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Increasing the capacity of the unsignalized three way petir intersection, Serang Regency

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ABSTRACT

Population growth increases every year, especially in Serang Regency, causing traffic problems including accidents, congestion, or being faced with conditions of frequent road scrambling. In preliminary observations, this happened to the Unsignalized Three Way Petir Intersection . This research was conducted to determine the existing performance of the intersection and find alternative solutions to overcome the problem situation and find out the cost needs needed in planning the proposal. Thus, of course, data is needed to be able to analyze it. The method used is based on the Indonesian Road Capacity Manual (MKJI) of 1997, the required data consists of primary data by conducting a field survey, to find out the volume of vehicles (Average daily traffic/ADT for seven days from 06.00 to 18.00 WIB, road geometrics, traffic conditions, and environmental conditions. It is known that the Unsignalized Three Way Petir Intersection type is type 322, meaning 3 arms 2 lanes 2 directions, the data uses the form USIG I and the form USIG II from MKJI 1997. The results showed that the existing performance at the Unsignalized Three Way Petir Intersection showed the largest total traffic flow value of 3,480 passenger car unit (pcu) / hour, the saturation degree (DS) value was 1,026, which means, the traffic flow has exceeded the road capacity, with an intersection traffic delay of 16,426 sec / pcu, a delay in main road traffic (B-D) of 7.4584 sec / pcu and a delay in minor road traffic (C) of 38.2352 sec / pcu, queue odds are between 42.3554% to 84%. Alternative solutions that can be done prohibit the right turn traffic from minor roads, as well as widening on the main road from 3 m per lane to 3.5 m so that the short width of each lane = 3.5 m and the shoulder width of 0.5 m, in total to 8 m, so that the cost required in the planning is Rp. 2,220,051,000 (two billion two hundred twenty million fifty-one thousand rupiah).

Keywords: intersection; improvement; widening; performance; USIG I.

INTRODUCTION

The increase in population along with the increasing need for transportation (Nila dkk,2020, Alvi.S,2021). Serang Regency is a relatively fast developing area and one of the areas in Banten Province that has a fairly high population. Which is characterized by consumptive, productive activities, public services, distribution and government services (Adi dkk,2020). Based on data from the Central Statistics Agency of Serang City in 2020, the total population of Serang City is 1,482,987 people, the size of Serang Regency is included in the Large category (1.0 – 3.0 million people). The development of the above sectors so that more and more motor vehicles are crowding the road sections, this causes complex problems in traffic in Serang Regency (Morlok EK,1985). One of the locations in Serang Regency that experiences traffic problems is on Three Way Petir Intersection (Ciruas Road – Petir Road – Cikeusal Road). With the geometric condition of the road, the width of the pavement for each arm are Ciruas Road 6 m , Petir Road, 6 m, and Cikeusal Road, 6 m . The intersection type is a commercial type because there are many shops on the side of the road, where the intersection is unsignalized, with 3 arms 2 lanes 2 directions or type (322) (Khisty, C.J, 2005). On these roads, there is often congestion during peak hours. In addition, motorists often do not obey the rules and scramble for road space by tending to precede each other so that the conditions can cause conflicts at intersections. From observations, the density at the intersection is also influenced by side obstacles that add to the problem at the intersection. From these conditions, it is necessary to know the performance of the current intersection, find alternative solutions that can be offered to improve or maintain the performance of the intersection and how much cost needs are needed (Harianto, Joni,2004).

Signalized intersections are very influential on traffic regulation. Traffic regulation based on signal lights is very good for the sustainability of the driver's behavior in controlling his vehicle. Motorized vehicles are tools for traveling. The desired trip is with the appropriate planning and concept. This is based on research that driver behavior is based on regulated traffic signals (Syaiful S et.al, 2022; Syaiful S, 2017; Syaiful S, Hariyadi D, 2019).

RESEARCH METHODS

The study location was carried out at the coordinates of 6°13'49.2"S 106°12'31.5"E which connects between Petir Road, Ciruas Road, and Cikeusal Road which is currently an unsignalized intersection with three arms and has rigid pavement as the pavement layer. The study was conducted over seven days with 12 surveyors. To facilitate research, the following research flow is made:

Preliminary Survey

Preliminary Survey where researchers make observations of locations that will be used as case studies, collection of surveyors for taking research data, determining surveyor points to facilitate observations and preparing forms for filling in vehicle survey data and related alternative solutions that can be done in increasing interchangeability (K.Hainim,2020).

