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PERFORMANCE OF UNSIGNALIZED JUNCTIONS (CASE STUDY ACCORDION STREET)

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ABSTRACT

Malang City, one of the cities with a tourist destination of around 875,771 people, increasing by 3.9% every year. From the ever-increasing traffic development, it must also be adjusted to the addition of sufficient transportation equipment so that the roads are free from congestion and other obstacles. Simpang Lima Akordion intersection is one of the areas affected by traffic jams. This study aims to determine the characteristics of traffic flow and capacity and find the best alternative to solve the problem of vehicle density at the five accordion intersection. The total volume of vehicles (LHR) on the third day with a total of 44397 from five directions, with traffic flow occurring at 16.00-17.00 at 4230 vec/hour, with a volume traffic (Q) 8668.9 vec/hour from the capacity (C) 6869.97 vec/hour with a degree of saturation (DS) 1,26. From the value of the degree of saturation, it can be seen that the performance of this intersection is classified as class F (very, very low). Moreover, handling is by the performance of the intersection in describing the problem of congestion, and traffic flow, namely by installing traffic signs that are prohibited from parking and widening the shoulder of the five accordion intersection.

Keywords: *Unsignalized Intersection; Capacity; Degree of Saturation; Delay.*

1. Introduction

Malang City is one of the second largest cities in East Java after Surabaya, and the 12th largest city in Indonesia. This city is located on a plateau which covers an area of 145.28 km2 and is located in the middle of Malang Regency. This city is also referred to as a unitary area commonly known as Malang Raya. For areas in Malang City, Batu City and Malang Regency, it is commonly called Malang Raya.

One of the cities with a tourist destination as well as an education city is Malang with a population of 875,771 people. The increase in population every year will always increase to coincide with the increasing use of transportation every year. From the ever-increasing traffic development, it must also be adjusted to the addition of sufficient transportation equipment so that the roads are free from congestion and other obstacles[1]. Jalan Accordion Simpang Lima Tunggulwulung, Lowokwaru District, Malang City is the route from Malang City to Batu City, Soekarno Hatta Street, MT Haryono Street, Tlogomas Street, and Singosari Street. The Accordion intersection, Lowokwaru District is the meeting place of five intersection roads, namely, Saxophone Street, Candi Panggung Bar, North Accordion Street, South Accordion Street, and Simpang Accordion Street. The five-way intersection of Tungguwulung[2] Accordion is called a local road secondary.

Transportation problems often occur with activities at the Simpang Lima market on Jalan Saxophone such as congestion and road capacity will continue to decrease due to the Simpang Lima Simpang Accordion Road which has a high activity stage because very busy activities often occur during peak hours, such as the intersection market activity. five, pedestrians who pass through the five-way intersection of Accordion Street during school hours, campuses, urban areas and other activities. Identification of problems such as Several factors that cause traffic jams at the Simpang Five Akordion Tunggulwulung Street are due to the high volume of traffic, street vendors, and slow vehicles.

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2. Material and Methods

2.1. Location

Research location was held in the junction between West of Saxophone Street (Pasar Tunggulwulung). South of South Accordion road (Lowokwaru, Stikes Maharani Campus and SMK). The north of the Accordion intersection. The Accordion road (SD Tunggulwulung and ITN.East side of Candi Panggung Bar road (Blimbing). The survey method is carried out by conducting direct observations in the field, this is done to determine the conditions in the field. The data obtained from this survey activity is called primary data.

The initial stage in this research is to identify the problem, namely to find out the problems that occur in the research to be taken, after knowing the problem, then the research is carried out, then determine what topic / title is in accordance with the previous problem. After that, conduct a preliminary survey, to find out the current conditions at the research location[3], including traffic conditions, observation points, and geometry at that location. Then collect data, both primary and secondary data[2]. The data that has been obtained will then be processed to determine the final results of the research to be carried out and can provide conclusions and suggestions in the research.

