

Performance Evaluation of Urban Road Sections on The Taman - Sepanjang Highway

Theresia MCA^{1a}, Ratih Sekartadji^{2a}, Kurnia H.P.^{3a}, Dewi Kusumaningrum^{4a}, Rizki R.^{5a}

^aInstitut Teknologi Adhi Tama Surabaya, Indonesia

Abstract. Taman - Sepanjang Highway is one of the roads that connects Sidoarjo Regency and Surabaya City. On this section of road there are many community activities which are dominated by shops, offices and education activities and are directly adjacent to dense residential communities. The volume of vehicles passing through this road is quite dense, such as motorbikes, light vehicles and heavy vehicles, plus side obstacles that disrupt the smooth flow of traffic, especially during peak hours. The method used for this research is the 1997 Indonesian Road Capacity Manual (MKJI) method and the main indicator is the degree of saturation (DS). The results of the analysis show that the performance of the Taman - Sepanjang Highway sections (Highway Kalijaten Segment and Ngelom Segment) in existing conditions does not meet the 1997 MKJI feasibility standards. The degree of saturation value for highway Kalijaten is 1.00 and highway Ngelom is 0.87. So both roads need to improve road performance. The alternatives are widening the road, the saturation degree (DS), widening the road and removing side obstacles, become a one-way road. By implementing those alternative, Taman - Sepanjang Highway was expected to meet degree of saturation by MKJI standard.

Keywords: Degree of Saturation, MKJI 1997, and Road Sections.

1. Introduction

Sidoarjo Regency has quite rapid physical development and growth, it is an area on the border of Sidoarjo and Surabaya, in this case the research location of Ngelom Village, Taman District. Taman District as part of the Sidoarjo Regency area has an area of 31.45 km² and with a population of 207,820 people (according to 2020 data), the overall population density of Taman District is 65.89 people/ha which is quite dense. The Along - Taman section is a provincial road which is the main access and connection between Sidoarjo district and the city of Surabaya. This road section is a two-lane, two-way undivided road type and has the function of Primary Collector Road-3 (JKP-3) which effectively connects district/city capitals (PERMENPU 2012). The Taman - Sepanjang Highway section is 1.45 km long and is divided into two segments, namely Ngelom Highway with a length of ± 500 m and Kalijaten Highway with a length of ± 950 m. On these two roads there is often a slowdown in traffic due to the large amount of activity on the side of the road which causes vehicles to park on the road (on street parking), vehicles moving slowly, pedestrian activity next to the road or crossing the road and vehicles stopping temporarily such as transport. general for dropping off or picking up passengers. Apart from that, there is access for vehicles in and out of the land at the edge of the road which is the cause of vehicle conflicts where incoming vehicles cut off the flow of vehicles joining the road. To overcome some of these traffic problems, it is necessary to conduct research to determine whether the performance of the two road sections is still capable of handling the current traffic flow. Based on research by Agus Hasan (2018) regarding Performance Evaluation of the Bogor Highway Section using MKJI 1997, it explains that the degree of saturation in the Cibinong direction is 0.81 on holidays, and the level of service tends to be unstable at low speeds, the degree of saturation in the Bogor direction is 0.59 on holidays and the level of service is smooth flow and low volume with high speed. According to Alyfia Indriana (2020) regarding the Performance of the Taman - Waru Road Section (Kletek Highway) based on the 1997 MKJI, explains that the Taman - Waru road segment has a DS value of 1.25 and a service level of E so that traffic engineering is needed to reduce the DS value so that road performance can increase.

2. Materials and Methods

The data required is road geometry, traffic situation and side obstacles

- Researchers obtained road geometric data through direct measurements at the location. The road geometric data includes the type of road, curbs and sidewalks, as well as the length and width of the road.
- The traffic survey was carried out using the enumeration method (traffic counting), and carried out at predetermined points/posts at the research location. All vehicles passing through survey points/posts will be recorded according to the type of vehicle. The survey was conducted over 3 days (2 working days and 1 holiday), and the survey was carried out every day at peak hours.
- Speed surveys are carried out by measuring the speed of light vehicles passing 2 (two) predetermined research points at a certain distance using a stopwatch.
- Side obstacle data is a direct calculation of every incident per hour per 200 meters in each lane being observed. This survey includes pedestrians (crossing the road), stopped vehicles, slow vehicles (rickshaws, carts and other non-motorized vehicles), as well as vehicles entering and exiting on the side of the road. Researchers obtained this data by positioning several observers at specified points, then recording the number of incidents mentioned above.