Data Collection

Primary data collection for analysis was carried out by surveying observations in the field in the study area, namely geometric conditions by paying attention to the number of arms, number of lanes, intersection drawings, arm width and short width through measurements directly at the intersection location by means of manual measurements (Bina Marga,1992). This survey was conducted by three surveyors. Two people serve as measurements and one person who records the measurement results, surveys of the number of vehicles obtained using manual / traffic counting methods (Hobbs,F.D,1995) namely by recording the number of vehicles passing through the intersection each 15-minute period starting from 06.00 – 18.00 hours for seven days by 12 surveyors. This is done in order to obtain the maximum value of the volume of the vehicle so that the data that can represent the existing conditions, as well as pay attention to environmental conditions. Meanwhile, the collection of secondary data in this study is data on the number of residents of the city of Serang in 2021 obtained from the BPS website in Serang City, Banten while the location map obtained from google maps.

Data Analysis

This stage is the result of observational data that has been collected, then calculations will be carried out based on the 1997 Indonesian Road Capacity Manual (DPU,1997, Selter R,1974). Some of the factors used as a reference for calculations are as follows to find out the capacity, previously it was necessary to know the width of the short and the type of intersection, the basic capacity, the short width adjustment factor, the main road median adjustment factor, the city size adjustment factor, the environmental type adjustment factor, the side obstacles of non-motorized vehicles, the left turn adjustment factor, the right turn adjustment factor, the minor road current ratio adjustment factor. For the determination of traffic behavior, it first determines the degree of saturation (Zulfikar dkk,2022), delays, queue opportunities, planning for handling selected alternative solutions for Three way Petir intersections by knowing the engineering planning and costs needed in increasing the Three Way Petir intersection (Tamin QZ,1997, Picataro,J.L,1973).

RESULT AND DISCUSSION

The analysis carried out on the Three Way Petir Intersection includes analysis of traffic, intersection capacity, degree of saturation, queue opportunities. Saturation degree (DS) values recommended in the Indonesian Capacity Manual (MKJI 1997) is 0.75, so an effort must be made to solve the solution at the value of the intersection capacity, if at the end of the calculation a DS value>75 is obtained. The following is a Location Map Three Way Petir Intersection and layout.

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Picture 1 Location Map Three Way Petir Intersection Source: Survey, 2022

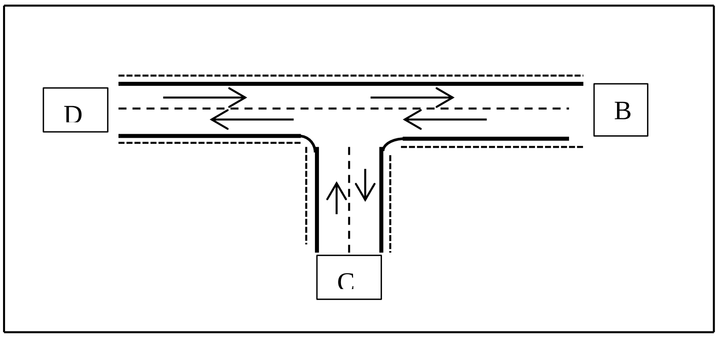

Figure 2. Three Way Petir Intersection Layout, Type 322

Info. C= Petir direction, B= Baros direction, D = Ciruas direction
Lane width = 3m, shoulder width = 0,5 m, without median
Source: survey, 2022

Table 1. Total Average Daily Traffic Volume (ADT)

Day	LV	Pce = 1	HV	Pce=1,3	MC	Pce=0,5	Sum (pcu)
Monday	1665	1665	469	609,7	2411	1205,5	**3480,2**
Tuesday	1277	1277	504	655,2	2103	1051,5	2983,7
Wednesday	1521	1521	314	408,2	2151	1075,5	3004,7
Thursday	1255	1255	495	643,5	2174	1087	2985,5
Friday	1051	1051	299	388,7	1705	852,5	2292,2
Saturday	1386	1386	377	490,1	2273	1136,5	3012,6
Sunday	1211	1211	345	448,5	2328	1164	2823,5

Source: Survey ,2022

*LV: Light Vehicle; HV: High Vehicle; MC: Motorcycle; pce: passanger car equivalent; pcu (pasanger car unit)
From the results of the traffic survey, the highest Average Daily traffic (ADT) number was on Monday, 3,480.2 pcu, while the lowest traffic was on Sunday, amounting to 2823.5 pcu. This is

because Monday is the first day of work, high mobility to work, while Sunday is widely used to rest and not travel. The ADT volume of the survey results shown in Picture 3 shows the number of each type of vehicle consisting of light vehicles, heavy vehicles and motorcycles as follows.

