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TRAFFIC ANALYSIS DUE TO DEVELOPMENT ON OFF RAMP BECAKAYU HIGHWAY

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ABSTRACT

The kalimalang highway is a connecting road between the city of Jakarta and Bekasi, the high mobility of passenger vehicles and goods is a problem of congestion that must be minimized. The volume of vehicles on the Kalimalang highway has increased quite high each year, but this has not been matched by growth in capacity. Therefore the government plants to build the Becakayu toll road to reduce congestion. This study aims to determine bottlenecks that occur due to the construction of an off-ramp on the Becakayu toll road, especially in section 2A, which is located on Jl. Veteran, while the location under review is the intersections affected by the construction of the off-ramp including the intersection of four signaling BCP, intersection of four signaling Veteran and Sarbini unsigned intersection, Data analysis in this study uses the MKJI 1997 method. From this method displays the behavior of traffic, for signal intersections will display signal time, capacity, vehicle stopped ratio, queue length, and average delay and for unsignalized intersections will display capacity, average delay and queue opportunity. From the results of this study it was found that the signaled intersection had an average value of $DS > 1$, so for the service level at the intersection is the current forced / jammed with low speed. Where the largest queue length occurred 1876.7 m, an average delay of 210.30 SMP/ sec, and vehicles stopped at an average of 7378 SMP/hour. And for unsignalized intersections having an average $DS < 0.45$, the service level at the intersection is a stable flow with operating speed starting to be limited by traffic conditions, this intersection has the greatest queue probability (QP%) 8.48-20.35 in the Saturday time period - afternoon and intersection delay 9.5 SMP / sec.

Keywords : Traffic Analysis, On Off Ramp, Becakayu Toll, Degree of Saturation

INTRODUCTION

Population and vehicle growth that occurs every year in the cities of Jakarta and Bekasi [4], resulting in high mobility of passenger vehicles and goods that occur on Jalan Raya Kalimalang, where this road is the connecting city of Jakarta and Bekasi. The condition of the Kalimalang Highway that has not been matched by the growth in capacity has become a problem of congestion. To overcome the imbalance, one of the ways the government has done is to build a toll road, the road built is above the Kalimalang river. The toll road will connect Kampung Melayu to Tambun, Bekasi [5].

The Becakayu highways has already entered section 2-A, where this section is on the KH Noer Ali road to Veteran Road, the plan to on off ramp starts from the KH Noer Ali road passing through the BCP (Bekasi Cyber Park) intersection to end at the Veteran intersection, of course when construction greatly affected the KH Noer Ali road to the Veteran road because in the construction process part of the existing road was used, the KH Noer Ali road experienced a diversion of lanes and also the closure of the lane from the Veteran

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intersection to the BCP (Bekasi Cyber Park). Therefore, the researchers calculated the performance of roads and intersections affected by the Becakayu Toll Road, namely the KH Noer Ali road, Ahmad Yani road, Major Madmuin Hasibuan road, Letjend Sarbini road, Veteran road, and also the BCP signal intersection. Bekasi Cyber Park), the Veterans four intersection and the Sarbini unsigned triple intersection.

