

Evaluation and Traffic Management of The Intersection of Lalove Road-Jati Road and Lalove Road-Emi Saelan Road Due to the Impact of the Operation of Palu V Bridge

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ABSTRACT

The construction of the Palu V Bridge infrastructure impacts traffic performance at the intersection. The purpose of this study is to determine the existing traffic performance at the intersection of Emmy Saelan, Anoa, and Lalove, and to determine the impact of the addition of access on the operation of the Palu V bridge. This research uses a survey research type with a quantitative approach. The results of the study show that in the Emmy Saelan Arm, traffic can still flow well between the north and south. The unsignaled intersection of Jati Street - Lalove Street has exceeded the congestion limit requirements. The impact of the operation of the Palu V bridge shows the rise of new movements and flow diversions of 1423 pcu/hour, consisting of movements from the direction of Emmy Saelan to Jati Street of 653 pcu/hour and vice versa from the flow of Jati Street to Emmy Saelan Street of 769 pcu/hour.

INTRODUCTION

Palu is one of the areas in Central Sulawesi Province, the largest city in Central Sulawesi, and the province's capital. The rapid year-to-year population increase drives growth and development in the region, raising several problems, including transportation issues that affect traffic volumes (Idrus, 2022). The West Palu area is part of the centers of social and economic activities of the people of Palu City, such as shops, warehouses, schools, hospitals and markets, which of course these activity centers are often visited by people both inside and outside the city, plus several roads in the West Palu area are logistics distribution routes to the village, and also become a route for transportation in and out of the city. The lack of alternative routes and the damage to the route that stretches for about 7.2 kilometers in the coastal area of Palu Bay, including the Palu IV bridge, due to the earthquake and tsunami disaster some time ago, forced the city government to divert traffic lanes into the city, most of which are included in the West Palu and South Palu areas. The western area of Palu City, along with the city's east and south areas, includes I Gusti Ngurah Rai Street, Hasanuddin Street, and Kimaja Street.

As a result, the Palu City government took the initiative to open alternative routes to anticipate traffic density in the area, including the construction of the V bridge, completed in 2020, as a connecting route between the two regions (Wardhani, Surjono, & Yudono, 2021). This effort is expected to minimize traffic density problems on other roads, which are also routes connecting the two sides of the Palu City area. The construction of bridge infrastructure connecting the two regions in Palu City is urgently needed as a strategic effort to mitigate congestion on several roads. The operation of this bridge can serve as an alternative route for public traffic both in and out of the West Palu area and its surroundings, so that when it opens, many vehicles will use it. Still, another problem that arises is that during peak hours, especially on weekdays, there is often a build-up of vehicles at the signaled intersection of Emmy Saelan Street - Lalove Street and the unsignaled intersection of Jati Street - Lalove Street after the operation of the V Bridge as one of the alternative routes connecting the two city areas.

Therefore, based on the background described, it is necessary to conduct research to assess the impact of infrastructure development on traffic performance across several road networks in the West Palu Region. The aims of this study are to determine the current traffic performance at the intersection of Emmy Saelan, Anoa, and Lalove. In addition, to find out the impact of additional access on the operation of the Palu V bridge.

THEORETICAL REVIEW

Characteristics of Urban Roads

Transportation is the activity of moving people and goods from one place (origin) to another place (destination) using means (vehicles). The balance between the capacity of the mode of transportation (fleet) and the number (volume) of goods and people who need transportation (Wardhani, Pratikso, & Mudjanarko, 2021). If the fleet's capacity is insufficient, many goods and people will not be

transported, or both will be crammed into existing vehicles (De Silva, Herath, Nakayama, & Kumarage, 2024).

Definition of urban road segment are have a permanent and continuous minimum development on one side, a road in or near an urban center with a population of > 100,000 people; Indications include the characteristics of morning and evening peak traffic flows (dominated by private vehicles and motorcycles), and a sufficient increase in flow during peak hours; The types of urban roads are: 2/2 UD, 4/2 UD, 4/2 D, 6/2 UD, One-way roads (1-3/1) (Mohammed, Ambak, Mosa, & Syamsunur, 2019).