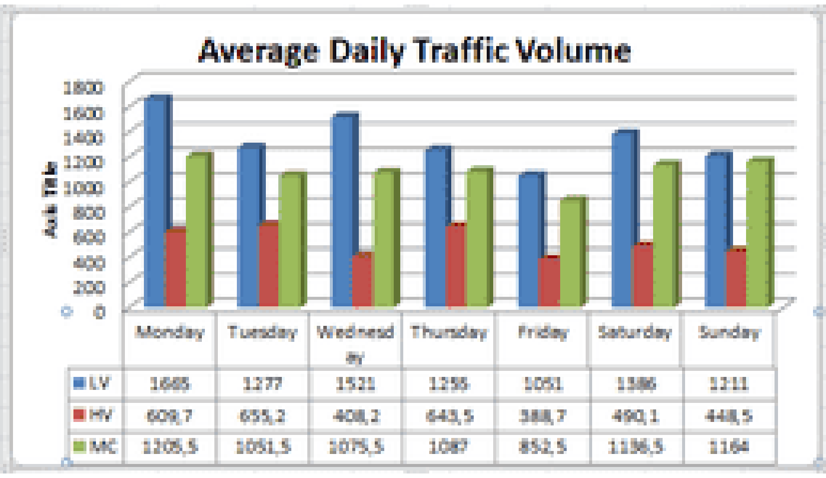

Figure 3. Total Traffic Volume Graph (LHR). Source: Analysis, 2022

In intersection traffic, in addition to calculating ADT on the main road, ADT must also be calculated on minor roads, to be able to see the distribution of vehicle directions on each intersection arm. The following table 2 shows the number of ADT in the direction of each of them at the Three way Petir Intersection on the next page.

Table 2. ADT on Intersection Approach

Tipe Vehicle	Intersection Approach									Sum
	C			D			B			
	LT	ST	RT	LT	ST	RT	LT	ST	RT	
Lv	275		80		461	152	170	527		1665
HV	66		51		78	92	79	103		469
MC	562		452		269	436	415	277		2411
UM	25		10		16	9	9	21		90
Sum	928	0	593	0	824	689	673	928	0	4635

Source: Analysis, 2022

Info. (Units in the vehicle / Day)
LV = Light vehicle, HV = High vehicle, MC = motorcycle, UM = Un- motorcycle
LT = Left turn , ST = straight, RT = Right turn

At the Three Way Petir Intersection, the highest number of traffic is on Monday, which is 4635 vehicles/ day, on the C arm, the left turning direction (LT) is dominated by the type of motor vehicle (Motorcycle, MC = 562) and in the right turn direction (RT) it is still the same dominated by the type of motor vehicle (MC = 452). On the D arm, the straight direction (ST) is dominated by light vehicles (Light Vehicle, LV=461), and the right turning direction (RT) is dominated by motor vehicles (MC=436). On the B arm, the left turning direction (LT) is dominated by motor vehicles (MC = 415), and the straight direction (ST) is dominated by light vehicles (LV=527). Traffic data for each arm on the intersection above can be shown in Picture 4 of the following graph:

