers activities of vehicles inhibit the movement of traffic flow. The toll-road access, which is not far from the intersection, makes the queue long enough to enter Jl. Raya Serang also affects the performance of the surroundings. The study aims to determine the performance of the above intersection this time, which is measured by the capacity, degree of saturation, speed, queuing opportunities, density, and level of services. Field surveys and further analysis of the calculations that have been carried out show the intersection performance. The peak traffic volume occurred on Wednesday, February 5 2020, at 3877 pcu / hour at 07.00 - 08.00 WIB, with a capacity (C) of 2937 pcu / hour. From the available data, the DS value is 1.32. at the Service level F.

Keywords: Performance of Unsignalized, Three Intersections and Roads, Degree of Saturation, Service Level.

1. Introduction

The intersection between Jl. Raya Serang and Jl. Raya Curug in Tangerang Regency has a reasonably high density, alternately in each lane, during peak hour. It is caused by the fact that the area is a mix of residential, business, and industrial sectors.

At the intersection, congestion is caused by side obstacles, such as the high population of vehicles, especially trucks and motorcycles. Other causes are the inadequate road infrastructures, irregular crossings, road bodies that become parking lots and places to sell, and the activities of passengers from public transportation. The toll-road access, which is located 500 meters from the intersection, causes congestion, making long vehicle queues that reduce travel time.

The success of development is greatly influenced by its role of transportation as the center of economic, socio-cultural, and security and political life. Isradi [1], accompanied by an increase in the number of vehicles such as buses, trucks, passenger cars, and two-wheeled vehicles also experienced a fairly high increase, from 13.7 million units in the first year to 17.7 million units in the fourth year (www.bappenas.go .id). Traffic engineering is a relatively

* Corresponding author.
E-mail address: isradi@mercubuana.ac.id (Muhammad Isradi)

new field of all fields covered by the scope of civil engineering, and provides a sizeable contribution to the construction and processing of infrastructure, especially solving problems related to transportation [2].

Morlok [3] defines transportation as "an action, process, or thing that is being moved from one place to another". More specifically, transportation is defined as "the activity of moving people and goods from one place to another". In transportation there is movement, and physical movement occurs over people or goods with or without means of transportation to other places. Here pedestrians are moving people without a conveyance. In meeting their needs, people travel between land uses using a transportation network system (such as walking or taking a bus). This causes the movement of people, vehicles and goods [4]. While transportation in general can be interpreted as an effort to move, or the movement of people or goods from a place of origin, to another location, commonly called a destination location, for certain purposes by using certain tools as well [5].

The reduced effective width of the road section, and conflicts that occur at the intersection, cause congestions at the intersection. The solution requires an analysis of the intersection performance based on clear measures.

From the analysis conducted, we can plan solutions so that congestion can be reduced in various ways, such as installing traffic signs, widening road bodies, or using traffic lights.

Some data are required to find out the level of service, where one of them is the volume of the vehicles.

1) Intersections

Intersections can be defined as general areas where two or more roads join, including roadside facilities for the movement of traffic within them [6].

Intersections are where you turn or the branch of a straight line. Intersections are a node in the transportation network where two or more roads meet, which cause traffic flow's conflicts. Traffic rules are set to determine who has the first right to use the intersection to control the conflict.

a) Field crossing

It is an intersection where various entrances to an intersection that direct traffic into a road that can be the opposite to other traffic.

Field crossing is a complicated part of a highway system. It is where most of the encounters between the vehicles with pedestrians occur, which always cause delays, accidents, and congestion [6].

b) Crossing performance without traffic signal

The Indonesian Road Capacity Manual [7] states that one measure of traffic performance is the Level of Service (LOS). LOS is a qualitative measure that reflects the perception of the drivers about the quality of the vehicle. LOS is related to a quantitative approach measure, which is generally expressed in terms of capacity (C), degree of saturation (DS), average speed, travel time, delay (D), queue probability (QP%), queue length, and stop vehicle ratio.

c) Traffic flow

Traffic flow is the number of traffic elements passing through the unobstructed upstream point at a time, expressed in units of vehicles/hour or pcu/hour. The composition of the movement of traffic that passes through the intersection is divided into four parts, namely:

1) Light Vehicles (LV) are light vehicles with four wheels and two axles within 2-3 meters. It includes passenger vehicles, microbuses, pickups, and small trucks.
2) Heavy Vehicles (HV) are vehicles with more than four wheels and axles spacing of 3-4 meters. It includes buses, two-axle trucks, three-axle trucks, and the like.
3) Motorcycle (MC) is a two or three-wheeled motor vehicles, such as a motorized pedicab and motorcycles.
4) Unmotorized (UM) are two or three-wheeled non-motorized vehicles, such as tricycles, bicycles, wheelchairs, and pedestrians.

