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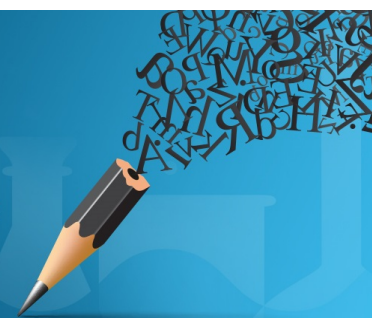


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# Reinforcing The Performance of Signalized Intersection on The Border of Malang and Batu City

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**Abstract.** The intersection of Sengkaling street and Sidomakmur is a signalized intersection with three arms that connects Sengkaling street towards Malang, Sengkaling street in the direction of Batu and Sidomakmur street. This area is occupied by shops, offices, and street vendors selling activities on the shoulder of the road and cafes where visitors park their vehicles on the shoulder of the road. This study aims to improve the quality of the performance of signalized intersections on Sengkaling street and Sidomakmur, Malang City, with the method of calculating traffic flows or traffic counting and providing alternative solutions to problems encountered at the intersection. Based on the results of the study, it is apparent that the intersection is not close to saturation, presenting the degree of saturation of 0.64674 or categorized as service level B and for Sidomakmur Street with the total value of the degree of saturation of 0.711059, categorized as service level C. However, the results of the questionnaire indicate that 45% of the community is categorized as disturbed by the activities of street vendors, 20% of the community is disturbed by illegal parking, 15% of the community is disturbed by the presence of stopped vehicles, encouraging the installation of signs to avoid vehicle delays, experiencing a decrease in the degree of saturation from 0.646 to 0.632 which means the level of service has increased.

## INTRODUCTION

Streets in cities generally intersect that connect each other, despite presenting problems, one of which is congestion influenced by road geometry, traffic capacity[1]. Signalized intersections are thus an important element in the road network that regulates traffic, but the drawback of these intersections is the continuous increase in traffic flow[2]. An intersection is a meeting point of various traffic flows that serves to connect two or more intersecting road segments[3][4]. Junctions are inseparable from the road network. Land transportation networks in urban areas such as signalized intersections are categorized as important because there are vulnerable points where conflicts can occur, such as traffic jams and even accidents[2].

One of the studies at the United Arab Emirates which examined the performance of signalized intersections and roundabouts on safety in service reported that accidents at intersections had accounted for most of the fatal road accidents worldwide. The severity of accidents at intersections is influenced by several factors such as traffic volume, speed limits, and number of vehicles involved in the accident[3].

There are several studies in India that examine the effect of side barriers such as slow-moving vehicles, buses stopping on the side of the road, pedestrians crossing inappropriately, vehicles parked along traffic lanes can affect traffic speed, reduce road capacity and safety[4][5]. As for research in Nanning, China which collects data at intersections from morning to peak hour, the results of this study explain that vehicle queues are influenced by lane position and road conditions[6].

Pedestrian movement that walks or crosses the road has a negative impact on the performance of traffic flow on certain roads (especially urban roads) that do not have sidewalks, forcing pedestrians to walk on the shoulder of the road, declining the speed of moving vehicles[7]. Non-motorized vehicles can cause side drag on traffic due to their limited top speed which can degrade the performance of the traffic flow.

Although some studies assume that side drag affects vehicle speed and urban road capacity affecting traffic performance[8], an appropriate traffic control strategy is required in order to improve and optimize intersection performance [9][10]. Another study in Malaysia analyzed that the level of saturation provides a comparison of the volume from traffic passing by with the limits that can be accommodated by the road [11].

The intersection of Sengkaling street and Sidomakmur street is located in Dau District, Malang City, which is a signalized intersection with three arms, ranging from the west of Sengkaling Road towards Malang City, the east of Sengkaling Road towards Batu City and the north of Sidomakmur street. In addition, there are office activities, food stalls, health centers, KUA, cafes and street vendors. The influence of side barriers also occurs at the intersection in

the form of street vendors who sell from morning to evening on the shoulder of Sidomakmur street and on the shoulder of Sengkaling street there is a café whose end users are at the shoulder of the road as a parking lot.

A large number of studies analyses the mechanism and the effect of side barriers on the lack of road capacity and traffic volume, along with the vehicle speed that affects pedestrian movement. This study aims to improve the quality of intersection performance and to provide alternative solutions for problems at intersections, One method that is believed to support this research is the traffic counting method, previously applied in several studies [12][13]. The selected methods are conducted in two ways, through hand calculations (manual) and mechanical calculations. The survey of each road flow will be observed for 1 week and for 1 hour during the busiest 1 hour, the data obtained are in the form of traffic volume, road geometric conditions, number of arms at each intersection, number of lanes and traffic flow, the data will be further processed to obtain the degree of saturation as the starting point. In addition, the level of service at the intersection is measured to evaluate and offer an alternative performance for intersection improvement.

