The Evaluation of Intersection Traffic Characteristics and Analysis by the Micro Simulation Program

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Abstract: This study evaluated the performance of an unsignalized intersection converted into a signalized intersection using the MKJI 1997 method and the VISSIM software. The stage began with conducting a traffic survey and calculating the capacity, degree of saturation, and queue length. Meanwhile, by the VISSIM method, Demak Road (1) gained 374.36 m, Kalibutuh Road (2) got 219.73 m, and Tembok Dukuh (3) obtain 295.24 m. LOS (Level of Service) went from F to D. Therefore, several alternatives should be carried out, such as allocating space to street vendors who use the roadside area. The average queue length from an unsignalized intersection to a signalized intersection on the three roads had decreased after analysis using the MKJI 1997 method and the VISSIM software simulation: from 206 m to 123.81 m on (1), 191 m to 164 m on (2), and 786 m to 203.33 m on (3). Meanwhile, by the VISSIM method, Demak Road gained 374.36 m, Kalibutuh Road got 219.73 m, and Tembok Dukuh gained 295.24 m. LOS (Level of Service) went from F to D. Therefore, several alternatives should be carried out, such as allocating space to street vendors who use the roadside area.

1 INTRODUCTION

Surabaya, the capital of East Java Province, cannot be separated from the density problems. Surabaya has a dense population reaching 2.9 million people and various activities such as government, economics, trade, education, industry, and other activities. This results in a very high level of transportation activity in the city of Surabaya. Particularly at unsignalized crossroads, traffic difficulties and vehicle disputes often occur in numerous locations.

A deficient transportation system not only creates barriers to economic events but also obstructs development. As developing countries are facing overpopulation, they also need to develop their economic activities to face the need of the extra population, and for this reason, they need to have good transportation facilities (Chowdhury, Raihan, Fahim, & Bhuiyan, 2016).

Urban traffic congestion has become an urgent problem to be solved in cities around the world. Problems such as air pollution and noise pollution caused by traffic congestion have seriously damaged human health and the urban (Tong, Liu, Wang, & Fang, 2020)ecological environment, reduced the quality of life of residents and social welfare (Lelieveld, Evans, Fnais, Giannadaki, & Pozzer, 2015).Congestion caused by parking on the road will affect the vehicle's operational costs (Firdausi et al., n.d.).

Intersections are the most collision-prone locations in transportation systems, due to the inherent nature of the heterogeneous movement of conflicting traffic (eg, different types of vehicles, pedestrians, bicycles). Intersections use signals to regulate the regular movement of conflicting traffic to minimize the risk of collisions and improve operational efficiency (Majhi & Senathipathi, 2021). However, developing a signal timing plan that will simultaneously maximize operational efficiency and reduce traffic conflicts at intersections) is an own challenge (Dey, Rahman, Das, & Williams, 2023)

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Road intersections (Signalized or Un-sig nalized) in urban areas are an important part of road transportation networks because they are hot spots where vehicles usually have accidents and points of traffic congestion (Olayode, Tartibu, Okwu, & Uchechi, 2020) (Rao, Dai, Dai, & He, 2021) (Tong et al., 2020) (Jiao, Wang, Zhang, Jin, & Liu, 2020) (Mehdi, Kim, Seong, & Arsalan, 2011) At intersections, not the speed of the vehicle, their delay indicators are the main measure (Abdurakhmanov, 2022).

This issue is present at the unsignalized intersections on Jalan Demak – Kalibutuh – Tembok Dukuh, which is one of the unsignalized in Surabaya. On the Demak - Kalibutuh - Tembok Dukuh route, the research aims to compare the performance of an unsignalized intersection to a signalized intersection. Traffic management at the intersection is cycle timing, yellow box junction management, and particular stopping areas for motorcycles.

Previous studies concluded that there is a close relationship between delay rates and violations of YBJ markings. This shows that there is a close relationship between the effectiveness of the presence of YBJ markings on intersection performance. If the YBJ marking violation changes, the delay rate will also increase or decrease following the direction of the change in the violation number (Firdausi, Putra, & Hafizah, 2022). Proposed a methodology to control the flow of vehicles at intersections with great results promising, the methodology became very complicated and it became necessary to employ different techniques more suitable for handling the flow of vehicles. For this reason, it was decided to use microsimulation (Medina, Morena, & Cabrera, 2009).

