

Performance Analysis of Unsignalized Intersections and Road Sections Using PKJI 2023

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ABSTRACT: Conflicts between motorists and non-motorcyclists and indiscipline frequently disrupt traffic at road intersections. These problems affect the quality of transportation operations, including road capacity, conditions, and travel route selection. Jalan Raya Kodau intersection is the main access to connect vehicles exiting and entering the intersection area, located at Jalan Raya Kodau, Jatimekar, Jatiasih, Bekasi City. The goal of this study is to determine the volume of vehicles passing through the Kodau road intersection, as well as to obtain performance and capacity results on road sections and intersections and then provide alternative solutions to problems that occur at the intersection. The research uses methods that refer to the Indonesian Road Capacity Guidelines (PKJI 2023) and include capacity analysis of intersections and road sections, taking into account the influence of traffic flow conditions, geometry, and the environment, based on primary data obtained directly through field surveys. Based on the results of the analysis, the saturation degree value is 0.46 and has level of service A, while in the intersection analysis, the saturation degree value is 1.23 and the delay at the intersection is 49.55 seconds per drive, as well as queuing opportunities of 126.428%–61.871% and level of service at intersection E. By using alternative 1, the degree of saturation (DJ) is obtained at 0.87, with a delay of 14.954 seconds per drive, as well as queuing opportunities of 60.01%–30.39% at intersection B.

KEYWORDS: Degree of saturation, unsignalized intersection, delay, queuing probability.

INTRODUCTION

Transportation is the movement of people or goods using the help of vehicles driven by humans or machines from one place to another. Transportation is used to facilitate humans in carrying out daily activities. Many experts have formulated and put forward the definition of transportation. The word transportation comes from Latin, namely transportate, which means to lift or carry. Transportation is used to make it easier for people and goods to move places to achieve their goals (Riyadi, 2022). Traffic conflicts arise when two or more roadways intersect. These conflicts can cause delays, traffic congestion, and possibly traffic accidents. Therefore, traffic control is necessary at every intersection. It is controlled by stop signs, traffic lights, and roundabouts (Hariyanto et al., 2022).

Intersections are an integral part of any road system. When driving in the city, one can see that most roads in urban areas usually have intersections, where drivers can decide to continue or turn and change roads. An intersection can be defined as the general area where two or more roads merge or intersect, including the roadway and roadside facilities for the movement of traffic across it (Isradi et al., 2021a). Because intersections must be shared by everyone who wishes to use them, they must be carefully designed, considering efficiency, safety, speed, operating costs, and capacity. The traffic

movements that occur and their sequences can be handled in various ways, depending on the type of intersection required. (Khisty, C. Jotin, 2005). According to the Indonesian Road Capacity Guidelines (2023) developed by the Directorate General of Highways, intersection capacity analysis takes into consideration the influence of traffic flow conditions, geometry, and the environment based on data obtained at an event or real events that have been experienced and obtained through research, observations, or experiments that have been carried out (Direktorat Jendral Bina Marga, 2023).

Several obstacles or conflicts in traffic flow at road intersections are frequently the result of inattentive behavior by both motorized and non-motorized vehicle users (Widyaningsih & Daniel, 2019). These problems are indicators of traffic flow and the operational quality of transportation facilities related to capacity, road and crossing conditions, side barriers, land users, and travel route choices (Ikawati & Januarti, 2019).

RESEARCH METHOD

In 2023, the directorate general of Bina Marga published the latest guidelines resulting from the renewal of MKJI 1997 and PKJI 2014. This research analyzes data using PKJI 2023. The focus of the research refers to the performance

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of road sections and intersection capacity (Direktorat Jendral Bina Marga, 2023).

The Jalan Raya Kodau intersection is the main access to connect vehicles leaving and entering the intersection area, located on Jalan Raya Kodau, Jatimekar Village, Jatiasih

District, Bekasi City. Due to the presence of several schools, during peak hours such as morning, afternoon, and evening, there is often congestion at the intersection point due to vehicles leaving and entering the intersection (Isradi & Pratama, 2020).