Traffic flow (Q) for each movement (turn left- Q_{LT}, straight Q_{ST}, and right-turn Q_{RT}) is converted from hourly vehicles to units of passenger cars (pcu) per hour. The conversion process uses equivalent passenger cars (emp) for each type of vehicle, as shown in the table 1.

Table 1 Urban road passenger car unit

Class	Type of Vehicle	Passenger Car Unit
LV	Sedan, Jeep, Oplet, Pickups, Microbus	1.00
HV	Standard bus, Medium truck, Heavy truck	1.30
MC	Motorcycle	0.50
UM	Horse-drawn carriage, rickshaw, bicycle, etc	1.00

Source: MKJI 1997 [7]

2) Capacity

Following the 1997 MKJI Method, the total capacity of all intersection arms is the result of the multiplication of the basic capacity (Co) obtained from certain conditions (ideal) and the correction factor (F) that takes into account the effect of actual conditions on capacity or can also be written as the formula below:

$$C = Co \times F_W \times F_M \times F_{CS} \times F_{RSU} \times F_{LT} \times F_{RT} \times F_{MI}$$

a) Basic Capacity (Co)

The type of intersection determines the basic capacity of an intersection. It is determined by the number of intersections and lanes on major roads and minor roads. A three-digit code. identifies the type of intersection

Table 2 Intersection type code

IT Code	Number of Intersections Arm Simpang	Number of Minor Road Lanes	Number of Main Road Lanes
322	3	2	2
324	3	2	4
342	3	4	2
422	4	2	2
424	4	2	4

Source: MKJI 1997 [7]

Table 3 Basic capacity by intersection type

IT Code	Basic Capacity (pcu/hour)
322	2700
342	2900
324 or 344	3200
422	2900
424 or 444	3400

Source: MKJI 1997 [7]

b) Approach Width Correction Factor (FW)

The approach width correction factor can be obtained from the above image, where the input variable for the approach is the average width of all approaches of W1 and the IT intersection type.

c) Road Median Correction Factor (F_M)

Table 4 Road median correction factor

Description	M type	F_M
There is no median of the main road	No	1.00
There is a median of the main road, width < 3m	Narrow	1.05

Description	M type	F_M
There is a median of the main road, width ≥ 3m	Wide	1.20

Source: MKJI 1997 [7]

d) *City Size Correction Factor (F_{CS})*

Table 5 City size correction factor

City Size	Total population (Million)	F_{CS}
Very Small	< 0.1	0.82
Small	0.1 – 0.5	0.88
Medium	0.5 – 1.0	0.94
Big	1.0 – 3.0	1.00
Very Big	> 3.0	1.05

Source: MKJI 1997 [7]