In this research using micro simulation with VISSIM and MKJI 1997 method. The appropriate modeling of the examined road network or intersection section can solve many ambiguities and show the most optimal solution to many transport problems. One possibility is to use microsimulation models to study the capacity of intersections with traffic lights(Ziemska-Osuch & Osuch, 2022).

The various parameters that can be calibrated in VISSIM are acceleration, desired speed, and clearance distance (Asamer & Heilmann, n.d.). In the simulation model, every vehicle is represented by an individual autonomous agent that is governed by a set of attributes and predefined behavior rules. Vehicles' attributes those remain unchanged throughout the simulation, e.g., length and width of the vehicles, are fixed attributes whereas the values of the dynamic attributes change over time during the simulation process, e.g., speed, acceleration, and deceleration (Rahman, Zhou, & Rogers, 2019).

In transportation modeling especially at intersections, different approaches based on the level of detail are considered in the modeling. One of the microscopic models in which individual vehicles and their interactions with the Algorithm is considered. On the other hand macroscopic models exist where aggregate quantities such as vehicle density, vehicle speed, flow network. The side of the macroscopic model exists where aggregate quantities are like Density, speed, flow and the relationship between them are used to assign vehicles to the network. For microscopic and macroscopic and the relationship between them is used to assign vehicles to the network (Ehlert, Schneck, & Chanchareon, 2017).

2 METHODOLOGY AND ANALYSIS

There are two types of intersections, signalized and unsignalized, based on the traffic flow management at the intersection.

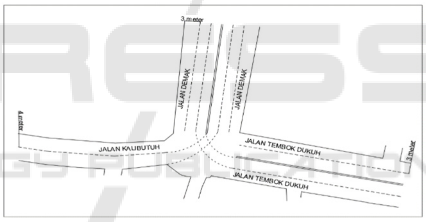


Figure 1: Sketch of Demak-Kalibutuh-Tembow Dukuh intersection.

2.1 Signalless Intersection

Unsignalized Intersection is a street intersection that does not use signals in its settings or Traffic Light. A regulation known as "*General Priority Route*" applies at unsignalized intersections, meaning that the first vehicle to arrive at or enter the intersection has the right of way.

Table 1: Peak Hour Volume at 16.45-17.45.

Road	Total (Vehicle/hour)	(smp/hour)
Demak	5332	2912,7
Kalibut	2423	1327,7
Tembok Dukuh	4571	2545,1

Table 2: Capacity calculation (1).

Basic Capacity (C0) (smp/hour)	Average Approach Width (FW)	Main Street Median (FM)	City Size (FCS)	Side resistance (FRSU)
3200	1.0722	1.05	1.00	0.88

Table 3: Capacity calculation (2).

Turn Right (FRT)	Turn Left (FLT)	Total Minor Ratio (FMI)	Capacity (C) (smp/hour)
1.413	0.697	1,010	3155,2

After doing these calculations at the Demak-Kalibutuh-Tembok Dukuh road intersection, it was determined that the capacity was 3155,2 smp/hour.

Table 4: Calculation of degrees of saturation, delays, and queuing probability (1).

Traffic Flow (Q) (smp/h)	Degree of Saturation (DS)	Interchange Traffic Delay (DT_1)	Primary Traffic Delay (DT_{MA})	Minor Traffic Delays (DT_{MI})
6785,5	2,151	− 4,067	− 3,667	− 5,710

Table 5: Calculation of degrees of saturation, delays, and queuing probability (2).

Interchange Geometric Delay (DG)	Interchange Delay (D)	Queuing Opportunities
4	− 0.067	550,143

Based on the analysis above, it can be indicated that in the existing condition of the unsignalized intersection during the Monday afternoon peak hour, the degree of saturation (DS) = 2.151 > 0.85, and the probability of a queue occurring between 219.292% and 550.143%, the intersection's performance does not meet the requirements of MKJI" 1997.

2.2 Signalized Intersection

A Signalized Intersection is an intersection with a Traffic Signaling Tool (APILL) installed as a traffic controller. At signalized intersections, the flow of vehicles entering the intersection alternates obtaining priority by using a Traffic Light.

Table 6: Peak covered vehicle volume at 16.45-17.45.