## METHOD

The analysis in this study was quantitatively and qualitatively conducted, the data obtained in the form of primary data which was carried out with a traffic counting survey technique, by making direct observations that occurred in the field by tracing the intersection and are then evaluated based on the Indonesian Road Capacity Manual[14]. Secondary data is obtained from distributing questionnaires to find out community assessments of intersection performance based on several assessment indicators contained in Table 1, survey point location is obtained in Figure 2.

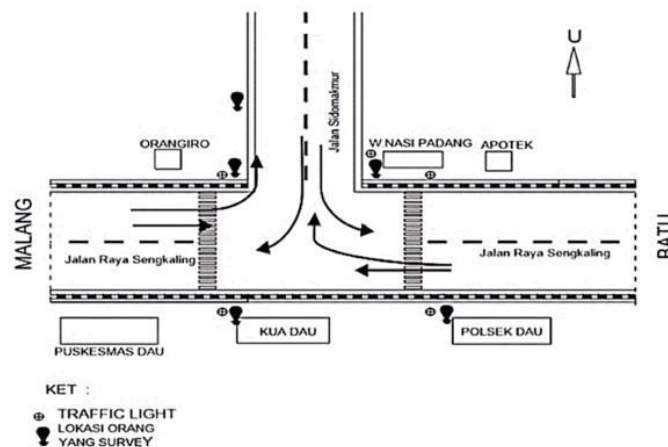


FIGURE 1. Survey Point Location

The location of the survey point, which is close to the traffic light of each road segment, is located at Figure 1. The location selection is located in Dau District which is the border of Malang City and Batu City, the location of this research is also close to the Dau Sector Police Office and Dau Religious Affairs Office. The implementation of this traffic counting requires several tools to support this research, such as: survey forms, stationery, counters, gadgets (communication tools), watches (watches), walking measure (meters).

TABLE 1. Side Barrier Factors Sengkaling Highway and Sidomakmur Road

No	Side Barriers	Description
1	Street vendors	Obstacles on the road due to street vendors
2	Vehicle Parking	Illegal street parking by motorized vehicles
3	Vehicle Stop	Public transportation or means of transportation that stop
4	Non-Motorized Vehicles	bicycle, rickshaw,
5	Vehicle In and Out	Activities in and out of vehicles using sidewalk

Side barrier factor or activity beside the road is based on community feedback which can have a major influence on road performance, such as street vendors (PKL), non-motorized vehicles (pedicabs, bicycles, stopped vehicles (city transportation), illegal parking or parking on the sidewalk, and vehicles going in and out on sidewalk.

## RESULTS AND DISCUSSION

This study analyses the calculation of traffic volume, degree of saturation, level of service, side barriers and planning alternatives in order to obtain intersection performance, Intersection Traffic Volume Calculation which is presented in Table 2.

### Traffic Performance Analysis

**TABLE 2.** Intersection Traffic Volume Calculation

Sengkaling Highway Intersection – Sidomakmur Street	Hour	Motorcycle	Light Vehicle	Heavy vehicle	junior high school
Sengkaling Highway, heading towards Batu - Sengkaling Highway, heading towards Malang	14.45- 15.45	419	390	90	716.5
Sengkaling Highway, heading towards Malang – Sengkaling, heading towards Batu	14.45-15.45	487	70	78	414.9
Sengkaling Highway, heading towards Malang – Sidomakmur Street	14.45-15.45	487	70	78	146
Sidomakmur Street – Sengkaling Highway, heading towards Malang	14.45-15.45	378	9	4	203.2
Sidomakmur Street - Sengkaling Highway, heading towards direction Batu	14.45-15.45	87	45	13	105.4
Sengkaling Highway, heading towards Batu - Sidomakmur Street	14.45-15.45	234	7	5	130.5
				Total SMP/hour	1716.5

The survey which was conducted for 60 minutes at each traffic flow, which was grouped into three types of vehicles, including motorcycles (Motorcycle), heavy vehicles (Heavy Vehicles) such as small buses, combination trucks with 6 wheels, and light vehicles (Low Vehicles) such as micro buses, pick-ups and small trucks, and the results of the traffic volume are expressed in Passenger Car Units (pcu) indicating 1716.5 smp/ next hour. The data will be analyzed based on the 1997 MKJI and the results of the degree of saturation are obtained in Table 3.

