Performance Analysis of Road Section and Unsignalized Intersections On Jalan Cileungsi Setu and Jalan Raya Narogong

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Abstract

The unsignalized intersection which is located in Cileungsi District, precisely on Jalan Cileungsi Setu and Jalan Raya Narogong, is a commercial area with dense economic activity and densely populated settlements. As a result of the dense activity, congestion occurs due to the large number of vehicles passing the road, especially during peak hours, namely the morning and evening. Seeing this problem, an analysis is needed that aims to determine the volume, performance of roads, and unmarked intersections as measured by capacity, degree of saturation, and level of service. In analyzing this study using the Indonesian Road Capacity Manual (MKJI) 1997 method which will determine the performance of roads and intersections without signs. The data needed in this research are primary data in the form of geometric road data, traffic volume, vehicle speed data, and side friction. As well as secondary data in the form of location maps, land use, and population data. From the results of data analysis and processing, the busiest traffic flow at the intersection occurred on Sunday, November 15, 2020 at 17.30 - 18.30 WIB, the saturation degree value was 1.17 with LOS F. By doing an alternative solution, the saturation degree value was 0.68 and LOS B with placing signs are prohibited from stopping around intersections, and prohibiting the flow of traffic turning right either from the main road D to the Minor C road or from the Minor C road to the main road B. On Jalan Raya Narogong, the degree of saturation is 0.74 LOS C service, this shows that the road sections do not exceed the figure required by MKJI 1997, namely $\leq$ 0.75.

Keywords: *Unsignalized Intersections, Roads, Degree of Saturation, Service Levels.*

1. Introduction

Bogor Regency is an area that is growing relatively fast and one of the areas in West Java which has a fairly high population. Based on projections, the total population in Bogor Regency in 2018 is 5,840,907 people, consisting of 2,983,278 male residents and 2,857,629 female residents. When compared to the population in 2017, the population of Bogor Regency experienced a population growth rate of 2.20% [2].

With the increase in population there has been a development in every sector, starting from the social, economic and cultural sectors which are marked by consumptive, productive, public services, distribution services and government, demanding an increase in transportation needs that are in harmony and balanced to support daily activities. However, another impact of the development of this sector is that there is a complex problem with traffic in Bogor Regency, namely congestion.

One of the locations in Bogor Regency which is experiencing traffic problems is in Cileungsi District, namely on Jalan Cileungsi Setu - Jalan Raya Narogong. Traffic jams and busyness often occur at roads and intersections, especially during rush hours, namely the morning and evening. The density of vehicles at the intersection can be caused because Jalan Cileungsi Setu and Jalan Raya Narogong are connecting routes between regions, and are road access to housing in Metland Transyogi, Pasar Cileungsi, Hospitals, Schools, Shopping Centers, etc.

From these observations, the density at the intersection is also influenced by the absence of traffic lights and side obstacles which also add to the problems at the intersection. From the conditions of the intersection of Jalan Cileungsi Setu and Jalan Raya Narogong that have been described, it can be seen that the intersection has quite a complex problem and it is necessary to conduct research to determine the performance of these roads and intersections. As well as looking for alternative solutions to deal with congestion at these road sections and intersections. The research location can be seen in Figure 1.

Fig 1. Research Locations for Intersections and Roads

2. Literature Review

Transportation in general can be defined as an effort to move, or the movement of people or goods from one location, which is called the location of origin, to another location, which is usually called the destination location, for certain purposes also use certain tools [6]. The transportation system can be interpreted as a unit of components that support each other and work together in the provision of transportation services that serve areas ranging from local (rural and urban) to national and international levels [6].

The presence of certain activity functions on land indicates that certain activities are taking place on the land in question, for example settlements, markets, tourist attractions, ports, terminals, train stations, businesses, offices, etc. All activities that take place on this land are referred to as land use. (TGL) which has the potential to cause travel flows. According to [7] predicting and estimating the number of potential travel flows arising from a land use is carried out through a 4-stage transportation planning concept, namely:

a. Travel awakening
b. Travel distribution
c. Choice of transportation mode that will be used
d. Choice of route

According to the Republic of Indonesia Law Number 38 of 2004 defines a road as land transportation infrastructure which includes all parts of the road, including complementary buildings and equipment intended for traffic, which are on ground level, above ground level, below ground level and / or water, as well as above the water level, except for railways, lorries and cable roads.