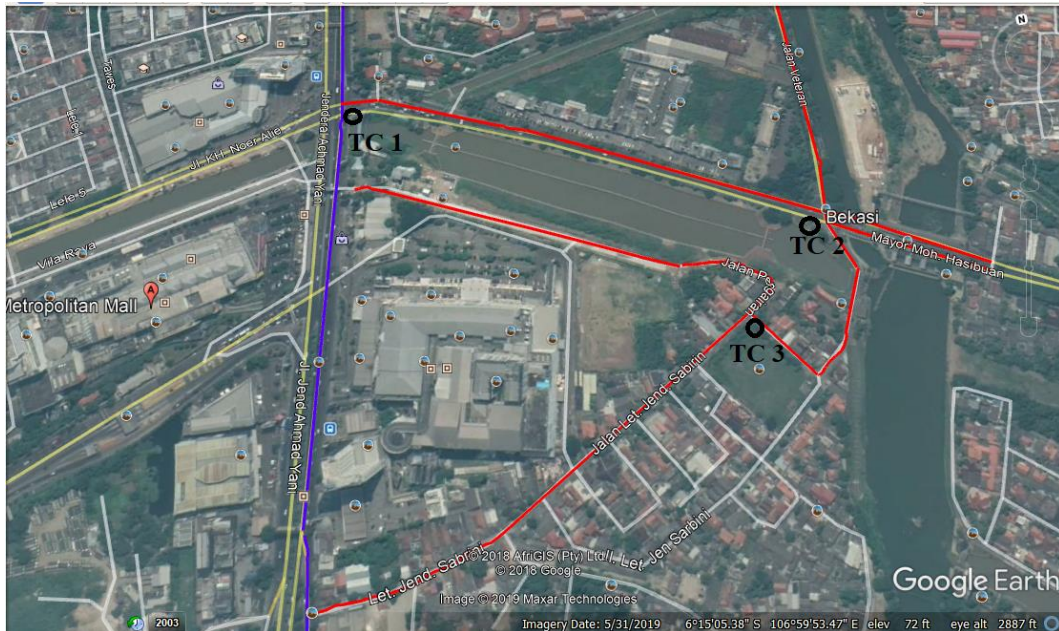


Figure 1. Location Survey Plans On Off Ramp
 Source: Author, 2020

METHODOLOGY

The survey was conducted at the BCP sign intersection, the Veterans sign intersection and the Sarbini unsigned intersection Bekasi, West Java. The road is controlled by the Becakayu Toll Road development, where the BCP intersection is a meeting of four roads, namely Ahmad Yani Utara Street, Ahmad Yani Selatan Street, KH Noer Ali Street and also Major Madmuin Hasibuan Street. Also the Veterans Intersection is a meeting of four roads, namely Jalan Veteran, Jalan Mayor Madmuin Hasibuan Barat, Jalan Mayor Madmuin Hasibuan Timur, and Jalan Letjen Sarbini, and the Sarbini Intersection which is a meeting of three road currents, namely Jalan Letjen Sarbini Timur, Jalan Sarbini Selatan and Irrigation Roads (Figure 1). The signaling crossing arrangement uses a two-phase arrangement.

The data needed as a signal for analysis of signalized and unsignalized intersections includes traffic flow data, cycle time regulation and intersection geometry.

1. Traffic flow data, including: Traffic flow released when the green light is on each arm, i.e. turn right, turn left and straight current.
2. Queue length data: Vehicle queue length data are reviewed in the North and South arms. Retrieval data length of all types of vehicles at the study site was done by counting the number of vehicles remaining from the previous green phase (NQ1) and the number of vehicles that were queuing next when the red light was on (NQ2). Queue length data is obtained by measuring the length of vehicles that queue at the end of the green and the end of the red with the help of a roll meter, white chalk / marker so that a white line appears on the asphalt placed the day before the survey so that it makes it easier to absorb. The length of the queue is made at a distance of 5 m to make it easier to read.
3. Signal data: Signal data required includes the total cycle, green time and yellow time on each arm, and the number of phases.

4. Intersection geometric data

Failure The survey was conducted for 2 days during the morning and afternoon rush hours of Friday and Saturday on the 25th and 26th October 2019 for 2 hours. the survey was conducted during hours estimated to have heavy traffic. The time used for the survey is at 06.00 - 08.00 and 16.00 - 18.00 with consideration that every period there are peak hours.

The research steps for each stage are carried out as follows. After getting data from field surveys, in the form of road geometric data, traffic volume, queue length and intersection environmental conditions, the following steps are taken :

1. Calculation of volume, capacity, cycle time and others is done based on the equation in Manual Road Capacity Indonesia, [5] for signalized intersections. Some basic equations that are important in this study are given below.

a. Calculation of the saturation current rating (S)

Calculation of the saturation current value can be completed using the equation below. The equation is from a direct survey in the field by looking at the amount of traffic composition, driver behavior and road side developments in Indonesia.