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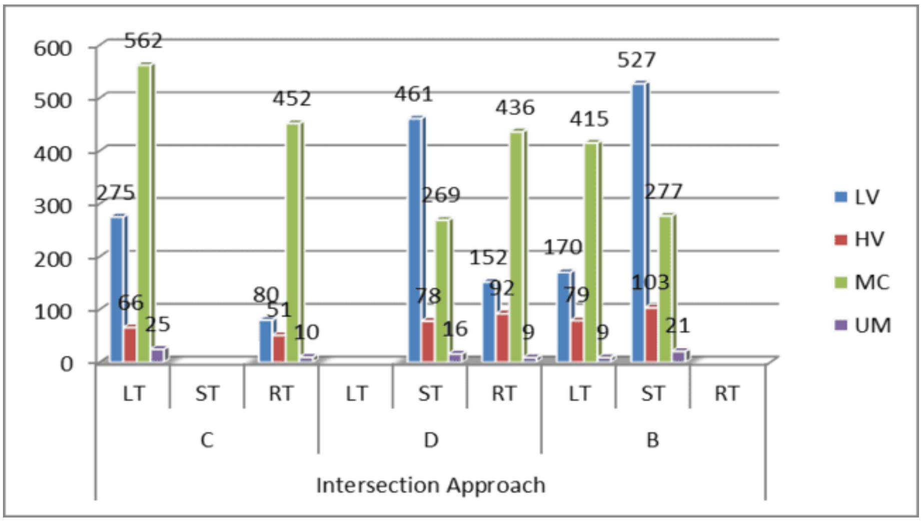

Figure 4. Graph of the Number of Vehicles on Intersection Approach. Source: Analysis, 2022

From Picture 4 of the graph of the number of vehicles on Intersection Approach, it can be seen that the left turning direction (LT) on the short arm C has the highest number of vehicles of all, namely motor vehicles (MC) as many as 562 vehicles. From arm B (Baros Direction) on Monday light vehicles (LV) numbered the most at 527 vehicles.

Table 3 Traffic Composition

Traffic Composition		**LV%**		**HV%**		**MC%**		**MV%**	**Pcu - Factor**	**K-Factor**	
Traffic Flow	**Direction**	**Light Vehicles (LV)**	**Pce= 1,0**	**Heavy Vehicles Pce=1,3 (HV)**		**Motorcycle Vehicles (MC)**	**Pce= 0,5**	**Total Motor Vehicles (MV)**		**Turn Ratio**	**Non-motorized vehicles (UM)**
Shorts		**Vhc/hr**	**Pcu/hr**	**Vhc/hr**	**Pcu/hr**	**Vhc/hr**	**Pcu/hr**	**Vhc/hr**	**Pcu/hr**		**Vhc/hr**
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
Minor Road A	LT										
	ST										
	RT										
	Total										
Minor Road C	LT	275	275	66	85,8	562	281	903	641,8	0,92387644	25
	ST										
	RT	80	80	51	66,3	452	226	583	372,3	0,3667112356	10
	Total	355	355	117	152,1	1014	507	1486	1014,1		35
Main Road B	LT	170	170	79	102,7	415	207,5	664	480,2	0,412664223	9
	ST	527	527	103	133,9	277	138,5	907	799,4		21
	RT										
	Total	697	697	182	236,6	692	346	1571	1279,6		30
Main Road D	LT										
	ST	461	461	78	101,4	269	134,5	808	696,9		16
	RT	152	152	92	119,6	436	218	680	489,6	0,41264223	9
	Total	613	613	170	221	705	352,5	1488	1186,5		25
Main Road Total B-D		1310	1310	352	457,6	1397	698,5	3059	2466,1		55
Main+ Minor	LT	445	445	145	188,5	977	488,5	1567	11222	0,32239526	34
	ST	988	988	181	235,5	546	273	1715	1496,3		37
	RT	232	232	143	185,9	888	444	1263	861,9	0,2476	19

Main+Minor Total	Total	1665	1665	469	609.7	2411	1205,5	4545	3480,2	5818	90
Rasio Minor Road/(Main Road + Minor)									0,291391	UM/MV	0,01980198

Source: Analysis, 2022

Based on Table 3, the total traffic composition on main roads and minor roads is 3480.2 pcu/hour after all vehicles are validated against light vehicle types (LV), with a ratio of 0.291391, while the ratio of non-motorized vehicles (UM) to motor vehicles (MV) is 0.0198. The width of the calculation of the approach as in Table 4 below:

Table 4. Intersection Approach width and Intersection Type

Choice	**Number of Intersection Arms**	**Short Width (m)**							**Number of Lanes**		**Intersection Type**
		Minor Road		**Main Road**				**Average**			
		WA	**WC**	**WAC**	**WB**	**WD**	**WBD**	Intersection Approach width **W1**	**Minor Road**	**Minor Road**	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**
1	3		7	7	7	7	7	7	2	2	322

Source: Analysis, 2022

Based on Table 4 shows the average short and short widths on minor roads and main roads. The average short width of the W1 is used to calculate the left turning capacity (FLT) and right turn (FRT) adjustment factors. Each of the arms C,B,and D has a lane width of 3 m with the shoulder width on each side of the road being 0.5 m, so the average short width of the W1 is 7 m.