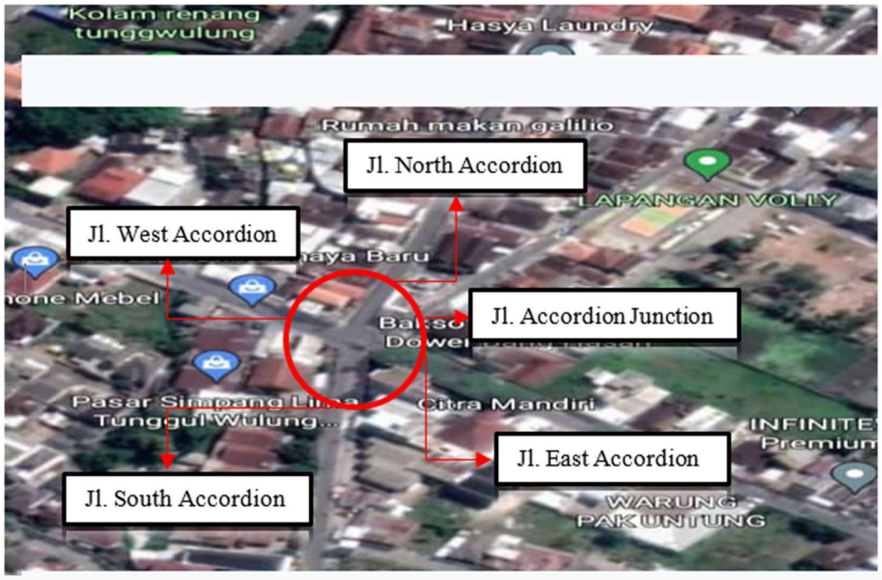

Figure 3. Research Location Map
Source: Google earth 2021

2.2. Data Collection

Data collection is the process of collecting data and information relevant to the needs of the study. In data collection activities, it is necessary to pay attention to several things such as the type of data, where to obtain it, how to obtain it, and the amount of data that must be collected.

The data used were obtained from direct surveys in the field and from relevant agencies. There are 2 types of data needed in this research, namely, primary data, and secondary data[2]. Primary data consists of vehicle traffic volume[4][5] and road geometric data[6][7] obtained from direct surveys in the field. Secondary data is data obtained from a related agency or can also be obtained from the internet, such as population data and maps of intersection locations.

2.3. Analysis Method

The data obtained from the field is the input for calculating unsignaled intersections using MKJI 1997. Analysis of unsignalized intersection data using the Indonesian Road Capacity Manual [3][8] aims to determine whether the performance of the intersection is still feasible or not. If the results of

the analysis show that the performance of the intersection is no longer feasible, it is necessary to solve the problem. From these results, we get the value of capacity, degree of saturation, delay and queuing opportunities based on the method in the Indonesian Road Capacity Manual Indonesian Road Capacity Manual[9].

3. Result and Discussion

3.1. Traffic Volume Data

Observations and enumerations were carried out for one week (7 days), namely on 12 August to 19 August 2021. The enumeration was carried out at 06: 00 - 20: 00 with an observation time interval of 15 minutes.

Calculating traffic volume, namely counting the number of vehicles that pass one intersection point per unit time at the five accordion intersection can use the equation below:

q = n/t
= 12424/15
= 828 vehicles/hour.

Based on the results of a survey conducted on the Simpang Lima Accordion Street, Tunggulwulung District, Lowokwaru District, precisely on the East Accordion Street, West Accordion, North Accordion, South Accordion and Accordion Intersection Road the research was carried out for one week, namely 7 days where in one week the survey was carried out for 15 hours with observation time. 15 minutes. Based on the classification of vehicles at the time of the survey, there are 4 classifications of vehicles, namely Motor Cycle (MC), Light Vehicle (LV), Heavy Vehicle (HV), Un Motorized (UM)

To get the peak hour volume in passenger car units (pcu), it is necessary to convert various types of vehicles into passenger car equivalents (emp). Based on research conducted for 7 days, the peak hours were obtained on each research day which was carried out from Thursday, August 12 to Thursday, August 20, 2021.