An intersection is an area where two or more roads meet, join, intersect or cross. An intersection can also be referred to as a meeting between two or more roads, either one level or not a level or a point in the road network where the roads meet and the road intersects.

3. Methods

Method used consists of several stages, namely the preparation stage, the data collection stage, and the data analysis stage. The preparatory stage discusses the preliminary survey carried out before the research, the data collection stage discusses data collection methods, the analysis stage discusses the processing and analysis of data carried out based on the 1997 Indonesian Road Capacity Manual (MKJI) for urban roads and unsigned intersections, and the evaluation stage for the conclusions of the study. The data used for the calculation of the performance analysis of roads and intersections without signal include primary and secondary data.

3.1 Primary Data Primary

Data is obtained by conducting direct surveys at the research location, including:

a. Geometric Conditions
b. Environmental Conditions
c. Traffic Data
d. Side Obstacle Data
e. Existing Speed Data

3.2 Secondary Data

For secondary data obtained from related agencies and self-search, secondary data required in the study include:

a. Population Data
b. Location Map
c. Land Use

3.3 Research Time

research was conducted for 3 (three) days, namely Monday (9 November 2020), Friday (13 November 2020) and Sunday (15 November 2020). The research was conducted for 2 hours during peak hours, namely in the morning at 06.30 - 08.30, at noon at 11.30 - 13.30 and in the evening at 16.30 - 18.30.

4. Results and Discussion

4.1 Performance of Unsignalized Intersections

Analysis of intersections is carried out atintersections on Jalan Cileungsi Setu and Jalan Raya Narogong. The data used are primary data in the form of geometric data, environmental data and traffic data, side friction data, and vehicle speed data obtained through direct observations and surveys at the research location. As well as secondary data obtained from related agencies.

4.2 Geometric Data

Intersection of Jalan Cileungsi Setu and Jalan Raya Narogong is an intersection of type 322 which means an intersection of 3 arms with 2 lanes on the minor road and 2 lanes on the main road. Existing geometric data at the intersection can be seen in table 1 and illustration of the intersection in Figure 2. Existing geometric data at the intersection include:

a. Geometric data for the main road on Jalan Cileungsi Setu (Arm D)
b. Geometric data for the minor road on Jalan Raya Narogong towards Bekasi (Arm C)
c. Geometric data of the main road of Jalan Raya Narogong towards Bogor (Arm B)

Table 1. Existing Geometric Data of Intersection

Description	Jalan Cileungsi Setu Road (Arm D)	Narogong Highway towards Bekasi (Arm C)	Narogong Highway towards Bogor (Arm B)
Road Type	Main	Minor	Main
Road Type	2/2 UD (2 lanes 2-way without separation)	2/2 UD (2 lanes 2-way without dividing)	2/2 UD (2-lane 2-way without dividers)
Lane Width (m)	3.55	3.8	3.9
Road Width (m)	2 x 3.55	2 x 3.8	2 x 3.9
Shoulders Width (m)	-	-	-
Median Road Width (m)	-	-	-
Sidewalks Street Width (m)	-	-	-

Fig 2. Illustration of Unmarked Intersection Jl. Cileungsi Setu - Jl. Raya Narogong

4.3 Intersection Traffic Data

Following is the intersection survey enumeration which was conducted for 2 hours in 3 days, namely Monday, Friday, and Sunday by taking morning, noon and evening. Recapitulation of Survey Results can be seen in table 2 and graphs of survey results can be seen in Figure 3.

Table 2. Recapitulation of Intersection Survey Results Monday, Friday, and Sunday