What is calculated is:

a. Traffic Volume

From the results of the traffic volume survey, the number of hourly traffic flows in vehicle units per hour (vehicles/hour) will be obtained, so to get the maximum traffic volume you must first convert the hourly traffic flow data for each movement into in pcu/hour which is done by multiplying pcu (passenger car units) by the number of traffic flows.

b. Side Obstacles

From the results of the side obstacle survey, the frequency of events is obtained, then each event will be multiplied by its respective weight value, then calculate the number of weighted events for all types of events, then this value can be used to determine the side obstacle class.

c. Road Capacity

The maximum flow capacity of a road section through a point on the road that can be maintained per unit hour under certain conditions. The value of road capacity is influenced by the basic capacity value and several factors such as road width, directional separation, side obstacles, sidewalk/road shoulder width, and city size.

d. Free Flow Speed

Free flow speed is the speed (km/hour) of a vehicle that is not influenced by other vehicles. The free flow speed of light vehicles is used as the primary measure of performance in this Manual. The value of the free flow speed is influenced by the basic free flow speed value of light vehicles and several factors such as the width of the road, side obstacles, the width of the sidewalk/road shoulder, and the size of the city.

e. Degree of Saturation

The degree of saturation (DS) is defined as the ratio of the ratio of flow (pcu/hour) to capacity (pcu/hour) and is used as the main factor in measuring the level of performance of a road segment.

f. Travel Speed

The travel speed value was obtained through a survey of the average travel time of light vehicles over a specified distance in the field.

3. Result and Discussion

3.1. Kalijaten Highway

The highest volume data occurs on Monday

Table 1. Monday's Vehicle Traffic Data

Time	Light Vehicle (LV)		Heavy Vehicle (HV)		Motor Cycle (MC)		Vehicle /hour	PCU/ hour
	1		1,2		0,25			
	Vehicle/ hour	PCU/ hour	Vehicle/ hour	PCU/ hour	Vehicle/ hour	PCU/ hour		
07.00-08.00	693	693	60	72	7215	1803,75	7968	2568,75
11.00-12.00	814	814	247	296,4	3700	925	4761	2035,4
16.00-17.00	795	795	102	122,4	4671	1167,75	5568	2085,15

The highest vehicle volume in the morning at 07.00 – 08.00 WIB was 7968, because the surrounding land use is an area of attraction and generation.

3.2. Ngelom Highway

The highest volume data occurs on Monday

Table 2. Vehicle Traffic Data for Monday

Time	Light Vehicle (LV)		Heavy Vehicle (HV)		Motor Cycle (MC)		Vehicle /hour	PCU/ hour
	1		1,2		0,25			
	Vehicle/ hour	PCU/ hour	Vehicle/ hour	PCU/ hour	Vehicle/ hour	PCU/ hour		
07.00-08.00	674	674	59	70,8	6316	1579	7049	2323,8
11.00-12.00	707	707	233	279,6	3133	783,25	4073	1769,85
16.00-17.00	739	739	134	160,8	4305	1076,25	5178	1976,05

The highest vehicle volume in the morning at 07.00 – 08.00 WIB was 7049, because the surrounding land use is an area of attraction and generation.

3.3. Side Obstacles of Kalijaten Highway

Table 3. Frequency of Side Obstacle Events Jl. Kalijaten

No	Type of Incident of side obstacle	Factor	Incident Frequency	Factor Frequency
1	Pedestrian (PED)	0,5	31	15,5
2	Parking and Stopping of Vehicle (PSV)	1,0	34	34,0
3	Enter and Exit Vehicle (EEV)	0,7	928	649,4
4	Slow Moving Vehicle (SMV)	0,4	41	16,4
Total				715,5

The total weighted frequency of events at the observation point on Kalijaten Highway is 715.5. Based on the 1997 Indonesian Road Capacity Manual (MKJI), the side obstacle class on the Kalijaten Highway is included in the High class, namely in the range 500 – 899 Events/Hour.