Table 3. Survey Data for Highest Peak Hour Traffic Volume

Five-Way Total Traffic Volume (LT, RT)					
Time	Transportation type				
	MC	LV	VH	UM	Amount
06.00 – 07.00	1819	849	29	162	2859
07.00 – 08.00	2228	1318	24	79	3649
08.00 – 09.00	2239	1415	37	83	3774
09.00 – 10.00	2302	1399	32	70	3803
10.00 – 11.00	2322	1428	30	54	3834
11.00 – 12.00	2322	1427	19	54	3822
12.00 – 13.00	0	0	0	0	0
13.00 – 14.00	2285	1457	28	48	3818
14.00 – 15.00	2301	1425	39	70	3835
15.00 – 16.00	2260	1475	33	106	3874
16.00 – 17.00	2377	1565	120	168	4230
17.00 – 18.00	2168	1400	28	75	3671
18.00 – 19.00	1861	1110	23	76	3070
19.00 – 20.00	1441	832	7	19	2299
Total					**46538**

Source: 2021 Analysis Results

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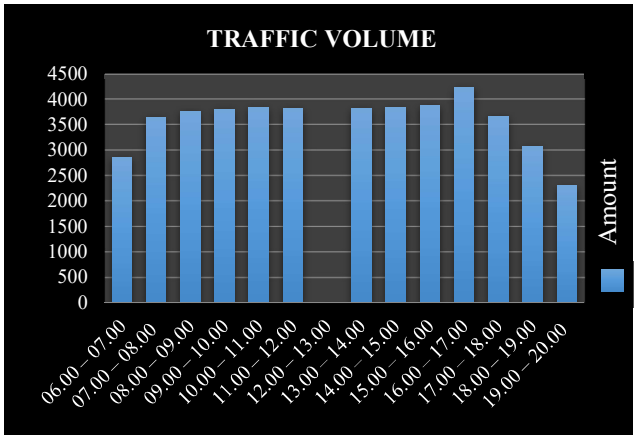

Figure 4. Highest Peak Hour Volume

3.2. Traffic Flow Data

After obtaining the peak hour volume from a total of five directions, the next is the traffic volume data from each road based on the calculation results, which are as follows:

1. Column (1) : the approach code consists of approach A (east direction), approach B (west direction), approach C (north direction), approach C (south direction), approach D (south direction) and approach E (direction Accordion Junction).
2. Column (2) : Vehicle ars consists of LT (turn left), ST (go straight) and RT (turn right).
3. Column (3) : The number of vehicle flows/hour for motorcycles (MC) on the main road (C) on the East approach, namely LT = 1496, RT = 1506, ST = 0.
4. Column (4) : Product of vehicle/hour with emp = 0.25 on motorcycle (MC) (pcu/hour). For MC vehicles, turn left (LT) which is 1496 x 0.25 = 374 smp/hour.
5. Column (5) : The number of vehicle flows/hour on light vehicles (LV) unit vehicle/hour on minor roads or the North approach has a total flow of vehicles/hour of LT = 1312, RT = 1393, ST = 0.
6. Column (6) : Product of vehicle/hour with emp=1.0 for light vehicle (LV) (pcu/hour). For light vehicles, LV turning right (RT) is 1393 x 1.0 = 1393 pcu/hour.
7. Column (7) : Total flow of vehicles/hour on heavy vehicles (HV). On the main road the West approach (D) has a number of vehicle flows/hour of LT = 1430, RT = 1360, ST = 0
8. Column (8) : Product of vehicle/hour with emp = 1.2 for heavy vehicle (HV) (pcu/hour). For heavy vehicles (HV) that turn left (LT) it is 363 x 1.2 = 435.6 pcu/hour.
9. Column (9): The total result of all vehicles/hour. Namely: 1406 + 1596 + 0 = 2790 (main street C).
10. Column (10) : Total result of all protected vehicles (pcu/hour). Example: 1496 + 1506 + 0 = 3001.
11. Column (11) : Ratio of left turning vehicles (PLT).
    PLT = (LT (pcu/hour)/(Total (pcu/hour)
    PLT = 748.2/1578 = 0.47.
12. Column (12) : Ratio of right turning vehicles (PRT).
    PRT = (RT (pcu/hour)/(Total (pcu/hour)
    PRT = 2976.4/3645.95 = 0.81.
13. Column (13) : Total flow of non-motorized vehicles (UM).
14. Column (14) : Ratio of non-motorized vehicles (PUM)
    PUM = UM/MV
    PUM = 344/8668.9 = 0.029