Table 5. Three Way Petir Intersection Capacity

Choice	**Base Capacity**	**Capacity completion factor**							
		Average Approach Width	**Main Road Median**	**City Size**	**Side Obstacles**	**Side Obstacles**	**Turn**	**Minor Ratio**	**Capacity**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
	Co	F_W	F_M	F_{CS}	F_{RSU}	F_{LT}	F_{RT}	F_{MI}	C
1	2700	1,62	1	1	0,9	1,35905	0,86165	0,94428	33991,112

Source: Analysis, 2022

In Table 5 for the calculation of intersection capacity C, The base capacity of C_o is multiplied by the entire capacity adjustment factor (F). The basic capacity of C0 used is in accordance with the 1997 Indonesian Road Capacity Manual in the Chapter of unsignalized Intersections, which is 2700 pcu/ hour for the 322 intersection type. To calculate Fw, the formula FW = 0.73 +(0.0760 x W1) = 0.73 + (0.0760 x 7) = 1.262 is used. Main road without median, FM = 1; Based on data from the Central Statistics Agency of Serang Regency in 2020, the total population of Serang Regency is 1,482,987 people, so that Serang Regency is included in the category of Big cities (1.0 – 3.0 million people), used FCS city size factor = 1. The road environment type is commercial, with a low side resistance class, so the side resistance adjustment factor is used 0.9. The left and right turn factors, FLT = 1.3590 and FRT = 0.8616, respectively, can be shown in charts 4 and 5 below. The adjustment factor for the ratio of minor roads to total main roads and minor roads (FMI) is 0.9442, so that the value of the intersection capacity, C is 3,391,112 pcu / hour.

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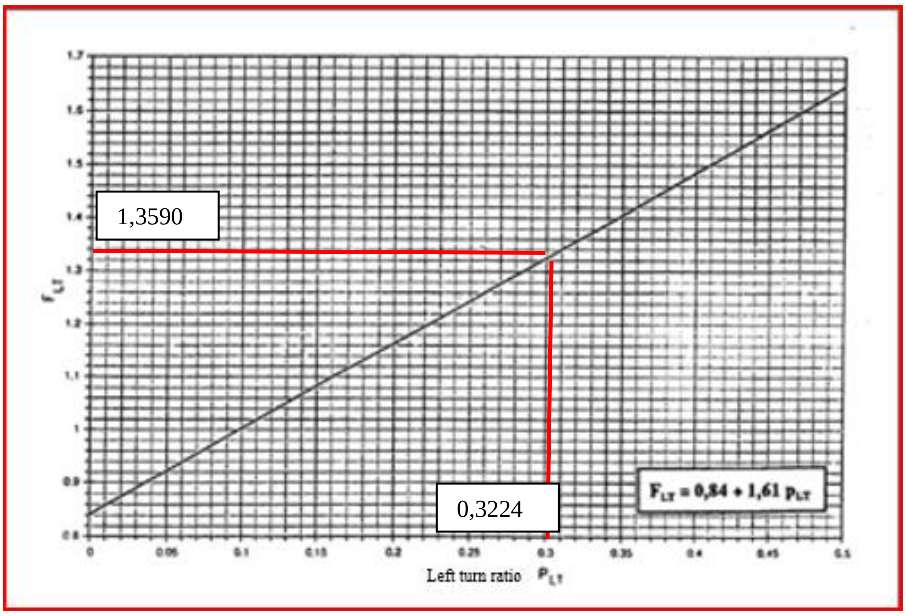

Figure 5. Left Turn Ratio Adjustment Factor Graph, FLT. Source: MKJI 1997, Analysis 2022

Based on Picture 5, the graph of the factor adjustment factor of the left turn ratio (FLT) to the left turn ratio (PLT) is shown by the relationship of the uphill linear line . The PLT value is 0.3224 so the FLT value is 1.3590. This shows that the value of the left turn ratio (FLT) factor is influenced linearly by the value of the left turn ratio (PLT). The higher the PLT value, the higher the FLT value.