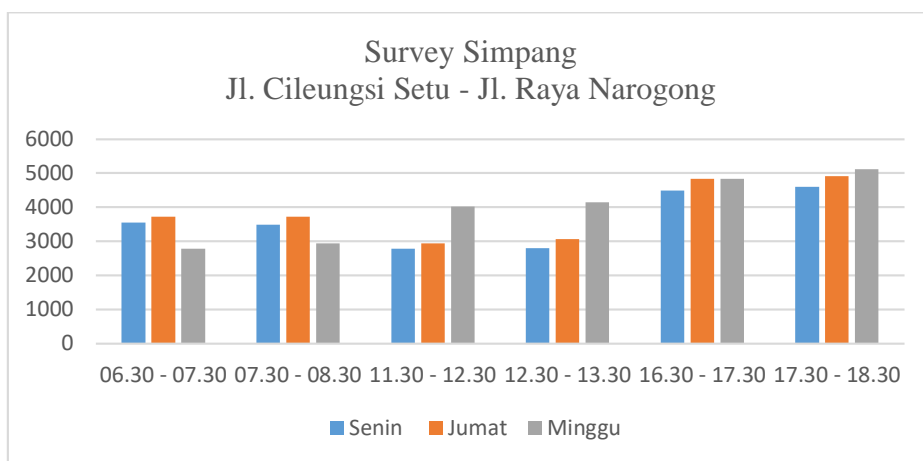| Time	Monday, November 9th, 2020	Friday, 13 November 2020	Sunday, November 15 2020
	Total (pcu / hour)	Total (pcu / hour)	Total (pcu / hour)
06.30 - 07.30	3549.1	3721.9	2785.8
07.30 - 0 8.30	3480.9	3728.6	2937.9
11.30 - 12.30	2784.3	2938.4	4015.4
12.30 - 13.30	2794.6	3066.3	4152.1
16.30 - 17.30	4492	4836.5	4837.1
17.30 - 18.30	4606.3	4912.6	5119.5

Fig 3. Graph of Intersection Survey Results for Cileungsi Setu - Jalan Raya Narogong

The busiest traffic volume occurs on Sundays and peak hours are obtained 17.30 - 18.30 with Qtotal = 5119.5 pcu / hour. This data will be used as a reference for calculating the unsignalized intersection analysis. The results of the intersection survey can be seen in table 3.

Table 3. The results of the intersection survey for Sunday, November 15, 2020 at 17.30 - 18.30

Approach		Sunday, 15 November 2020 Afternoon (17.30 - 18.30)						
		LV	LV (emp: 1)	HV	HV (emp: 1.3)	MC	MC (emp: 0.5)	UM
		veh / h	smp / hour	veh / h	smp / hour	veh / h	smp / hour	veh / h
road Cileungsi Setu (Arm D)	LT	—	—	—	—	—	—	—
	ST	366	366	13	16.9	953	476.5	6
	RT	382	382	21	27.3	929	464.5	4
Jalan Raya Narogong towards Bogor (Arm B)	LT	359	359	31	40.3	889	444.5	3
	ST	336	336	14	18.2	901	450.5	5
	RT	—	—	—	—	—	—	—
Narogong Highway towards Bekasi (Arm C)	LT	348	348	29	37.7	915	457.5	8
	ST	—	—	—	—	—	—	—
	RT	369	369	47	61.1	929	464.5	10
		2 160	2 160	155	201.5	5516	2758	36
Total Vehicles		7867						veh / h
Total Vehicle		5119.5						smp / hour

4.4 Results of the calculation of the intersection without signal
a. Total Capacity of Unsignalized Intersection

The total capacity for all intersection arms is the result of the multiplication of the basic capacity (C_0), namely the capacity under certain conditions (ideal) and the adjustment factors (F) taking into account the effect of field conditions on capacity. The formula for the total capacity of the unnamed intersection and the results of the intersection capacity can be seen in   table 4.

C = C0 x FW x FM x FCS x FRSU x FLT x FRT x FMI

C = 2700 x 1.01 x 1 , 00 x 1.05 x 0.86 x 1.37 x 1.40 x 0.92

C = 4345.2 pcu / hour

Table 4. Capacity for the Intersection of Jalan Cileungsi Setu and Jalan Raya Narogong

Basic Capacity CO pcu / hour	Capacity adjustment factor (F)							Capacity (C) pcu / hr
	width approach Average FW	Median road main FM City	size FCS	Side obstacle	Turn left FLT	Turn right FRT	ratio Minor / totalFMI	
(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)
2700	1.01	1.00	1.05	0.86	1.37	1.40	0.92	4345,2

b. Degree of Saturation

Degree of saturation is defined as the ratio of traffic flow to capacity, used as a major factor in determining the level of performance of intersections and road segments (MKJI 1997). The degree of saturation for all intersections, and traffic behavior can be seen in table