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3.3. Data Analysis of Approach Width, Type of Intersection, Capacity and Traffic Behavior

1. Junction Capacity

a. Basic capacity

For the type 422 intersection, the basic capacity is 2900 smp/hour.

b. Approximate average width

W1(A/2 + B/2 + E/2 + C/2 + D/2)/5 = (4/2 + 4/2 + 4/2 +5/2 + 5/2)/5 = 11 m.

c. Approach width adjustment factor

422: Fw = 0.7 + 0.0866 x W1 = 0.7 + 0.0866 x 11 = 1.22.

d. Main road median adjustment factor

The unsignalized intersection of Jalan Accordion does not have a median on the main road, so we get FM = 1.00

e. Fcs . city size adjustment factor

The population of the city of Malang in 874890 Soul. Then obtained FCS at the intersection of the five accordion = 0.94.

f. Adjustment factors for the type of road environment, side barriers and non-motorized vehicles

UM/MV = 344/8668.9 = 0.029.
Value X = (0.030-0.00)/(0.05-0.00) x (0.93-0.98)+(0.98) = 0.97
Then the value of FRSU = 0.97.

g. Left turn adjustment factor

PLT = QLT/QTotal = 5740/5792 = 0.99
QLT value = Volume of vehicles turning left from the main and minor roads
QTOT value = Overall vehicle volume from main and minor roads.
FLT = 0.84 + 1.61 PLT
= 0.84 + 1.61 x 0.99 = 2.42

h. Right turn adjustment factor

For the intersection of 4 arms
FRT = 1.0 x FRT
= 1.0 x 0.99 = 0.99.

i. Minor current ratio adjustment factor

The input variable is the ratio is the total ratio of minor roads divided by the total volume of major and minor road vehicles which can be calculated by the formula:
PMI = QMI/QTOTAL
PMI = 5444.65/3224.25 = 0.68
Then the value of FMI = 1.19 x PMI2 – 1.19 x PMI +1.19
= 1.19 x 0.682 – 1.19 x 0.68 + 1.19
= 0.88.

j. Capacity

C = Co x FW x FM x FCS x FRSU x FLT x FRT x FMI (pcu/hour)
= 2900 x 1.22 x 1.00 x 0.94 x 0.97 x 2.42 x 0.99 x 0.88

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= 6869.97 smp/hour

2. Performance level

Levels include:

a. Degree of saturation

DS = QTOT/C = 8668.9/6869.79
= 1.26

b. Delay

1) Intersection Traffic Delay

DTI = 1.0504/ (0.2742 – 0.2042 x DS) – (1 – DS) x 2
= 1.0504/ (0.2742 – 0.2042 x 1.26) – (1 – 1.26) x 2
= 59.60 sec/hour.

2) Main road traffic delay (DTMA)

DTMA = 1.05034/ (0.346 – 0.24 x DS) – (1 – DS) x 1.8
= 1.05034/ (0.346 – 0.24 x 1.26) – (1 – 1.26) x 1.8
= 21.82 sec/hour.

3) Minor road traffic delay (DTMI)

DTMI = (QTOT x DTI) – (QMA x DTMA)/QMI
= (8668.9 x 59.60) – (3224.25 x 21.82) / 5444.65
= 81 sec/hour.

4) Intersection geometric delay (DG)

DG = Ds < 1.0 : DG = (1-DS) x (PT x 6+ (1 – PT) x 3 + DS x 4
= DS 1.0.
DG = 4

5) Intersection delay (D)

D = DG + DTI
= 4 + 59.60
= 63.6 sec/pcu.

3. Queue probability (QP%)

Lower limit:

QP% = 9.02 x DS + 20.66 x DS2 + 10.49 x DS3
= 9.02 x 1.26 + 20.66 + 1.262 + 10.49 x 1.263
= 97.961%

Upper limit:

QP % = 47.71 x DS – 24.68 x DS2 + 56.47 x DS3
= 47.71 x 1.26 – 24.68 x 1.262 +56.47 x 1.263
= 251.45%.