3.4. Side Obstacles of Ngelom Highway

Tabel 4. Frekwensi Kejadian Hambatan Sampung Jl. Ngelom

No	Type of Incident of side obstacle	Factor	Incident Frequency	Factor Frequency
1	Pedestrian (PED)	0,5	55	27,5
2	Parking and Stopping of Vehicle (PSV)	1,0	24	24,0
3	Enter and Exit Vehicle (EEV)	0,7	228	159,6
4	Slow Moving Vehicle (SMV)	0,4	26	10,4
Total				221,5

The total weighted frequency of events at the observation point on Ngelom Highway is 221.5. Based on the 1997 Indonesian Road Capacity Manual (MKJI), the side obstacle class on Ngelom Highway is included in the Low class, namely in the range 100 – 299 Events/Hour.

3.5. Kalijaten Highway Capacity

C_0 = Basic capacity is 2900 pcu/hour total in two directions. Because the road surveyed has 2 lanes in 2 undivided directions.

FCW = Capacity adjustment factor for traffic flow lane width is 1.25 (Table 2.4.) because the road width is 9 meters.

$FCSP$ = Capacity adjustment factor for direction separation is 0.94 (Table 2.5.) because the vehicle volume ratio for the two lanes is 60:40.

$FCSF$ = Capacity adjustment factor for side resistance is 0.84 (Table 2.6.) because the weighted frequency value of side resistance is 715.5 (High Side Resistance)

$FCCS$ = The capacity adjustment factor for city size is 0.90 (Table 2.7.) because the population in Taman District according to the source "Sidoarjo Regency in Figures 2021" is 207,820 people.

So:

$$C = C_0 \times FCW \times FCSP \times FCSF \times FCCS$$

$$C = 2900 \times 1,25 \times 0,94 \times 0,84 \times 0,90 = 2576,07 \text{ PCU/hour}$$

3.6. Ngelom Highway Capacity:

C_0 = Basic capacity is 2900 pcu/hour total in two directions. Because the road surveyed has 2 lanes in 2 undivided directions

FCW = Capacity adjustment factor for traffic flow lane width is 1.14 (Table 2.4.) because the road width is 8 meters.

$FCSP$ = Capacity adjustment factor for direction separation is 0.94 (Table 2.5.) because the vehicle volume ratio for the two lanes is 60:40.

$FCSF$ = Capacity adjustment factor for side resistance is 0.95 (Table 2.6.) because the weighted frequency value of side resistance is 221.5 (High Side Resistance)

$FCCS$ = The capacity adjustment factor for city size is 0.90 (Table 2.7.) because the population in Taman District according to the source "Sidoarjo Regency in Figures 2021" is 207,820 people.

So:

$$C = C_0 \times FCW \times FCSP \times FCSF \times FCCS$$

$$C = 2900 \times 1,14 \times 0,94 \times 0,95 \times 0,90 = 2657,03 \text{ PCU/hour}$$

3.7. Free Flow Speed on the Kalijaten Highway:

FV_0 = Basic free flow speed of light vehicles for two-lane two-way undivided roads (2/2 UD) 44 km/hour (Table 2.8.)

FVW = Speed adjustment for road width is 4 km/hour (Table 2.9.) because the road width is 9 meters.

$FFVSF$ = side resistance condition adjustment factor is 0.84 (Table 2.10.) because the side resistance weighted frequency value is 715.5 (High Side Resistance)

$FFVCS$ = speed adjustment factor for city size is 0.90 (Table 2.11.) because the population in Taman District according to the source "Sidoarjo Regency in Figures 2021" is 207,820 people.

So:

$$FV = (FV_0 + FVW) \times FFVSF \times FFVCS$$

$$FV = (44 + 4) \times 0,84 \times 0,90 = 36,28 \text{ km/h}$$

3.8. Free Flow Speed on the Ngelom Highway:

FV_0 = Basic free flow speed of light vehicles for two-lane two-way undivided roads (2/2 UD) 44 km/hour (Table 2.8.)

FVW = Speed adjustment for road width is 3 km/hour (Table 2.9.) because the road width is 8 meters.