e) *Left Turn Correction Factor (F_{LT})*

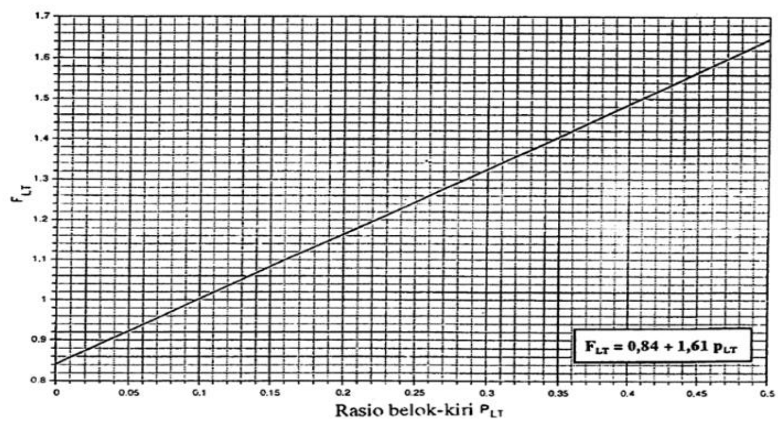

Figure 1. Left Turn Ratio Graph

$F_{LT} = 0.84 + 1.61\ P_{LT}$

f) *Right Turn Ratio Graph (F_{RT})*

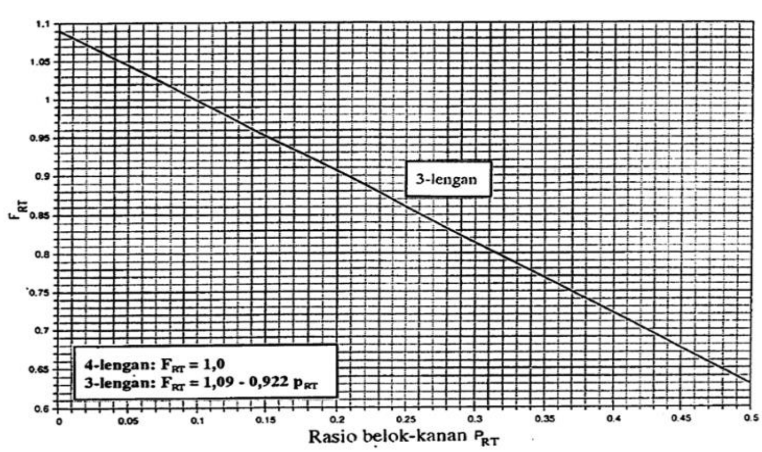

Figure 2. Right Turn Ratio Graph

3-Arm : $F_{RT} = 1.09 - 0.922\ P_{RT}$

g) Proportion Correction Factor for Road Flow

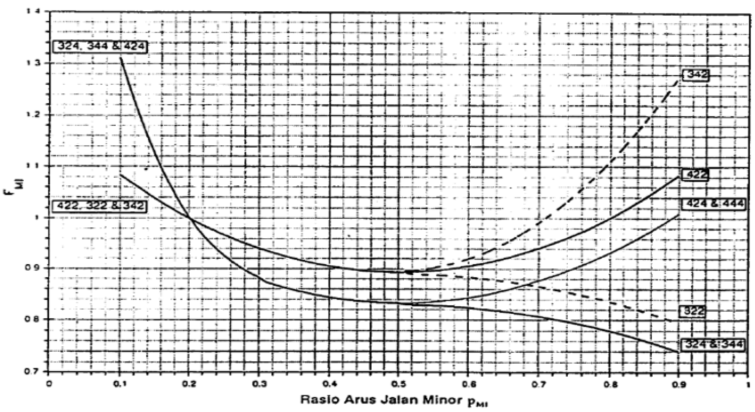

Figure 3. Minor Road Flow Ratio Graph

Table 6 Minor road adjustment factors

IT	F_{MI}	P_{MI}
422	$1.19xP_{MI}^{2} - 1.19xP_{MI} + 1.19$	0.1 – 0.9
424	$16.6xP_{MI}^{4} - 33.3xP_{MI}^{3} + 25.3xP_{MI}^{2} - 8.6xP_{MI} + 1.95$	0.1 – 0.3
444	$1.11xP_{MI}^{2} - 1.11xP_{MI} + 1.11$	0.3 – 0.9
322	$1.19xP_{MI}^{2} - 1.19xP_{MI} + 1.19$	0.1 – 0.5
	$-0.595xP_{MI}^{2} + 0.595xP_{MI}^{3} + 0.74$	0.5 – 0.9
342	$1.19xP_{MI}^{2} - 1.19xP_{MI} + 1.19$	0.1 – 0.5
	$2.38xP_{MI}^{2} - 2.38xP_{MI} + 1.49$	0.5 – 0.9
324	$16.6xP_{MI}^{4} - 33.3xP_{MI}^{3} + 25.3xP_{MI}^{2} - 8.6xP_{MI} + 1.95$	0.1 – 0.3
344	1.11xPMI2 – 1.11xPMI + 1.11	0.3 – 0.5
	-0.555xPMI2 + 0.555xPMI + 0.69	0.5 – 0.9

Source: MKJI 1997 [7]

3) Degree of Saturation

The degree of saturation (DS) states the level of density that occurs due to the movement of vehicles that pass the intersection. DS value is the ratio of the volume to the capacity of the existing intersections and expressed by the formula:

$$DS = Qsmp / C$$

DS =Degree of saturation

Qsmp = Total Flow (pcu/hour)

C = Capaicty (pcu/hour)

a) Delays

Delays at intersections can occur due to two reasons, namely:

1) Traffic Delays (DT) due to traffic interactions with other movements in the intersection.
2) Geometric Delays (DG) due to slowing and acceleration of disturbed and undisturbed vehicles.

Geometric delay (DG) can be calculated by:

$DS < 1.0$: $DG = (1-DS) \times (PT \times 6 + (1-PT) \times 3) + (DS \times 4)$

$DS \geq 1.0$: $DG = 4$

with:

DS : Degree of saturation

PT : Turn flow ratio to total flow.