3.4. Traffic Growth Analysis

Analysis of intersection performance[10] in the next ten years is carried out to be able to predict the feasibility of the intersection in the next ten years based on the value of the degree of saturation[3] according to the standards of the Directorate General of Highways (MKJI 1994). To be able to find out

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the value of the degree of saturation (DS) in 2031, it is necessary to analyze the growth of the population and the number of motorized vehicles in order to estimate the number of residents and the number of vehicle flows[11] that pass through the intersection.

Table 4. Vehicle growth in Malang Regency in the last five years

Year	Number Of Vihecles				Growht			
	MC	LV	HV	Total	MC	LV	HV	Total
2020	361329	91299	17718	470346	361229	91199	17618	470046
2019	482816	98391	21766	602973	482716	98291	21666	602673
2018	477687	97078	21627	596392	477587	96978	21527	596092
2017	476252	95320	21435	593007	476152	95220	21335	592707
2016	456693	90058	20968	567719	456593	89958	20868	567419
2015	436123	74060	20401	530584				

Source: Data Analysis, 2021

To calculate the percentage of traffic growth in the city of Malang can use the following equation:
Growth (%) = ((MC 2020 – MC 2019) / MC 2019 x 100%

Table 5. Percentage of Total Growth of Motorized Vehicles in Malang Regency

Year	Number Of Vihecles				growht			
	MC	LV	HV	Total	MC (%)	LV (%)	HV(%)	Total (%)
2020	361329	91299	17718	470346	3,61	9,11	1,76	14,5
2019	482816	98391	21766	602973	4,82	9,82	2,16	16,8
2018	477687	97078	21627	596392	4,77	9,69	2,15	16,6
2017	476252	95320	21435	593007	4,76	9,52	2,13	16,4
2016	456693	90058	20968	567719	4,56	8,99	2,08	15,6
2015	436123	74060	20401	530584				

Source: Data Analysis, 2021

3.5. Solutions to Overcome Intersection Congestion

Five No Signals On The Accordion Street

Table 6. Alternatives and Implications

Alternative	Implication
Installation of signs prohibiting parking on the shoulder of the road.	Installation of prohibited signs in order to regulate parking vehicles or prohibition for parking vehicles on the side of the road. The installation of signs for no parking is intended to reduce side barriers from high to low. The installation of no parking signs can be seen in Figure 4.5
Road widening with an additional 1 meter wide	Road widening is carried out to increase traffic performance at the intersection and can reduce the degree of saturation at the intersection to 1.69 pcu/hour from the current saturation degree of 1.92 pcu/hour.

Source: Data Analysis, 2021

4. Conclusions

The five-way intersection of Tunggulwulung Accordion, Lowokwaru District, Malang City has an approach width of each intersection, namely: East Accordion Road 5m, West Accordion 5 m, North accordion 4m, South accordion 4m and Accordion Intersection 4m, traffic volume characteristics traffic 4230 vehicles/hour. The value of the capacity of the Five Accordion Intersection in 2021 is 8668.9 pcu/hour, with a degree of saturation of 1.26. Meanwhile, the predicted capacity for the next 10 years is 3545.15 smp/hour. From the results of the calculation analysis predicting traffic flow for the next 10 years (2031), the level of service for the Simpang Lima Akordion road has a degree of saturation 0.92. so that the five-way Akordion intersection is classified as service level E (very low) with unstable current conditions and frequent traffic jams for a while. Alternative models of the best conditions in this study are: Implementing the installation of traffic signs, prohibited parking on the shoulder of the road and widening the road with an additional 1 meter widening for each approach.

Based on the results of the research analysis and conclusions, the researchers outline some suggestions as follows: Future research is expected to examine the planning and arrangement of intersections based on the 2014 PKJI method; Further research is needed on roundabouts with traffic signs; Future research is expected to use more guidelines and references related to improving intersection performance in order to obtain accurate alternative solutions; Restrictions on entry of vehicles or prohibitions for vehicles with certain classifications such as heavy vehicles (trucks, trontons and large buses).

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