$FFVSF$ = side resistance condition adjustment factor is 0.96 (Table 2.10.) because the side resistance weighted frequency value is 221.5 (Low Side Resistance)

$FFVCS$ = speed adjustment factor for city size is 0.90 (Table 2.11.) because the population in Taman District according to the source "Sidoarjo Regency in Figures 2021" is 207,820 people.

So :

$$FV = (FV_0 + FVW) \times FFVSF \times FFVCS$$

$$FV = (44 + 3) \times 0,96 \times 0,90 = 40,61 \text{ km/h}$$

3.9. Analysis of the Degree of Saturation of the Kalijaten Highway:

$Q = 2568.75$ PCU/hour

$C = 2576.07$ PCU/hour

So :

$$DS = Q / C = 2568.75 / 2576.07 = 1.0 \text{ (LOS E)}$$

3.10. Analysis of the Degree of Saturation of the Ngelom Highway:

$Q = 2323.80$ pcu/hour

$C = 2657.03$ pcu/hour

So :

$$DS = Q / C = 2323.80 / 2657.03 = 0.87 \text{ (LOS E)}$$

3.11. Speed analysis of light vehicles on Jl. Kalijaten

Table 5. Speed on the Kalijaten Highway

Time	Velocity (km/hour)	
	West Lane	East Lane
07.00 - 08.00	21,03	23,44
	42,35	17,14
	28,39	10,95
	24,42	34,29
	34,88	22,58
	25,82	30,03
	31,14	19,65
	37,89	24,73
	29,27	37,42
	17,84	29,51
Total	293,05	250,01
Average	29,30	25,00

Table 6. Speed on the Ngelom Highway

Time	Velocity (km/hour)	
	West Lane	East Lane
07.00 - 08.00	23,14	28,66
	21,10	28,48
	22,39	24,59
	21,40	26,91
	17,29	18,89
	24,00	25,82
	33,15	25,94
	19,46	26,20
	21,71	27,19
	17,79	23,41
Total	221,43	256,09
Average	22,14	25,60

3.12. Speed and Travel Time Analysis

Speed and Travel Time on the Kalijaten Highway:

Using the Formula:

$$V = L / TT$$

Where $V = 27.15$ km/hour

$L = 0.950$ km

So :

$$TT = L / V = 0.950 / 27.15 = 0.0350 \text{ hours} = 125.97 \text{ seconds}$$

3.13. Speed and Travel Time on the Ngelom Highway:

Using the Formula:

$$V = L / TT$$

Where $V = 23.88$ km/hour

$L = 0.500$ km

$$\text{So : } TT = L / V = 0.500 / 23.88 = 0.0209 \text{ hours} = 75.37 \text{ seconds}$$

4. Discussion:

Performance of Kalijaten and Ngelom highway (Existing Condition)

From the results of data processing above, the DS of Jl Raya Kalijaten is $1.00 > 0.74$ (tolerance limit) and Jl Ngelom DS is $0.87 > 0.75$ (tolerance limit) then the Jl. Raya Kalijaten and Jl. Ngelom has a low level of service = E, the flow is not constant, the speed varies and is low, the volume is close to the tamping capacity, for this reason, alternative solutions to overcome traffic problems that affect the performance of the road section with alternative routes on the road section change the direction of traffic flow to one direction. :

4.1. Kalijaten Highway:

Existing condition: Road width = 9 m, Sidewalk = 1.5 m

Alternative plan: Road width = 10 m, Sidewalk = 1 m

So, changes occurred

Table 7. Capacity analysis of Jl. Raya Kalijaten

Arah	Kapasitas Dasar	Faktor Penyesuaian Kapasitas				Kapasitas
		Lebar jalur	Pemisah arah	Hambatan Samping	Ukuran kota	
	Co	FCw	FCsp	FCsf	FCcs	C
1	2	3	4	5	6	7
	3300	1,25	0,94	0,84	0,90	2931,39

Table 8. Analysis of the Degree of Saturation of Alternatives

No	Q (PCU/hour)	C (PCU/hour)	DS	LOS
1	1549,05	2931,39	0,53	C

4.2. Free Flow Speed:

Existing conditions: road type = two lanes, two directions

Alternative plan: two-lane, one-way road type

So the change occurs in: FVo for a two-lane one-way road = 57 km/hour

Table 9. Free Flow Speed Analysis Jl. Raya Kalijaten alternative

Direction	Velocity	Adjustment factor	FVo + FVw	Adjustment factor		Velocity
				Side obstacle	Size of the city	
	FVo (km/hour)	FVw (km/hour)	(km/hour)	FFVsf	FFVc	FV (km/hour)
	57	3	60	0,96	0,90	51,8