6 : Normal geometric delays for vehicles turn undisturbed (sec/pcu)

4 : Normal geometric delays for vehicles turn disturbed (sec/pcu)

So the Intersection Delay (D) is the sum of the delays caused by traffic and geometrically or empirically:

$$D = DT + DG$$

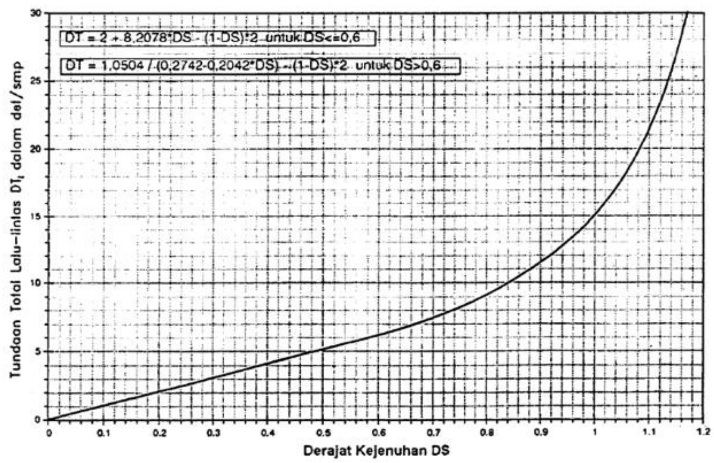

Figure 4. Traffic Delay vs Degree of Saturation

$DT = 2 + 8.2078 \times DS - (1 - DS) \times 2$,

for $DS \leq 0.6$

$DT = 1.0604/(0.2741 - 0.2042 \times DS) - (1 - DS) \times 2$, for $DS \geq 0.6$

$DT = 1.8 + 5.8234 \times DS - (1 - DS) \times 1.8$, for $DS \leq 0.6$

$DT = 1.05034/(0.346 - 0.246 \times DS) - (1-DS) \times 1.8$, for $DS \geq 0.6$

b) Queue Opportunities

Queuing opportunities are expressed in the range of values obtained from the relationship curve between queuing probability (QP%) and degree of saturation (DS). The following equation can obtain queue opportunities with upper and lower limits:

Upper Limits

$$Qp\ \% = 47.71 \times DS - 24.68 \times DS^2 + 56.47 \times DS^3$$

Lower Limits

$$Qp\% = 9.02 \times DS + 29.66 \times DS^2 + 10.49 \times DS^3$$

4) Urban Roads

Urban roads are roads that experience permanent and continuous development along or almost all roads or at least on one side of the road, whether in the form of land development or not. Included in the group of urban roads are roads that are near urban centres with a population of more than 100,000 people [7].

5) Speed

Speed is expressed as the rate of movement of a vehicle calculated in terms of time unit distance (km/hour) (F.D Hobbs, 1995), as formulated:

$$V = s/t$$

With:
V = Speed (m/sec)
s = Distance (m)
t = Time (dt)

Whereas in MKJI there are known free-flow speeds and operational speeds as explained in the next sub-chapter.

1. Free-flow speed

   The free-flow velocity is calculated based on the following equation:

   $$FV = (FV_0 + FV_W) \times FF_{SF} \times FFV_{CS}$$

   where

   FV : Light vehicle free-flow speed for real conditions.
   FV_W : Speed adjustment for road width (km/h)
   FV_0 : Basic free-flow speed for light vehicles (w)
   FFV_{CS} : Speed adjustment for city size
   FFV_{SF} : Adjustment factors for side and shoulder-width barriers

2. Operational Speed

Table 7 Measure of road section performance

Road Type	Effective traffic lane width (Wc) (m)	FCw
Divided four lanes or a one-way road	Per Lane	
	3	0,92
	3,25	0,96
	3,5	1
	3,75	1,04
	4	1,08
Undivided four lanes	Per Lane	
	3	0,91
	3,25	0,95
	3,5	1
	3,75	1,05
	4	1,34
Undivided two lanes	Per Lane	
	5	0,56
	6	0,87
	7	1
	8	1,14
	9	1,25
	10	1,29
	11	1,34

The Indonesian Road Capacity Manual [7] uses travel time as a measure of road section performance because it is easy to understand and measure. Travel speed is a function of Ds and FF_{LV}.