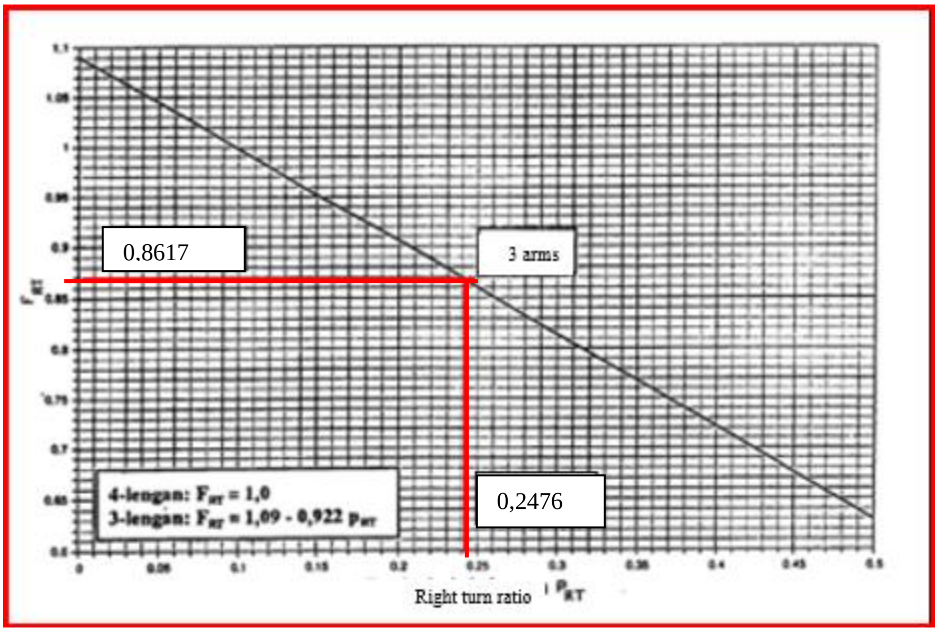

Figure 6. Right Turn Ratio Adjustment Factor Graph, FRT. Source: MKJI 1997, Analysis 2022

Based on Picture 6, the graph of the right turn ratio (FRT) to right turn ratio (PRT) adjustment factor is still shown with a decreasing linear line relationship. The PRT value is 0.2476 so the FRT value is 0.8617. This shows that the value of the right turn ratio (FRT) factor is influenced linearly by the value of the right turn ratio (PRT). However, in contrast to the left turn ratio (FLT) factor, if the PLT value is higher, then the FLT value is higher as well. Conversely, on the right turn factor, the higher the prt value, the lower the prt value. This is due to the possibility that the interchange arms are only three in number, from the short sleeve B there is no direction to turn right.

Table 6. Traffic Behavior

Choice	Traffic Flow	Degree of Saturation	Intersection traffic delay	Traffic Delay Main Road	Traffic Delay Minor Road	Intersection Geometric Delay	Snooze Intersection	Queue Opportunities	Goal
	Q (pcu/hr)	DS	DT1	DMA	DMi	DG	D	QP%	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	3480,2	1,0267	16,4265	7,45846	38,23552	4	20,4265	84,0088	Ds<0,75

Source: Analysis, 2022

From Table 6, several parameters of traffic behavior at the Three Way Petir Intersection showed the Total Value of traffic flow of 3,480 pcu / hour, the saturation degree (DS) value was 1,026, which means, the traffic flow has exceeded the road capacity, the delay of intersection traffic is 16.426 sec/pcu, the delay of main road traffic (B-D) is 7.4584 sec /pcu and the delay of minor road traffic (C) is 38.2352 sec /pcu, geometric delay of intersection (DS≥1.0 ; = 1.026) i.e. 4 s/smp, intersection delay of 20.425 sec/pcu, queue odds between 42.3554% and 84 %). For the target of an acceptable degree of saturation, according to the 1997 MKJI, DS < 0.75, an alternative problem solving is needed at the Three Way Petir Intersection.