DS = Qsmp / C

DS = 5119.5 / 4345.2

DS = 1.17

Table 5. Traffic Behavior at the Intersection of Jalan Cileungsi Setu and Jalan Raya Narogong

options	flow traffic Q (smp / hour)	degree of satura-tion (DS)	Delay traffic intersec-tion DTI	Delay traffic Jl.Utama DTMA	Delay Jl.Mi-nor traffic DTMI	Delay geometric intersection (DG)	Delay inter-section (D)	Opportunity Queue (QP%)	Goal
1	5119,5	1,17	30,10	18,35	52,96	4	34,1	55,63 - 112,47	DS ≤ 0,75

c. Service Level

From the results of the analysis with the Indonesian Road Capacity Manual Method (MKJI) 1997, the intersection of Jalan Cileungsi Setu and Jalan Raya Narogong has a degree of saturation of DS = 1.17 which exceeds the target of the study, namely ≤ 0.75 and is at the *Level of Service.* ClassF. Therefore, it is necessary to do an alternative solution so that the congestion at the intersection of Jalan Cileungsi Setu and Jalan Raya Narogong can be overcome.

4.5 Alternative Solutions for Alternative Intersection

Alternative 1

Alternative one is carried out by changing the value of the adjustment factor for the type of side obstacle road and non-motorized vehicle (F_{RSU}) from 0.86 to 1.0, placing signs that are prohibited from stopping and controlling public transportation so that it does not stop too long around the intersection.

Alternative 2

Alternative two is to change the value of the adjustment factor for the environmental type of sideways and non-motorized vehicles (F_{RSU}) from 0.86 to 1.0, placing prohibited stop signs, and prohibiting the flow of traffic that will turn right from the minor road C.

Alternative 3

Alternative three is by changing the value of the environmental type adjustment factor, side friction and non-motorized vehicles (F_{RSU}) from 0.86 to 1.0, placing prohibited stop signs, and prohibiting the flow of traffic that will turn right either from Main D road to Minor road C and from road Minor C to main road B.

To recapitulate the results of data processing of unsigned intersections on Jalan Cileungsi Setu and Jalan Raya Narogong can be seen in table 6.

Table 6. Recapitulation of Unmarked Intersection Data Processing Results

Components ofIntersection Capacity	Sunday Afternoon			
	Existing	Alternative 1	Alternative 2	Alternative 3
Intersection Type	322	322	322	322
Capacity (Co)	2700	2700	2700	2700
Approach Width Adjustment (Fw)	1.01	1.01	1.01	1.01
Median Width (FM)	1.00	1.00	1.00	1.00
City Size Adjustment (FCS)	1.05	1.05	1.05	1.05
Side Barriers (FRSU)	0.86	1.00	1.00	1.00
Left Turn Ratio (PLT)	0.33	0.33	0.39	0.50
Turn Left(FLT)	1.37	1.37	1.46	1.64
Turn Right Ratio (PRT)	0.34	0.34	0.20	0
AdjustmentRight Turn Adjustment (FRT)	1.40	1.40	1.27	1.09
Adjustment Minor Road Flow Ratio (FMI)	0.92	0.92	1.00	0.96
Intersection Capacity (pcu / hour)	4345.2	5052.5	5309.2	4913.7
Traffic Flow (pcu / hour)	5119.5	5119.5	4224.9	3351.1

Degree of Saturation (DS)	1.17	1.01	0.79	0.68
Intersection Traffic Delay (sec / junior high school)	30.10	15.47	8.88	7.12
Major Traffic Delay (sec / smp)	18.35	10.78	6.54	5.3
Minor Traffic Delay (sec / smp)	52.96	24.59	18.26	12.53
Intersection Geometric Delay (sec / pcu)	4	4	4.16	4.16
Intersection Delay (sec / pcu))	34.1	19.47	13.04	11.28
Chance of Queuing (%)	55.63% - 112.47%	40.99% - 81.19%	25.19% - 50.13%	18.98% - 38.78%
Target LOS	F	F	C	B

4.6 Performance Roads

Analysis ofAnalysis of roads in Do this on the main road, namely Jalan Raya Narogong, using standard tables described in the 1997 Indonesian Road Capacity Manual (MKJI) on Urban Roads. Analysis of road data refers to data on Sundays at 17.30 - 18.30 WIB where the highest peak flow occurs.