**TABLE 3.** The degree of saturation of the signalized intersection of Sengkaling street to Sidomakmur Street

ROUTE	Co	FCw	FCsp	FCsf	FCcs	C	DS	LOSS
Jl. Raya Sengkaling	2900	1	1	0.88	1.04	2654.08	0.64674	B
Jl.Sidomakmur	2900	0.87	1	0.92	1.04	2414,006	0.711059	C

**TABLE 4.** Service level at the signalized intersection of Sengkaling Highway to Sidomakmur Road

Road	Approach Type	The width of the road	WLTOR (m)	Effective Width	So (pcu/ hour)	Adjustment Factor						S (pcu/hour)
						FCS	FSF	FG	FP	FR T	FLT	
Sidomakmur - Batu	protected	7	1	9	5400	1.05	0.92	1	1	1	1	5216
Sidomakmur – Batu	protected	5	2	6	3600	1.05	0.92	1	1	1.08	1	3756
Sidomakmur - Malang	protected	5	1	6	3600	1.05	0.92	1	1	1	1	3478
Sidomakmur - Malang	protected	7	2	9	5400	1.05	0.92	1	1	1.08	1	5634

The degree of saturation is = 0.64674 which means the level of service on the Sengkaling Highway is classified B, thereby indicating as a stable flow, the speed is slightly limited by traffic, the driver can still freely choose the speed, while at the service level of Sidomakmur Street the value of the degree of saturation is = 0.711059 which is classified as C, marked to be steady flow, and speed can be controlled by traffic. The level of service intersections is contained in Table 4.

Sengkaling Highway heading towards Batu – Sidomakmur Street indicates a congested intersection due to the accumulation of vehicles on the road, from Sidomakmur Street - Sengkaling street heading towards Batu shows an intersection that is not too crowded and the flow of vehicles and speed is quite controlled by traffic, while from Sidomakmur Street - Sengkaling Street, heading towards Malang shows the intersection is not too crowded and the flow of vehicles and the speed can be controlled by traffic, Sengkaling Street heading towards Malang- Sidomakmur Street shows a dense intersection due to the accumulation of vehicles on these roads, the percentages of obstacles beside Sengkaling Highway - Sidomakmur Road are obtained in Figure 2.

### Analysis of Side Resistance Percentage

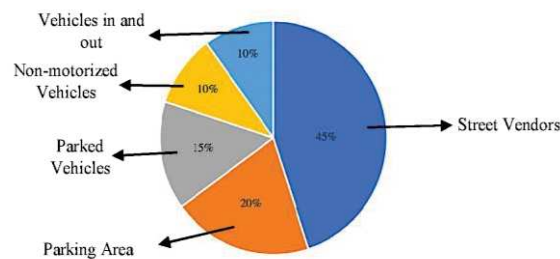


FIGURE 2. Percentages of Obstacles beside Sengkaling Highway - Sidomakmur Road

The results of the questionnaire, as many as 45% of the community were categorized as disturbed by the activities of street vendors selling on the shoulder of the road, 20% of the people were disturbed by the illegal parking, 15% of the people were disturbed by the presence of parked vehicles, 10% of the people were disturbed by the existence of a vehicle without a motor and 10% of the community feel quite disturbed by the activity of vehicles. Through all the results of the analysis at this intersection, alternative improvements are planned based on the percentage of side barriers from the community who feel disturbed, this alternative planning is in the form of installing no-parking signs on Sengkaling street and controlling street vendors selling on the shoulder of Sidomakmur Street, in order to improve performance of the intersection.

### Analysis of Signalized Intersection Alternative Planning

Table 6 presents the results of alternative planning on Sidomakmur Street which have increased the level of service with a degree of saturation of 0.570 (A) or which means free flow, low volume and high speed, the driver can choose the desired speed and the Sengkaling Highway section experiences a decrease in the value of the degree of saturation from 0.646 to 0.632 which means that the service level of Sengkaling Highway has a B value, regarded to be stable flow, the speed is slightly limited by traffic, the driver can still freely choose the speed. The following is a plan for installing signs on both roads in Figure 3.

TABLE 6. Alternative planning for the signalized intersection of Sengkaling Highway - Sidomakmur Road

ROUTE	Co	FCw	FCsp	FCsf	FCcs	C	DS	LOSS
Sengkaling Highway	2900	1	1	0.90	1.04	2714.04	0.632	B
Sidomakmur Street	2900	1	1	0.92	1.04	2774.72	0.570	A



FIGURE 3. Alternative planning

## CONCLUSION

The level of feasibility on the Sengkaling Road section is categorized B, which means the road has a stable flow, the speed is slightly limited by traffic and the driver can still freely choose the speed while on the Sidomakmur Road section is categorized C, indicating that the road has stable flow characteristics, and the speed is, however, from the distributed questionnaires, it can be concluded that 45% of the people feel disturbed by the activities of street vendors selling on the shoulder of the road, 20% of the people are categorized as disturbed by illegal parking, and 15% of the people feel disturbed by the presence of illegal parking or a stopped vehicle, 10% of the people feel disturbed by the presence of vehicles without motorbikes and 10% of the people feel disturbed by the activities of vehicles in and out. Therefore, an alternative is planned on both lanes on Sidomakmur Street, there will be control of street vendors on the sidewalk, after planning alternative values of the level of service shows an increase. Moreover, on Sengkaling Highway, there will be installation of a no-parking sign indicating a decrease in the value of the degree of saturation. Future research is expected to implement alternative planning to improve the performance of the intersection of Sengkaling Street and Sidomakmur Street.

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