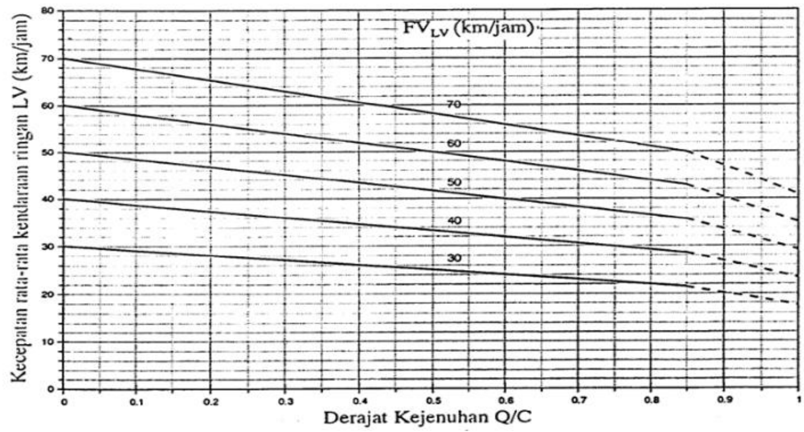

Figure 5. Graph of Ds and FF_{LV} functions to determine travel time (2/2UD).

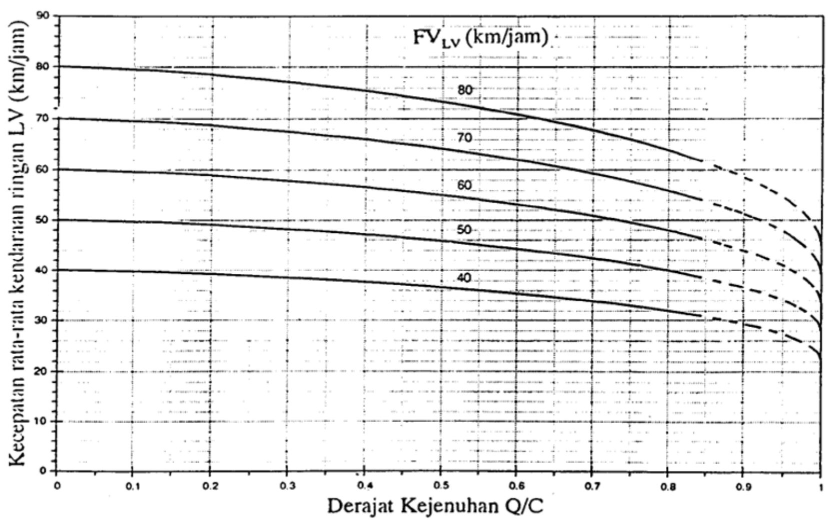

Figure 6. Graph of Ds and FF_{LV} functions to determine travel time (multiple lanes / one-way).

Source: MKJI 1997 [7]

6) Urban Road Capacity

Capacity is the maximum flow level at which a vehicle can be expected to run a piece of a certain time period for lane, traffic, traffic control and weather conditions. The formula used to calculate urban road capacity, according to MKJI, 1997 is as follows:

$$C = Co \times FC_W \times FC_{SP} \times FC_{SF} \times FC_{CS}$$

Table 8. Adjustment of FCW capacity to influence the width of the traffic lane

Road Type	Basic Capacity (pcu/hour)	Note
Divide four lanes or one-way road	1650	Per lane
Undivided four lanes	1500	Per lane
Undivided two lanes	2900	Two-way total

Source: MKJI 1997 [7]

Table 9. FC_{SF} adjustment factor for the influence of side barriers and shoulder-width

Road Type	Side Barrier Class	Adjustment Factor for side barrier and shoulder-width FC_{SF}			
		Effective shoulder-width Ws			
		≤ 0,5	1,0	1,5	≥ 2,0
4/2 D	VL	0,96	0,98	1,01	1,03
	L	0,94	0,97	1,00	1,02
	M	0,92	0,95	0,98	1,00
	H	0,88	0,92	0,95	0,98
	VH	0,84	0,88	0,92	0,96
4/2 UD	VL	0,96	0,99	1,01	1,03
	L	0,94	0,97	1,00	1,02
	M	0,92	0,95	0,98	1,00
	H	0,87	0,91	0,94	0,98
	VH	0,80	0,86	0,90	0,95
2/2 UD or one-way Road	VL	0,94	0,96	0,99	1,01
	L	0,92	0,94	0,97	1,00
	M	0,89	0,92	0,95	0,98
	H	0,82	0,86	0,90	0,95
	VH	0,73	0,79	0,85	0,91

Source: MKJI 1997 [7]

Table 10. The capacity adjustment factor for directional separators (FC_{SP})

Directional separator							
SP %-%		50-50	60-40	70-30	80-20	90-10	100-0
FCsp	Two lane	1	0,94	0,88	0,82	0,76	0,7
	Four lane	1	0,97	0,94	0,91	0,88	0,85

Source: MKJI 1997[7]

7) *Level of Service*

Road service level is one of the methods used to assess road performance, which is an indicator of congestion. The capacity of the road (C) has to be known to calculate LOS in a road section. It can be calculated by knowing the basic capacity, road adjustment factors, direction separator adjustment factors, side obstacle adjustment factors, and city size adjustment factors.