Road	Total (Kend/hour)	(smp/hour)
Demak	5332	1481.9
Kalibut	2423	681.5
Tembok Dukuh	4571	1361.6

Table 7: Planning of phase sequence and direction of traffic movement.

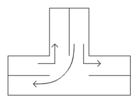
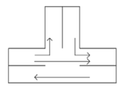
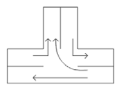
Phase Sequence	1	2	3
Direction of Traffic Movement			

Table 8: Calculation of real saturated current (S).

Approach	We	S0	FCS	FSF	FG	FP	FRT	FLT	S
A	10.5 m	6300	1.00	0.91	1.00	1.00	1,211	0.902	6266.73
B	4.5 m	2700	1.00	0.91	1.00	1.00	1.00	0.917	2479,28
C	6 m	3600	1.00	0.91	1.00	1.00	1,299	1.00	4255.86

After doing these calculations, it is found that the Real Saturated Current is approach A which is 6266.73, approach B is 2479.28, and approach C is 4255.86.

Table 9: Calculation of current ratio, phase ratio, and green time.

Approach	S	Q	FR
A	6266.73	1481.9	0.236
B	2479,28	681.5	0.275
C	4255.86	1361.6	0.320
		IFR = ∑FRcrit	0.831

PR	Cua	LTI	g	c
0.284	74,089	5	20	74
0.331			23	
0.385			26	
			69	

In this calculation, it is obtained that the specified cycle time is 74 seconds, which means that according to MKJI'1997 requirements for 3 phases, it is 50-100 seconds.

The signal time division is described as follows:

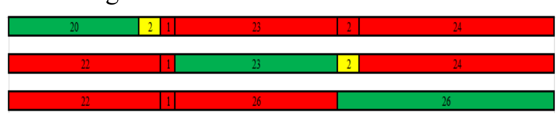


Table 10: Calculation of Capacity (C) and Degree of Saturation (DS).

Approach	S	g	c	Q	C	DS
A	6266.73	20	74	1481.9	1662.36	0.89
B	2479,28	23	74	681.5	764.49	0.89
C	4255.86	26	74	1361.6	1527.41	0.89

These calculations result in a Degree of Saturation of 0.89 or < 0,9.

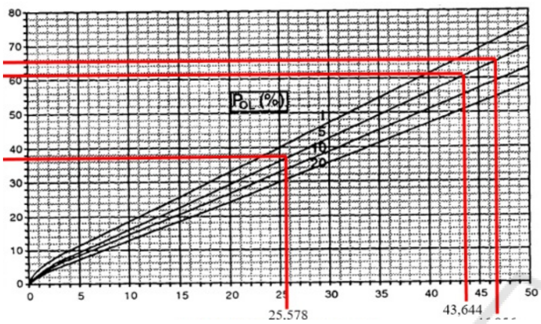


Figure 2 Calculation of the Number of Queues (NQmax).

Table 11: Calculation of the Number of Queues (NQ) and Queue Length (QL)

Approach	NQ1	NQ2	NQ	NQmax	QL (m)
A	17,571	29,300	46,856	65	123.81
B	12,232	13,355	25,578	37	164
C	17,290	26,367	43,644	61	203,33

Table 12: Calculation of Stopping Numbers (NS) and Number of Stopped Vehicles (NSV).

Approach	NS	nsv
A	1,384	2051,525
B	1,643	1119,885
C	1.403	1910,903

The table demonstrates that approach A has the most number of stopped vehicles per hour (2051.525) and approach B has the highest stopping rate (1.643 smp/hour).

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Table 13: Comparison of signalized and non-signalized intersections recapitulation.