Table 7. Intersection Capacity After Change

Choice	Base Capacity	Capacity completion factor							
		Average Intersection Approach Width	Main Road Median	City Size	Side Obstacles	Side Obstacles	Turn	Minor Ratio	Capacity
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Co	F_W	F_M	F_{CS}	F_{RSU}	F_{LT}	F_{RT}	F_{MI}	C
1	2700	1,3122666667	1	1	0,9	1,421235	0,944753	0,995005	42261,578

Source: Analysis, 2022

The capacity of the intersection after the change in the form of a ban on right turns from minor roads and the addition of the width of the main road lanes rose to 4,261,578 which was previously 3,391,112 (an increase of 25.67%).

Table 8. Traffic Behavior After The Change

Choice	Traffic Flow	Degree of Saturation	Intersection traffic delay	Traffic Delay Main road	Traffic Delay Minor road	Intersection Geometric Delay	Snooze Intersection	Queue Opportunities	Goal
	Q (pcu/hr)	DS	DT1	DMA	DMi	DG	D	QP%	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1	3107,9	0,729283	20,20272	-3,2752199	1100,41612	4	24,202273	43,5711521	Ds<0,75

Based on Table 8, after the change, the value of the degree of road saturation (DS) has dropped to 0.729 which was previously 1.0262, which means that the target of saturation degree of 0.75 according to the 1997 MKJI can be achieved. The widening of the road is planned by increasing the width from 3m to 3.5 meters per lane, as well as a shoulder width of 0.5 m, 1000 m long, so that the required volume of cast concrete is (1000 m x 1 m x 0.3 m x 2.4 = 720 m3) The calculation of planning costs needed for this work can be shown in table 4.9 below. The total cost required is Rp. 2,220,051,000 (two billion two hundred and twenty million fifty-one thousand rupiah).

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Table 9. Planning the Cost of Widening the Main Road at the Three Way Petir Interchange

	Job Price Recapitulation	
Program:	**Increased Capacity of Three Way Petir Intersection**	
Activities:	**Main Road Widening Plan**	
Job Package:		
Prop/Kab/Kodya:	**Serang City**	
No.	**Description**	**Amount of Job Price (Rp)**
1	Common	180.750.000,00
2	Drainage	-
3	Earthworks	59.262.599,63
4	Pavement Widening and Road Shoulders	41.172.074,03
5	Non asphalt pavement	1.188.391.656,25
6	Asphalt Pavement	
7	Structure	528.310.000
No.	**Description**	**Amount of Job Price (Rp)**
8	Return of conditions and minor work	20.391.656,25
9	Daily Work	
10	Routine maintenance work	
(A) Total Employment Price (including general costs and profits)		2.018.228.201,28
(B) Value Added Tax (PPN) = 10% x (A)		201.822.820,13
(C) Total Amount of Employment Price = (A + B)		2.220.051.021,41
(D) Rounded		2.220.051.000,00
Fairly fair	Two Billion Two Hundred Twenty Million Fifty-One Thousand Rupiah	

CONCLUSION

Based on the above Analysis, it can be concluded that, the existing performance at the Three way Petir Intersection which shows the Total Value of traffic flow is 3,480 pcu / hour, the degree of saturation (DS) value is 1.026, which means, the traffic flow has exceeded the road capacity, the delay of intersection traffic is 16.426 sec / pcu, the delay of main road traffic (B-D) is 7.4584 sec /pcu and the delay of minor road traffic (C) is 38.2352 sec /pcu, intersection geometric delay (DS≥1.0 ; = 1.026) , intersection delay 20.425 sec/pcu, queue odds between 42.3554% and 84 %). Based on calculations using the 1997 MKJI so that the DS value is not greater than 0.75 Alternative problem solving is tried by prohibiting in turn right traffic from minor roads, as well as widening efforts on the main road from 3 m per lane to 3.5 m so that the short width of each lane = 3.5 m and the shoulder width of 0.5 m, the total becomes 8 m, so that the saturation degree value below 0.75 can be obtained. The costs required by planning the widening of the road are planned by increasing the width from 3m to 3.5meters per lane, as well as a shoulder width of 0.5 m, 1000 m long, so that the volume of cast concrete needed is (1000 m x 1 m x 0.3 m x 2.4 = 720 m3) of Rp 2,220,051,000 (two billion two hundred twenty million fifty-one thousand rupiah)

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