Table 11. Road service level based on (Q / C) C)

No	Service level	Ratio Q/C	Characteristics
1.	A	0 – 0.19	Free flow, low volume, high speed, the driver can choose the desired speed
2.	B	0,2 - 0,44	The flow is stable, speed is limited by traffic, and the volume of service used for the design of roads outside the city
3.	C	0,45 - 0,74	Stable flow, speed controlled by traffic, service volume used for urban road design
4.	D	0,75 - 0,84	Approaching an unstable low speed flow
5.	E	0,85 – 1	Unstable flows, low speed and vary, the volume approaches capacity
6.	F	≥ 1	Flow is hampered, speed is low, the volume is below capacity, many stops

Source: Morlok [3]

2. Methods

The study using survey method with collection data. The collection data on this study from the primary data and secondary data. Primary Data include data of : Traffic volume, Intersection Geometric, Speed, Side, Environmental conditions, and Secondary Data include: Location Map, Total Population, and Land Use. The data will processing with Side Performance Analysis and Performance Analysis of Roads. The flowchat of the study can seen in figure 9.

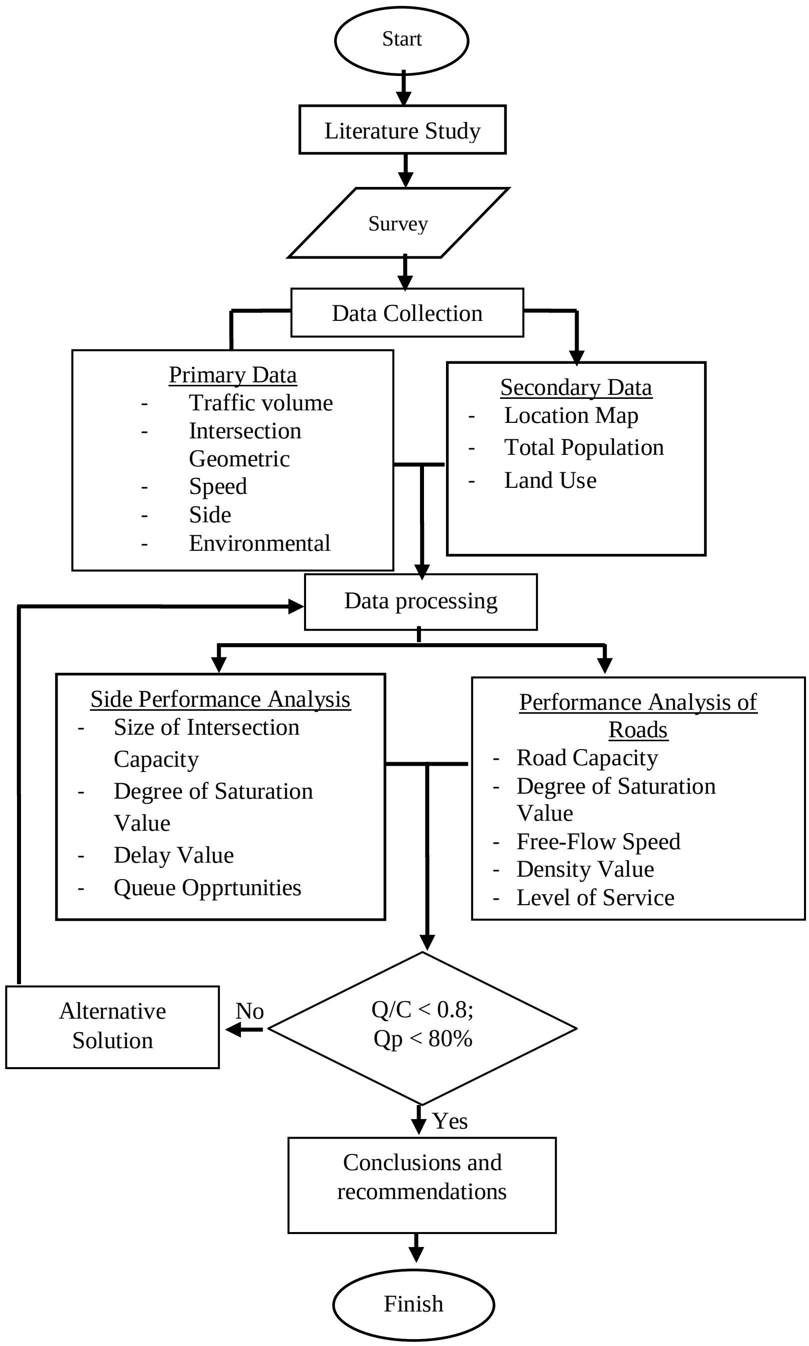

Figure 7. Research flowchart

3. Results and Discussion

3.1. No-Signal Intersection Performance

Jl. Raya Serang - Jl. Raya Curug's intersection is located in Tangerang Regency, Banten Province, with a population of more than 3 million. The existing conditions of the intersection are as in table 12.