$$S = S_0 \times F_{CS} \times F_{SF} \times F_G \times F_P \times F_{RT} \times F_{LT} \quad (1)$$

with,

- S_0 = Basic Saturated Current
- F_{CS} = City Size Correction factor
- F_{SF} = Correction Factor For Side Disorders
- F_G = Slope Correction Factor
- F_P = Parking Correction Factor
- F_{RT} = Right Turn Correction Factor
- F_{LT} = Left Turn Correction Factor

b. Capacity (C)

The capacity for each crossing arm is calculated by the following equation $C = S \times g/c$

$$(2)$$

with,

- C = Capacity (smp/hours)
- S = Saturated Current (smp/hours)
- g = Green Time (detik)
- c = Green Time Specified Cycle Time (sec)

c. Degree Of Saturation (DS)

The degree of saturation is the ratio of traffic flow to capacity, which is used as a major factor in determining the performance of intersections. The value of the degree of saturation is determined by the equation below.

$$DS = Q/C \quad (3)$$

dengan,

- DS = Degree Of Saturation
- Q = Traffic Flow (smp/hours)
- C = Capacity (smp/ hours)

d. Queue Length

From the value of the degree of saturation can be used to calculate the number of junior high school queues (N_{Q1}) which is the remainder of the previous green phase, obtained from the equation:

For $DS > 0,5$

$$N_{Q1} = 0.25 \times C \times \left\{ (DS - 1) + \sqrt{(DS - 1)^2 + \frac{8 \times (DS - 0.5)}{c}} \right\} \quad (4)$$

For $DS \leq 0,5$

$$N_{Q1} = 0 \quad (5)$$

with,

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- N_{Q1} = for the number of junior high schools remaining from the previous green phase
 DS = Degree Of Saturation
 GR = Green Ratio
 C = Capacity (smp/hours) = $S \times GR$

Then count the number of smp queues that came during the phase (NQ_2), with the following equation:

$$NQ_2 = C \times \frac{(1-GR)}{(1-GR \times DJ)} \times \frac{Q}{3600} \quad (6)$$

With,

- NQ_2 = The SMP Arrivals During The Red Phase
 Q = The Volume Of Incoming Traffic outside LTOR (smp/sec)
 c = Cycle Time (sec)
 DS = Degree Of Saturation
 GR = Green Ratio (sec)

To calculate the total queue by adding up the two results above..

$$NQ = NQ_1 + NQ_2 \quad (7)$$

1. Calculation of the average queue length obtained from the sum of the average value of the queue length ending in green with the average value of the length of the red queue time.
2. Calculation of volume, capacity, delay and others is done based on the equation in Manual Road Capacity Indonesia, [5] for unsignalized intersections. Some basic equations that are important in this study are given below.

a. Capacity

The capacity for each crossing arm is calculated by the following equation

$$C = C_o \times F_W \times F_M \times F_{CS} \times F_{RSU} \times F_{LT} \times F_{RT} \times F_{MI} \text{ (smp/hours)} \quad (8)$$

with,

- C_o = Basic Capacity
 F_W = Adjustment width approach factor
 F_M = Main road median adjustment factor
 F_{CS} = City size adjustment factor
 F_{RSU} = Side drag adjustment factor
 F_{LT} = Left turn adjustment factor
 F_{RT} = Right turn adjustment factor
 F_{MI} = Minor road current ratio adjustment factor

b. Intersection Delays

Calculated as Follows :

$$D = DG + DT_1 \quad (9)$$

with,

DG = Intersection geometric delay

Intersection geometric delay is the average geometric delay of all motorized vehicles entering an intersection. DG is calculated from the following formula:

For $DS < 1.0$

$$DG = (1-DS) \times (P_T \times 6 + (1-P_T) \times 3) + DS \times 4 \text{ (smp/sec)} \quad (10)$$

For $DS \geq 1,0$; $DG = 4$

where :

- DG = Intersection geometric delay
 DS = Degree of Saturation
 P_T = Total Turn ratio

DT_1 = Intersection traffic delay

Intersection traffic delays are traffic delays, on average for all motorized vehicles that enter the intersection.