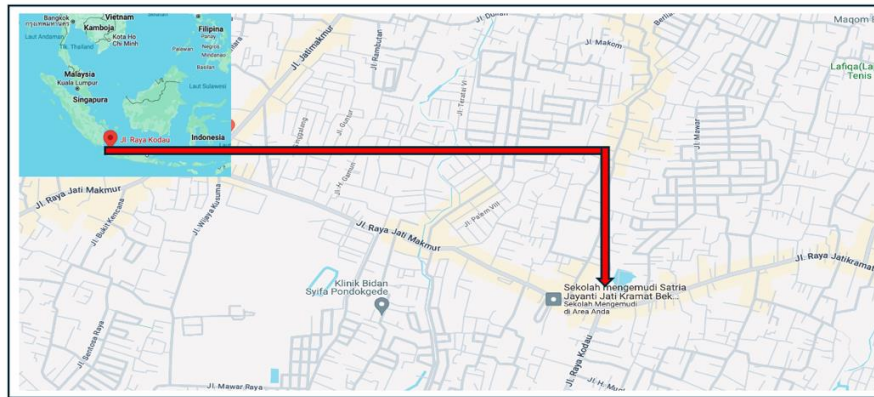


Figure.1: Research location

The collection of data needed, such as road geometric data, vehicle volume data, and vehicle speed data, can be taken during a field survey, which lasts for three days on Monday, November 20, 2023, Thursday, November 23, 2023, and Sunday, November 26, 2023. The data collection is divided into three sessions: morning, afternoon, and evening, where the survey time is determined at 06.30–08.30, 11.30–13.30, and 16.30–18.30. The purpose of this data collection is to be able to know the volume of vehicles crossing the Jalan Raya Kodau Intersection and also the volume of vehicles passing through the Jalan Raya Jatikramat section, then get the results of the performance of the Jalan Raya Jatikramat section and the Jalan Raya Kodau intersection using the PKJI 2023 method and also provide alternative problem solving at the Jalan Raya Kodau Intersection.

The data used in the analysis of the performance of road sections and unsignalized intersections includes primary and secondary data. Primary data is obtained by conducting surveys directly at the research location, which includes (Isradi et al., 2022; Prasetijo & Ahmad, 2012):

1. Traffic Data Survey.

2. Geometric Data.
3. Side Obstacle Data.
4. Vehicle Speed Data.

Then, for secondary data obtained from related agencies as a research area, the secondary data needed in this research are (Brilon & Wu, 2001):

1. Location Map.
2. Environmental Conditions.

RESULT AND DISCUSSION

Road Section Performance

Based on the survey that has been conducted, the road section to be studied and analyzed is the road section on Jl.Raya Jatikramat. During peak hours, the road section experiences an increase in vehicle volume, which impacts the density of traffic flow. The data will be described based on road geometric conditions, driver activities, and facilities available at the intersection.

Road Geometric Data

Road geometric data is collected by field surveys; the following data is obtained, as shown in Table 1 below:

Table 1. Road Geometric Data

Description	Jl.Raya Jatikramat
Road Type	2/2 TT (2 lanes 2-way Undivided)
Width of Road	7,8m
Shoulder Width	1,5m
Median	None
Road Condition	Flat
Type of Pavement	Flexible pavement

Traffic Volume Data

Traffic volume data on the Jalan Raya Jatikramat section obtained the highest peak hour on Monday, November

20, 2023, from 06.30 to 07.30. A recapitulation of peak hour traffic data can be seen in Table 2 below:

Table 2. Recapitulation of Peak Hour Traffic Data

Monday November 20, 2023 (Vehicles/Hour)				
Jl.Raya Jatikramat 06.30 - 07.30				
Road Segment	MP	KS	SM	Total
Direction W	113	11	2265	2389
Direction S	177	13	1997	2187
Total 2 directions	290	24	4262	4576
Thursday November 23, 2023 (Vehicles/Hour)				
Jl.Raya Jatikramat 17.30 - 18.30				
Road Segment	MP	KS	SM	Total
Direction W	186	19	1813	2018
Direction S	213	13	2006	2232
Total 2 directions	399	32	3819	4250
Sunday November 26, 2023 (Vehicles/Hour)				
Jl.Raya Jatikramat 17.30 - 18.30				
Road Segment	MP	KS	SM	Total
Direction W	181	6	1116	1303
Direction S	158	4	1157	1319
Total 2 directions	339	10	2273	2622

From the results of peak hour traffic data that has been obtained, namely on Monday, November 20, 2023, from 06.30 to 07.30 with a total vehicle volume of 4576 vehicles per hour, the data

is calculated using the PKJI 2023 method as shown in Table 3 below:

Table 3. Calculation of Peak Passenger Car Equivalency Values

Vehicle types	MP	KB	SM	Q _{TOT}						
EMP	1	1.2	0.25							
EMP	1	1.2	0.25							
Direction	veh/hour	pcu/hour	veh/hour	pcu/hour	veh/hour	pcu/hour	direction,%	veh/hour	pcu/hour	
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	
West	113	113	11	13.2	2265	566.25	50%	2389	692.45	
South	177	177	13	15.6	1997	499.25	50%	2187	691.85	
Total	290	290	24	28.8	4262	1065.5	100%	4576	1384.3	
Separation, PA=q1/(q1+q2)								50%		
PCU Factor , F_{SMP}								0.30		

From the calculation results in table 3 above, the Q_{TOT} based on EMP for both directions is 1384.3 pcu / hour.

Table 4. Road Section Capacity

Road Section Parameters	Jl.Raya Jatikramat (2/2-TT)
C ₀	2800
FC _{LJ}	1,112
FC _{PA}	1,00
FC _{HS}	0,97
FC _{UK}	1,00
C	3020,2

Road Section Capacity

Road Segment Capacity specifies the provisions of road capacity calculation procedures for traffic performance evaluation and design of urban road segments. The following are the calculation results:

$$C = C_0 \times FC_{LJ} \times FC_{PA} \times FC_{HS} \times FC_{UK}$$

$$C = 2800 \times 1,112 \times 1,00 \times 0,97 \times 1,00$$

$$C = 3020,2 \text{ pcu/hour}$$

Degree of Saturation

Determining the value of the degree of saturation based on the Indonesian Road Capacity Guidelines (PKJI 2023) is the result of the calculation by dividing the value of vehicle volume (vcu/h) (Q) with the value of road capacity (vcu/h) (C). If the results obtained are <0.85, then the results obtained are not good. This result can show whether there are capacity problems with the existing facilities on the road.

$$DJ = q/C$$

$$DJ = 1384,3/3020,2$$

$$DJ = 0,46$$

Level of Service of Road Sections

The value of the level of service is obtained by calculating the results of the degree of saturation. From the LOS results that have been obtained and defined according to the Minister of Transportation Regulation No. 14, the level of road

service classification on the road section under review is A with a DJ value <0.85, which is DJ = 0.46 on the Jl.Raya Jatikramat section.

Unsignalized Intersection Performance

Unsignalized intersection performance analysis was conducted at the Jalan Raya Kodau Intersection. The data required for the research process are traffic data, geometric data, and side-obstacle data obtained through observations and surveys at the research location. As well as secondary data obtained from related agencies.