Table 12. Intersection Geometric Data

Description	Roads Jl. Raya Serang – Jl Gatot Subroto (B Arm)	Jl. Raya Curug (C Arm)	Jl. Raya Serang (D Arm)
Road Type	Major	Minor	Major
Road Width (m)	13.5	10	13.9
Road Shoulder (m)	-	-	-
Road Median	Yes	-	Yes
Median Width (m)	0.5	-	0.5

Source: Survey Observation Result

3.2. Traffic Data

Traffic data is obtained through surveys taken at representative hours. It is assumed that the quantity of traffic flow increases at that hour. Data are taken per 15 minutes in 1 hour. The traffic data collection survey was carried out in 3 days as a representative to obtain the highest volume of intersections. Survey schedule conducted on:

1) Monday, February 3 2020
2) Wednesday, February 5, 2020
3) Sunday, February 9, 2020

From the three data taken, the highest vehicle volume data will be used as a reference for the calculation of the next no-signal intersection analysis. The highest vehicle volume data occurred on Wednesday, February 5, 2020, at 07:00 - 08:00 WIB.

Table 13. No-Signal Intersection Traffic Flow Wednesday, February 5, 2020

Wednesday, February 5, 2020											
Time	**Vehicle type.**	**Approach**									**Total (Vehicle/hour)**
		D			**C**			**B**			
		LT	**ST**	**RT**	**LT**	**ST**	**RT**	**LT**	**ST**	**RT**	
07:00 - 08:00	LV		575	127	142		186	156	586		
	HV		66	14	50		47	57	46		
	MC		1241	195	284		286	255	1220		
	UM		8	5	3		3	5	2		
	Tot		**1890**	**341**	**479**		**522**	**473**	**1854**		**5559**
12:00 – 13:00	LV		543	120	32		159	297	555		
	HV		115	16	15		54	80	86		
	MC		625	175	116		191	225	633		
	UM		1	3	5		2	0	4		
	Tot		**1284**	**314**	**168**		**406**	**602**	**1278**		**4052**
17:00 - 18:00	LV		525	124	75		148	152	476		
	HV		96	13	17		48	97	97		
	MC		1027	397	297		479	468	1003		
	UM		2	1	3		0	2	0		
	Tot		**1650**	**535**	**392**		**675**	**719**	**1576**		**5547**

Source: Survey Observation

3.3. Survey Data Calculation

1) Approach Width and Intersection Type

Table 14. Approach Width and Intersection Type

Options	Number of the arms of the intersection	Approach Width (m)							Number of lanes		Intersection Type
		Minor Road			Major Road			The average of the approach width			
		W_A	W_C	W_{AC}	W_B	W_D	W_{BD}		Minor Road	Major Road	
1	3		5.0	5.0	6.9	6.9	6.9	5.43	2	4	234M

Source: Results of Analysis

2) Capacity

a. Basic Capacity Value (Co)

Table 15. Basic capacity by intersection type

IT Code	Basic Capacity (pcu/hour)
322	2700
342	2900
324 or 344	**3200**
422	2900
424 or 444	3400

Source : MKJI 1997 [7]

b. Average Approach Width (F_W)

F_W = 0.62 + 0.0646 x W1

= 0.62 + 0.0646 x 5.43

= 0.97 pcu/hour

c. Major Road Median (F_M)

Table 16. Road median correction factor

Description	M Type	F_M
No major median road	No	1.00
There is the major median road, width < 3m	**Narrow**	**1.05**
There is the major median road, width ≥ 3m	Wide	1.20

Source: MKJI 1997 [7]

d. City Size (F_{CS})

Table 20. City size correction factors

City Size	Number of Population (Million)	F_{CS}
Very Small	< 0.1	0.82
Small	0.1 – 0.5	0.88
Medium	0.5 – 1.0	0.94

Big	1.0 – 3.0	1.00
Very Big	**> 3.0**	**1.05**

Source: MKJI 1997 [7]

e. Side Barrier Factor (F_{RSU})

The adjustment factor for side barriers and non-motorized vehicles of UM/MV = 0.0067. With the commercial environment type and its side barrier class being moderate, the FRSU value is between 0.94 and 0.89, so the interpolation of the two values must be carried out. From the interpolation results that have been calculated, the FRSU value is 0.93.