For $DS < = 0,6$

$$DT = 2 + 8,2078 \times DS - (1 - DS) \times 2$$

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For $DS > 0,6$

$$DT = 1,0504 / (0,2742 - 0,2042 \times DS) - (1 - DS) \times 2$$

In evaluating urban traffic problems it is necessary to review the functional classification and network systems of existing road segments. In general, urban traffic problems only occur on main roads, which in the classification of roads only include arterial and collector roads. On this main road, traffic volume is generally large. On local roads, because traffic volume is generally low and access to surrounding land is high, traffic problems are absent and are local in nature. [6]

ANALYSIS AND DISCUSSION

Geometric data intersections obtained by direct measurement in the field and visual observation, for the value of the slope value is considered zero because visually at the intersection does not indicate slope (Table 1).

Table 1. Geometry and environmental condition data

FIELD CONDITIONS										
Approach Code	Road Environment Type	Side Barriers	The Median	Slope	Turn Left Directly	Parking Distance Of The Vehicle (m)	Approach Width (m)			
							Approach	Enter	Turn Left Directly	Exit
Veteran Intersection										
N	COM	T	T	0	T	-	8.00	4.00	3.00	4.00
S	RES	S	T	0	Y	-	6.00	3.00	1.00	2.00
E	COM	T	Y	0	Y	-	16.00	8.00	2.00	6.00
W	COM	T	Y	0	T	-	18.00	9.00	-	-
BCP Intersection										
N	COM	T	Y	0	T	-	27	13.5	0	13
S	COM	T	Y	0	Y	-	25	12.5	3.5	9
E	COM	T	Y	0	Y	-	18	-	3.00	6
W	RES	T	Y	0	Y	-	15.7	7.85	2.00	5.5
SarbinI Intersection										
U	RES	R	T	0	Y	-	6.00	3.00	1.00	2.00
S	RES	R	T	0	T	-	6.00	3.00	-	3.00
T	RES	R	T	0	Y	-	6.00	3.00	1.00	2.00

Information:

COM = Commercial

RES = Settlements

Source: Author, 2020

The constant factor on each arm that is used to find the base saturated current is distinguished with the aim of obtaining optimum results, namely the length of the queue that is close to or equal to field conditions.

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Table 2 Base Saturated Current (So)

No	Approach Code	Effective Width (m)	So (smp/jam)
Veteran Intersection			
1	East	9	3800
2	West	4	1750
3	South	3	1480
BCP Intersection			
1	West	12,5	3400
2	East	9.1	3800
3	North	13.5	6000
4	South	9.5	5500

Source: Author, 2020

So on, the calculation of the capacity of each arm depends on the ratio of the green time and the saturation current adjusted. The results of the analysis based on MKJI (1997) for Saturday afternoons at the four Veterans intersection and Saturday afternoons at the BCP intersection of the study sites are given in Table 3.

The calculation of the capacity of each arm depends on the ratio of the green time and the adjusted saturation current. The results of the analysis based on MKJI (1997) for all arms at the two signalized intersections of the study locations are given in Table 4.

The value of the degree of saturation is determined by a constant factor in the saturation current and a side drag correction factor and this affects the queue length value. Based on Table 5. Then it appears that the largest degree of saturation in the segment reviewed is 1.91.

Table 3 Saturated Current (S) In All Arms At Peak Hours

Approach	Base Saturated Current (smp/hours)	Correction Factor						Saturated Current (smp/hours)
		FCS	FSF	FG	FP	FRT	FLT	
Veteran Intersection								
East	3800	1.00	0.93	1.00	1.00	1.10	1.00	3904
West	1750	1.00	0.93	1.00	1.00	1.05	0.87	1712
South	1490	1.00	0.97	1.00	1.00	1.22	0.98	1757
BCP Intersection								
West	1118	1.00	0.93	1.00	1.00	1.16	1.00	3162
East	2967.6	1.00	0.93	1.00	1.00	1.19	1.00	3254
North	6000	1.00	0.93	1.00	1.00	1.00	1.00	5580
South	5500	1.00	0.97	1.00	1.00	1.00	1.00	5335

Source: Author, 2020

Table 4. Capacity On All Arms During Peak Hours

Approach	Green Time, g (sec)	Cycle Time, c (sec)	Saturated Current (smp/hours)	Capacity, C = S.g/c (smp/hours)
BCP Intersection				
West	73	156	3162	1471
East	73	156	3534	1644
North	74	156	5580	2628
South	74	156	5335	2512