Change in traffic direction on Kalijaten and Ngelom Highway from a two-lane, two-way road to a two-lane, one-way road, both roads will only be passed by vehicles from Sidoarjo (south direction) to Surabaya (north direction), while in the opposite direction you can passing the Karang Pilang – Wonocolo Bridge.

5. Conclusion

- Performance of the Kalijaten Highway and Ngelom Highway in existing conditions

a. On the Kalijaten Highway section, the peak hour for maximum traffic volume occurs on Monday, May 31 2021 at 07.00 – 08.00, with a total traffic volume of 2568.75 pcu/hour. The side resistance value is 715.5 which is included in the high side resistance class. The road capacity has a value of 2576.07 pcu/hour. The free flow speed has

value of 36.28 Km/Hour. The value of the degree of saturation on the Kalijaten Highway section is 1.00, where this value is included in Service Level E, namely the flow is not constant, the speed varies and is low, the volume is close to the capacity.

b. On the Ngelom Highway section, the peak hour for maximum traffic volume occurs on Monday, 31 May 2021 at 07.00 – 08.00, with a total traffic volume of 2323.80 pcu/hour. The side resistance value is 221.5 which is included in the low side resistance class. The road capacity has a value of 2657.03 pcu/hour. The free flow speed has

value of 40.61 Km/Hour. The value of the degree of saturation on the Ngelom Highway section is 0.87, where this value is included in service level E, namely the flow is not constant, the speed varies and is low, the volume is close to the tamping capacity.

Solution to improve road performance by changing from two-way to one-way with a value of DS = 0.53 and level of service C, speed can be controlled by traffic

References

- Badan Pusat Statistik Kabupaten Sidoarjo. 2020. Sidoarjo Dalam Angka Tahun 2020. Sidoarjo : Badan Pusat Statistik Kabupaten Sidoarjo.
- Direktorat Jenderal Bina Marga. 1997. Manual Kapasitas Jalan Indonesia (MKJI) 1997. Jakarta : Departemen Pekerjaan Umum, Direktorat Jenderal Bina Marga.
- Hasan, Agus. 2018. Evaluasi Kinerja Ruas Jalan Raya Bogor (Studi Kasus: Jalan Raya Bogor). Bogor : Universitas Ibn Khaldun.
- Hobbs, F.D. (1995). Perencanaan dan Teknik Lalu Lintas. Terjemahan oleh Suprpto. Gadjah Mada University Press. Yogyakarta.
- Indriana, Alyfia. 2020. Kinerja Ruas Jalan Berdasarkan MKJI 1997 pada Segmen Jalan Taman – Waru, Sidoarjo. Surabaya : Universitas Negeri Surabaya.
- Keputusan Gubernur Jawa Timur Nomor 188/127/KPTS/013/2016 Tentang Penetapan Ruas-Ruas Jalan dalam Jaringan Jalan Primer Menurut Fungsinya sebagai Jalan Kolektor – 2 dan Jalan Kolektor – 3. Surabaya. Keputusan Gubernur Jawa Timur Nomor 188/128/KPTS/013/2016 Tentang Penetapan Ruas-Ruas Jalan Menurut Statusnya sebagai Jalan Provinsi. Surabaya.
- Menteri. 2012. Peraturan Menteri Pekerjaan Umum Nomor : 03/PRT/M/2012 Tentang Pedoman Penetapan Fungsi Jalan Dan Status Jalan. Jakarta : Departemen Pekerjaan Umum, Direktorat Jenderal Bina Marga.
- Morlok. (1991). Pengantar Teknik dan Perencanaan Transportasi. Erlangga. Jakarta.
- Pangestu, Orbit Rizky. 2018. Evaluasi Kinerja Ruas Jalan Brigjen Katamso Dan Usulan Perbaikan Sampai Lima Tahun Mendatang. Yogyakarta : Universitas Islam Indonesia.