4.7 Road Section Geometric Data

Geometric conditions of the road sections required for the calculation are as follows:
Road Section Name   : Narogong
Highway Type of road   : 2/2 UD, 2 lanes 2 undivided directions
Width per lane   : 3.9 meters
City Size   : Very Large (> 3.0 million people)
Environmental Type   : Commercial, there are markets, shops, residential areas, etc. Median
                       : None
Alignment Type   : Flat
Traffic Signs   : No
Road Markings   : None

Fig 4. Front View of the Road Raya Narogong

4.8 Road Traffic Volume Data

For road section analysis, traffic data were obtained from direct surveys at the research location for 3 days. The research was conducted on Monday, 9 November 2020, Friday, 13 November 2020 and Sunday, 15 November 2020. From the results of the occurred at Sunday, November 15 2020, 17.30 - 18.30. Graph of total flow can be seen in Figure 5.
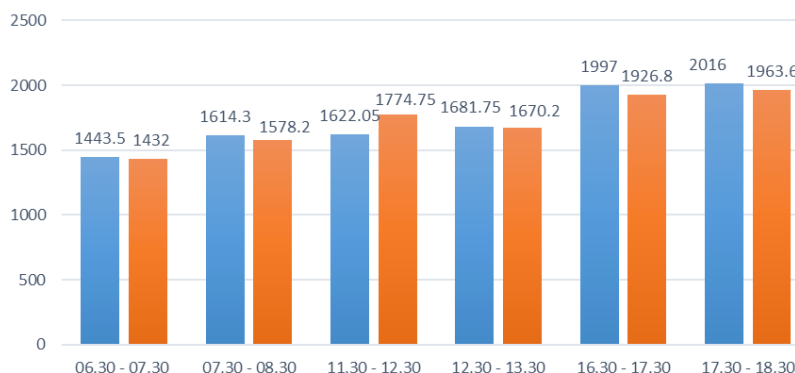

Fig 5. Graph of Total Flow on Jl. Raya Narogong on Sundays

Based on the survey results, the Narogong Highway section on Sunday, November 15, 2020, has the highest traffic in the morning, namely 1614.3 pcu / hour on Jl. Raya Narogong heading to Cileungsi at 07.30 - 08.30, during the day at 1774.75 pcu / hour on Jl. Raya Narogong heading to Bogor at 11.30 - 12.30, and in the afternoon, 2016 smp / hour on Jl. Raya Narogong heading towards Cileungsi at 17.30 - 18.30. Recapitulation of volume of roads can be seen in table 7.

Table 7. Recapitulation of Volume of Roads Used

Time	Jl. Raya Narogong			
	Direction Cileungsi		Direction Bogor	
	Vehicle / hour	Pcu / hour	vehicle hour	Pcu / hour
Morning	2814	1614.3	2747	1578.25
Noon	2713	1681.75	2861	1774.75
Afternoon	4219	2016	4179	1963.6

4.9 Calculation of Road Performance

a. Actual Speed of Roads

To get the actual speed of vehicles on Jalan Raya Narogong, a vehicle speed survey was carried out using a *speed gun*. This survey was carried out along 300 m, where the distance is part of the research survey location segment. In taking the sample the researchers took 3 samples of each type of vehicle in the form of light vehicles, heavy vehicles and motorbikes. Vehicle speed on Jalan Raya Narogong can be seen in table 8.

Table 8. Sample Vehicle Speed

Time	Direction Cileungsi						Direction Bogor					
	LV	Kec. Average (km / hour)	HV	Kec. Average (km / hour)	MC	Kec. Average (km / hour)	LV	Kec. Average (km / hour)	HV	Kec. Average (km / hour)	MC	Kec. Average (km / hour)
Morning	28		21		30		30		18		29	
	30	**30**	19	**21.3**	34	**31**	27	**28.6**	22	**22.6**	30	**28.6**
	32		24		29		29		28		27	
Noon	29		25		27		32		25		32	
	30	**28.6**	26	**24.3**	32	**29.6**	27	**28**	27	**25**	30	**30**
	27		22		30		25		23		28	
After-noon	26		24		32		27		26		29	
	24	**26.3**	21	**22.6**	29	**29**	31	**27.3**	23	**23.6**	31	**29**
	29		23		26		24		22		27	

b. Capacity

Capacity can be defined as sustained traffic flow from a part of the road under certain conditions, in vehicles / hour or pcu / hour (MKJI 1997). The basic equation for determining capacity on urban roads can be seen in table 9.