Source: Author, 2020

Table 5 Degree Of Accidence In All Arms At Peak Hours

Approach	Green Time, g (sec)	Green Ratio g/c	Current, Q (smp/hours)	Capacity, C (smp/Hours)	Degree of Saturation DS = Q/C
BCP Intersection					
West	73	0.47	1371.8	1471	0.93
East	73	0.47	1531.1	1644	0.93
North	74	0.47	2448	2628	0.93
South	74	0.47	4803.7	2512	1.91

Source: Author, 2020

$$NQ_1 = 0.25 \times 1471 \times \left\{ (0.93 - 1) + \sqrt{(0.93 - 1)^2 + \frac{8 \times (0.93 - 0.5)}{1471}} \right\}$$

$$= 5.773 \text{ smp/hours}$$

$$NQ_2 = 156 \times \frac{(1-0.47)}{(1-0.47 \times 0.93)} \times \frac{1371.8}{3600}$$

$$= 56.24 \text{ smp/hours}$$

To find the average queue length by adding NQ1 to NQ2 like equation 7 as follows:

$$NQ \text{ average} = 5.773 + 56.24 = 62.01 \text{ smp}$$

The maximum queue length (max NQ) is obtained by matching the average NQ value by referring to figure 2 with the desired loading probability for the queue probability of 95% then using the following equation.

$$NQ \text{ max} = (NQ \times 1.3139) + 3.3 \tag{8}$$

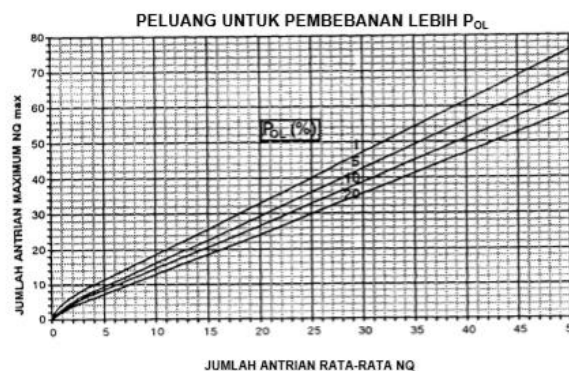


Figure 2 Calculation of Queue Amount (NQMAX) in SMP
 Source : MKJI, 1997

Based on the results of calculations with equation 8 NQ values obtained max = 84.8 SMP. So on, the length of the queue in meters can be calculated by the equation (MKJI,1997) :

$$QL = \frac{NQ_{MAX} \times 20}{W_{ENTER}} \tag{9}$$

with,

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Q_L = Queue Length (meters)

NQ_{MAX} = Maximum queue length (smp/hours)

W_{ENTER} = Lane width reviewed (hours)

$$\text{then, } Q_L = \frac{84.8 \times 20}{7.85} = 216 \text{ m}$$

The value of the length of the queue on all arms during rush hour in units of SMP and meters can be seen in table 6 below..

Table 6 Queue Length On All Arms At Peak Hours

Approach	NQ1 (smp)	NQ2 (smp)	NQ total (smp)	NQ maks (smp)	NQL (meter)
BCP Intersection					
West	5.773	56.24	62.01	84.8	216
East	5.727	62.70	68.43	204.9	204.9
North	5.92	100.12	106.04	211.3	211.3
South	1147.2	1107.3	2254.52	4744.8	4744.8

Source: Author, 2020

CONCLUSION

- Signalized intersections namely BCP and Veterans intersections have an average value of $DS > 1$, which means that traffic is forced or congested where the largest queue length occurs 4744.8 m with an average delay of 790.73 smp/ sec.
- Unsignalized intersections namely Sarbini intersections have DS values < 0.45 which means stable or smooth current, this intersection has a queue probability intersection (QP%) 8.48 - 20.35 in the Saturday-afternoon time period and a delay of 9.96 smp / sec.
- Traffic lights settings need to be reviewed such as changing cycle times due to delays and large queue lengths.
- Analysis for the calculation of signal intersections that have close distances should be done using software for traffic control.

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