f. Left Turn Adjustment Factor (F_{LT})

F_{LT} = 0.84 + 1.61 x PLT

F_{LT} = 0.84 + 1.61 x 0.694

F_{LT} = 1.957

g. Right Turn Adjustment Factor (F_{RT})

F_{RT} = 1.09 – 0.922 x PRT

F_{RT} = 1.09 – 0.922 x 0.687

F_{RT} = 0.457

h. Minor Road Adjustment Factor (F_{MI})

$F_{MI} = 16.6 \times P_{MI}^4 - 33.3 \times P_{MI}^3 + 25.3 \times P_{MI}^2 - 8.6 \times P_{MI} + 1.95$

$F_{MI} = 16.6 \times 0.19^4 - 33.3 \times 0.19^3 + 25.3 \times 0.19^2 - 8.6 \times 0.19 + 1.95$

F_{MI} = 1.021

i. Capacity (C)

$C = C_O \times F_W \times F_M \times F_{CS} \times F_{RSU} \times F_{LT} \times F_{RT} \times F_{MI}$

C = 3200 x 0.97 x 1.05 x 1.05 x 0.93 x 1.957 x 0.457 x 1.021

C = 2937 pcu/hour

3) Traffic Behavior

a. Degree of Saturation (DS)

$DS = Q_{TOT}/C$

DS = 3877 / 2937

DS = 1.32

b. Intersection Traffic Delays (DT_1)

For DS> 0.6, the formula below can be used:

DT_1 = 1.0504 / (0.2742 - 0.2042 x DS) – (1-DS) x 2

DT_1 = 1.0504 / (0.2742 - 0.2042 x 1.32) - (1-1.32) x 2

DT_1 = 226.24 sec/pcu

c. Major Road Traffic Delays (DT_{MA})

For DS> 0.6, the formula below can be use:

$DT_{MA} = 1.05034 / (0.346 – 0.246 \times DS) – (1 – DS) \times 1.8$

$DT_{MA} = 1.05034 / (0.346 – 0.246 \times 1.32) – (1 – 1.32) \times 1.8$

$DT_{MA} = 49.93$ set/pcu

d. Minor Road Traffic Delays (DT_{MI})

$DT_{MI} = (Q_{TOT} \times DT_I – Q_{MA} \times DT_{MA}) / Q_{MI}$

$DT_{MI} = (3877 \times 226.24 – 3138 \times 49.93)/739$

$DT_{MI} = 974.90$ sec/pcu

e. Intersection Geometric Delays

$DS = 1.32 \geq 1.0$

$DG = 4$

f. Intersection Delays

$D = DG + DT_I$

$D = 4 + 226.24$

$D = 230.24$ det/smp

g. Queue Opportunities

- Upper Limit

$QP_A = (47.71 \times DS) – (24.68 \times DS^2) + (56.47 \times DS^3)$

$QP_A = (47.71 \times 1.32) – (24.68 \times 1.32^2) + (56.47 \times 1.32^3)$

$QP_A = 149.85$ %

- Lower Limit

$QP_B = (9.02 \times DS) + (20.66 \times DS^2) + (10.49 \times DS^3)$

$QP_B = (9.02 \times 1.32) + (20.66 \times 1.32^2) + (10.49 \times 1.32^3)$

$QP_B = 72.03\%$

From the above results, it can be seen that the value of the degree of saturation obtained is 1.32. The above value exceeds the target DS <0.8. The upper limit value of queuing probability (Qp) is more than 80% shows that the performance of the intersection is not good enough.

4. Conclusions and Recommendations

4.1 Conclusion

Based on the writing and discussion Based on the results described in the previous chapter, it could be concluded as follows.

1. The peak traffic volume at the intersection of Jl. Raya Serang and Jl. Raya Curug occurred on Wednesday, February 5, 2020, at 07.00 - 08.00 in the amount of 3.877 pcu/hour. With the capacity (C) of 2.937 pcu/hour, the DS value of 1.32 is obtained.
2. Alternative three is the one that meets the target of the several alternatives used to overcome congestion at the intersection, with DS = 0.42, Delay intersection = 4.29, Queuing opportunity = 8.21% - 19.87%, and the service level of B.

4.2 Recommendations

a) It is expected that the authority acts decisively to control public transportation so that it does not stop for too long and carelessly on roads and intersections that are prone to traffic jams.

b) It is expected that the authorized personnel also implement alternative suggestions to reduce the level of congestion at the intersection so that the performance of the surrounding roads is also undisturbed.

c) Alternatively, bypass routes can also be built to anticipate traffic jams at Jl. Raya Serang - Jl. Raya Curug and roads.

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