$C = C_o \times FC_W \times FC_{SP} \times FC_{SF} \times FCCS$

C = 2900 x 1.112 x 1 x 0.81 x 1.04

C = 2716.5 pcu/ hour

Table 9. Capacity of Narogong Highway

Parameter Roads	Highways Narogong (2/2 UD)
Co.	2900
FCW	1,112
FCSP	1
FCSF	0.81
FCCS	1.04
C	2716.5

d. Degree of Saturation

value of the degree of saturation is used as the main factor that can determine the level of service of a road, whether the road section under study has a capacity problem or not. The degree of saturation is defined as the ratio or ratio of traffic flow to capacity. The degree of saturation is calculated using the formula below and can be seen in table 10.

DS = Q / C
DS = 2016 / 2716.5
DS = 0.74

Table 10. Degree of saturation of Narogong Highway

Roads	Time	Traffic Volume (Q)	Road Capacity (C)	Degree of Saturation
Highway Narogong	Morning	1614.3	2716.5	0.59
	Noon	1681.75	2716.5	0.61
	Afternoon	2016	2716.5	0.74

e. Service Level

The Indonesian Road Capacity Manual (MKJI. 1997) defines the *level of service (LOS) of* a road segment as a qualitative measure that reflects the driver's perception of the quality of driving a vehicle. Service level value refers to DS. The level of road service can be seen in table 11.

Table 11. Service Levels of Jalan Raya Narogong

Time	Volume Traffic (Q)	Capacity (C)	Free Flow Speed	Degree of Saturation (DS)	Average Vehicle Speed (FVLv)	Level Road Service (LOS)
	Smp / hour	Smp / hour	Km / hour		Km / hour	
Morning	1614.3	2176 , 5	43.01	0.59	33	A
Noon	1681.75	2176.5	43.01	0.61	33	B
Afternoon	2016	2176.5	43.01	0.74	30	C

5. Conclusion

From the results of field surveys and the results of data analysis calculations that have been carried out, The following conclusions can be drawn:

1. At the unsignalized intersection at Jalan Cileungsi Setu and Jalan Raya Narogong based on the results of a survey conducted for three days, the highest volume was found on Sunday, November 15, 2020 at 17.30 - 18.30 WIB, indicating the volume intersection 5119.5 pcu / hour with an intersection capacity of 4345.2 pcu / hour.
2. Based on the calculations that have been made in accordance with MKJI 1997, the value of the degree of saturation (DS) at peak hour traffic volume is 1.17 for the intersection traffic delay (DT$_I$) of 30.10 sec / pcu, traffic delay main road (DT$_{MA}$) is 18.35 sec / pcu, minor road traffic delay (DT$_{MI}$) is 52.96 sec / pcu, intersection geometric delay (DG) is 4 sec / pcu, intersection delay (D) is 34 , 1 sec / pcu. With these results, the Queuing Chance (QP%) value is 55.63% - 112.47%. Because the DS value exceeds the target of the study, namely ≤ 0.75 and is at the *Level of Service* class F, it is necessary to make alternatives to reduce the degree of saturation and delay at the intersection.
3. Of the several alternatives made, only alternative 3 gets saturation (DS) and the smallest delay is the degree of saturation (DS) of 0.68 meaning that this is included in the number required by MKJI 1997, namely ≤ 0.75, with Intersection delay is 11.28 sec / smp, and the opportunity to queue is 18.98% - 38.78%. Alternative 3 is done by changing the value of the environmental type adjustment factor, side friction and non-motorized vehicles (F$_{RSU}$) from 0.86 to 1.0, providing a stop sign, and prohibiting the flow of traffic that will turn right from either the main road D leads to road Minor C or from road Minor C to main road B.
4. For roads, the highest volume of vehicles is on Jalan Raya Narogong heading to Cileungsi and Bekasi which is obtained on Sunday, November 15, 2020 at 17.30 - 18.30 WIB, namely 2016 pcu / hour with a capacity of 2716.5 pcu / hour. The degree of saturation value obtained for the performance of the Narogong Highway section at peak hours (DS) = 0.74 with the level of service (*Level of Service)* C, this indicates that the road section does not exceed the figure required by MKJI 1997, namely ≤ 0, 75.

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