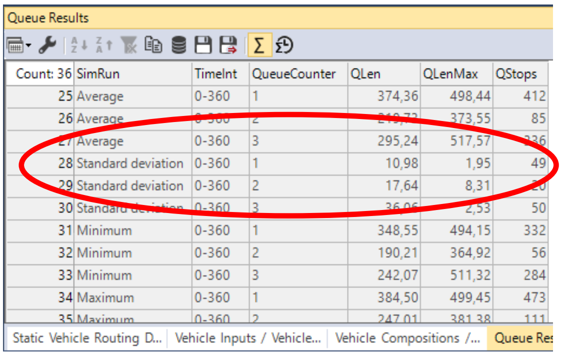
Parameter	Approach	Non-Signalized intersection	Signalized Intersection
Capacity	A	3123.5	1662.36
	B		764.49
	C		1527.41
Degree of Saturation		2.151	0.89
Queue Length(m)	A	206	123.81
	B	191	164
	C	786	203.33
	Average	394.3	163.71
Level of Service (LOS)		F	D

A comparison of signalized and non-signalized intersections may be seen in the table, According to the findings, from the results above where using Signalized Intersections or using APILL (Traffic Signing Auxiliary Equipment) assistance can reduce the impact of density that occurs at these intersections which can be seen in the Degree of Saturation (DS) which decreased from 2.151 to 0.89 and the average queue length at an unsignalized intersection to a signalized intersection was 394.3 meters to169.89 meter, which shows that the use of APILL is possible at the Demak – Kalibutuh − Tembok Dukuh.

Table 14. Comparison of Queue Length between Existing Data, MKJI'1997 Method, and Vissim.

Queue Length	Eksisting Data	MKJI'1997 Method Signalized Intersection	VISSIM Signalized Intersection
A	206	123.81	374.36
B	191	164	219.73
C	786	203.33	295.24
Average	394.3	163.71	296.44

Based on the result of this research, the degree of saturation at an unsignalized intersection converted to a signalized intersection decreased from 2.151 to 0.89, and the level of service improved from category F to category D, Consequently, the comparison between queue lengths has dropped, with the existing data receiving 394.3 meters and the simulation software receiving 296.44 meters, while for calculations using MKJI'1997 to obtain 163.71 meters in the technique represented the difference in results between MKJI'1997 and the method and Vissim likely because on account of the usage of VISSIM SOFTWARE's for student , which may be less thorough in conducting the analysis, the obtained results are unsatisfactory; still, there is a reduction in the queue length at the DEMAK-KALIBUTUH-TEMBOK DUKUH intersection.



Queue Results

Count: 36	SimRun	TimeInt	QueueCounter	QLen	QLenMax	QStops
25	Average	0-360	1	374,36	498,44	412
26	Average	0-360	2	[illegible]	373,55	85
27	Average	0-360	3	295,24	517,57	[illegible]
28	Standard deviation	0-360	1	10,98	1,95	49
29	Standard deviation	0-360	2	17,64	8,31	[illegible]
30	Standard deviation	0-360	3	36,06	2,53	50
31	Minimum	0-360	1	348,55	494,15	332
32	Minimum	0-360	2	190,21	364,92	56
33	Minimum	0-360	3	242,07	511,32	284
34	Maximum	0-360	1	384,50	499,45	473
35	Maximum	0-360	2	247,01	381,38	111

Figure 3 Vissim Analysis Results.

3 CONCLUSIONS AND SUGGESTION

Conclusion

1) Existing conditions at the intersection indicate that its performance does not fulfill the requirements of MKJI'1997 for an unsignalized intersection or existing conditions where DS= 2.151 > 1 and then in signalized intersection conditions where DS= 0.89 ≤ 0.9. From no signal to signal, the degree of service (Level Of Services) at the intersection ranges from category F to category D.
2) In comparison to the Vissim program with existing data calculations and calculating data utilizing MKJI'1997 computations, the queue length has decreased, with the existing data now measuring 394.3 meters than for calculations using MKJI'1997, the result is 163.71 meters while the vissim software returns 296.44 meters.
3) Comparing the existing data to the planning data reveals that restrictions or limitations can be placed on parking spaces at the intersection for traffic management.

Suggestion

1) Additional research can be conducted on other ways to enhance the intersection performance at Jl. Demak – Jl. Kalibutuh – Jl. Tembok Dukuh.
2) It is evident from the decline in the degree of saturation, or DS (Degree Of Saturation)., that traffic engineering, in the form of a Traffic Light, is necessary on Jl. Demak, Jl. Kalibutuh, and Jl. Tembok Dukuh.
3) To avoid interfering with traffic activities, it can be designated for street sellers or street vendors who utilize surrounding lanes, such as selling or parking in the area on Jalan Tembok Dukuh, and adding traffic signs that state that parking is not permitted in the intersection area.

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