Geometric Data

Jalan Raya Kodau Intersection is an intersection with a 322-road type, which means a 3-arm intersection with 2 lanes on the minor road and 2 lanes on the major road. The following is a description of the intersection geometry at the Kodau Road intersection:

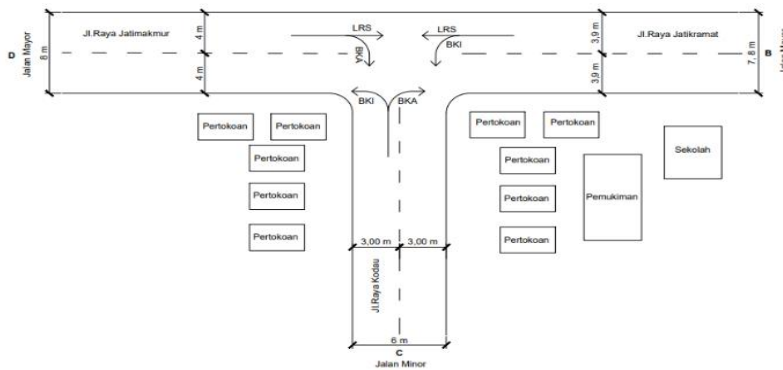


Figure 2: Illustration of an Unsigned Intersection at Jalan Raya Kodau

Traffic Data

The following are the results of the total vehicle volume obtained in the intersection survey and carried out for 2

hours in 3 days, which are Monday, Thursday, and Sunday, by taking morning, afternoon, and evening times.

Table 5. Recapitulation of Intersection Traffic Data Results

Time	Monday, 20 Nov 2023	Thursday, 23 Nov 2023	Sunday, 26 Nov 2023
	Total veh/h	Total veh/h	Total veh/h
06.30 – 07.30	6590	6441	3845
07.30 - 08.30	6175	4766	4299
11.30 - 12.30	4915	5460	5472
12.30 - 13.30	5221	5655	5654
16.30 - 17.30	5376	5361	5449
17.30 - 18.30	6144	6163	6162

The peak hour traffic volume is on Monday morning at 06.30–07.30 am, amounting to 6590 vehicles per hour. This data will be used as a reference in analyzing the capacity of

unsignalized intersections. The calculation results can be seen in the following table:

Table 6. Calculation of Traffic Data on Monday, November 20, 2023 (06:30-07:30)

Traffic composition(%):	MP =	KS =	SM =	K factor =
SMP factor =	MP, EMP= 1.0	KS, EMP= 1.3	SM, EMP= 0.5	$q_{KB} \text{ Total} = \sum q_{KB}$
Traffic flow	veh/h	vcu/h	veh/h	vcu/h
				R_B
				veh/h

Intersection Traffic Delay

Due to the degree of saturation value obtained by researchers > 0.60 is described as follows:

$$T_{LL} = \frac{1,0504}{(0,2742 - 0,2042 D_J)} - (1 - D_J)^2$$

$$T_{LL} = \frac{1,0504}{(0,2742 - 0,2042 \times 1,23)} - (1 - 1,23)^2$$

$$T_{LL} = 45,55 \text{ detik/kend}$$

Traffic Delay for Major Roads

Due to the degree of saturation value obtained by researchers > 0.60 is described as follows:

$$T_{LLma} = \frac{1,0503}{(0,3460 - 0,2460 D_J)} - (1 - D_J)^{1,8}$$

$$T_{LLma} = \frac{1,0503}{(0,3460 - 0,2460 \times 1,23)} - (1 - 1,23)^{1,8}$$

$$T_{LLma} = 24,17 \text{ detik/ken}$$

Geometric Delay of Intersection

The degree of saturation (D_J) = 1.23 ≥ 1, then for D_J ≥ 1 the geometric delay value (T_G) = 4 sec/vcu.

Intersection Delay

$$T = T_{LL} + T_G$$

$$T = 45,55 + 4$$

$$T = 49,55 \text{ sec/vcu}$$

Queue Opportunity

Upper Limit of Probability (P_a)

$$P_a = 47,71 D_J - 24,68 D_J^2 + 56,47 D_J^3$$

$$P_a = (47,71 \times 1,23) - (24,68 \times (1,23^2)) + (56,47 \times (1,23^3))$$

$$P_a = 126,428 \%$$

Lower Limit of Probability (P_a)

$$P_a = 9,02 D_J + 20,66 D_J^2 + 10,49 D_J^3$$

$$P_a = (9,02 \times 1,23) + (20,66 \times (1,23^2)) + (10,49 \times (1,23^3))$$

$$P_a = 61,871 \%$$

Intersection Level of Service Analysis for Delay

The results of calculations related to intersection performance and traffic behavior can be presented in the form of Table 8 below.:

Table 8. Intersection Traffic Performance

Options	Traffic performance							
	Total traffic flow q_{TOT}	Degree of saturation D_J	Intersection traffic delay T_{LL} (sec/veh)	Major road traffic delay T_{LLma} (sec/veh)	Minor road traffic delay T_{LLmi} (sec/veh)	Intersection geometry delay T_G (sec/vcu)	Intersection delay $T = T + T_{LLG}$ (sec/veh)	Queuing opportunity P_a (%)
	SMP/hour							
1	3704	1,23	45,55	24,17	105,225	4	49,55	126,428% - 61,871%

The results of the analysis of the performance of the unsignalized intersection at the Jalan Raya Kodau Intersection obtained a degree of saturation of 1.23 with a delay value of 49.55 seconds per vehicle, indicating that the level of service of the intersection based on delay is type "E.". Therefore, an alternative solution or handling is needed at the unsigned intersection.

Improvement Solution at Intersections

The first alternative solution that will be given is the prohibition of right turns on Minor Road C (Jl.Raya Kodau) which leads to Major Road B (Jl.Raya Jatikramat) by installing signs prohibiting right turns on Minor Roads.

Table 9. Calculation of Vehicle Volume at Intersection (Improvement Solution)

Traffic composition(%):	MP =	KS =	SM =	K factor =							
SMP factor =	MP, EMP=	1.0	KS, EMP=	1.3	SM, EMP=	0.5	q_{KB} Total	qKTB			
Traffic flow	veh/h	vcu/h	veh/h	vcu/h	veh/h	vcu/h	veh/h	vcu/h	R_B	veh/h	
Minor Road from Approach C	qBK _i	126	126	9	12	837	419	972	556	1.00	11
	qLRS										
	qBK _a										
qTotal	126	126	9	12	837	419	972	556		11	
Minor road total, q_{mi}	126	126	9	12	837	419	972	556		11	
Major Road from	qBK _i	159	159	6	8	1356	678	1521	845	0.64	6
	qLRS	104	104	3	4	751	376	858	483		9
	qBK _a										

- a. The peak hour traffic flow volume on Jalan Raya Jatikramat was 4576 vehicles/hour or 1384.3 vcu/hour on Monday morning.
 - b. The volume at the unsignalized intersection at the peak flow hour is 6590 vehicles per hour, or 3704 vcu per hour. On Monday morning
2. Based on the analysis of the capacity of road sections and Unsignalized intersections and their performance, the following capacity values are obtained:
 - a. The capacity level of Jatikramat Highway is obtained (C) = 3020.2 vcu/h. Degree of Saturation (DJ) = 0.46, PKJI-2023 standard <0.85. Thus, obtaining a level of service (LOS) value with level A.
 - b. The capacity value of Jalan Raya Kodau Intersection is obtained as (C) = 3014 vcu/h, Degree of Saturation (DJ) = 1.23, and Delay (T) 49.55 sec/veh with the level of service of the intersection based on LOS delay with level E, which means bad.
 3. Improvement solutions are needed to overcome the congestion that occurs at the Jalan Raya Kodau Intersection with the appropriate level of service value in the Indonesian Road Capacity Guidelines (PKJI 2023), as follows:
 - a. The limitation of vehicle flow has caused changes to the road intersection. The intersection capacity (C) is 3753 smp/h with a degree of saturation (DJ) of 0.87 and a delay (T) of 14.954 seconds/clock. As a result, the intersection service is LOS B, indicating the effectiveness of the traffic management alternative in reducing congestion.

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