Intersection

According to Morlok (1991), the types of intersections based on the way they are arranged can be grouped into two types, namely intersections without a signal intersection and signaled intersections, of which the two types of intersections will be explained as follows:

1) Junction without a signal

An intersection without a signal is an intersection that does not use traffic signals. At this intersection, road users must decide whether they are safe enough to pass through the intersection or must stop first before passing through the intersection. According to the MJKI (1997), unsignaled intersections are typically used in urban residential areas and in inland areas for intersections between local roads with low traffic flow, with right-of-way arrangements (priority from the left). For intersections with different road classes and functions, traffic on minor roads must be regulated with yield or stop signs (Awadallah, 2009). Ahmad (2004) stated that unsignaled intersections are used when traffic flow on the main road and turning movements are relatively low. However, if traffic on the main road is so high that the risk of accidents increases (due to motorists being too bold in taking a small gap), it may be necessary to install traffic lights (Reinolsmann, Alhajyaseen, Brijs, Pirdavani, Hussain, & Brijs, 2021).

a) Capacity

Capacity is calculated using the following formula, where the various factors are calculated beforehand.

$$C = Cox FW \times FCS \times FM \times FRSU \times FLT \times FRT \times FMI \text{ (pcu/hour)}$$

Information:

C	=	Capacity (junior high school/hour)
Co	=	Basic Capacity (pcu/hour)
FW	=	Approach Width Adjustment Factor
FCS	=	City Size Adjustment Factor
FM	=	Median Width Adjustment Factor
FRSU	=	Factors for Adjusting Road Environment Type, Obstacles Side and Non-Motorized Vehicles
FLT	=	Left Turn Adjustment Factor
FRT	=	Right Turn Adjustment Factor
IMF	=	Minor Road Flow Ratio Factor Intersection Performance Level

b) Degree of Saturation (DS)

To determine the degree of saturation, use the formula below. The required variables are the total current value and the road capacity value.

$$DS = QTOT / C$$

Information:

DS = Degree of Saturation (Degree of Saturation)

QTOT = Total Current (Quantity) (pcu/hour)

C = Capacity (Capacity) (pcu/hour)

2) Signaled junction

The signaled intersection in question is one with traffic lights. Oglesby (1999) stated that traffic lights are defined as all traffic control equipment that uses electric power, except flashing lights, signs, and road markings, to direct and warn motorists, cyclists, and pedestrians. Traffic lights must be installed at intersections when the traffic flow is already elevated. The measure of the increase in traffic flow is the average vehicle waiting time at intersections (Fahrurnisa, Rahmadwati, & Setyawan, 2024). Therefore, Ahmad (2004) stated that if the average waiting time without traffic is already greater than the average waiting time with traffic lights, then traffic lights should be installed.

Based on the MKJI issued by the Director General of Highways (1997), most facilities, capacity, and traffic behavior are functions of the state of the traffic geometry. Using signals, a designer or engineer can distribute capacity across different approaches by allocating green lights to each. Therefore, to calculate capacity and traffic behavior, it is first necessary to determine the signal phase and timing that are most suitable for the conditions under review (Jiang, Wang, & Chen, 2021)

a) Capacity

To determine the capacity of the signaled junction, the following formula is used:

$$C = S \times g / c$$

Information:

C = Capacity (pcu/hour)

S = Gen current (pcu/hour)

g = Green time (seconds)

c = Adjusted cycle time (seconds)

From the results of the calculation above, the degree of saturation for each approach can be determined by the equation.

$$DS = q / c$$

Where:

DS = Degree of saturation

q = Traffic flow (pcu/hour)

c = Capacity (pcu/hour)

If the cycle time obtained from the growth result ($c = \Sigma g + LTI$) is greater than the recommended limit for the same section, and the degree of saturation (DS) generally has a value higher than 0.85, then this indicates that the junction is detecting a saturation flow. If this happens, it will result in long queues in peak traffic conditions

METHODOLOGY

In this study, the author uses a survey research type with a quantitative approach (Ganji, Zhang, & Hatzopoulou, 2022). Meanwhile, the research is planned to be conducted on weekdays, namely Monday–Friday, with Tuesday chosen. Research data collection is conducted during peak hours: in the morning at 6.30 – 10.30 and in the afternoon at 14.00 – 18.00, for 4 hours per session.

Data Primer

Traffic volume data, which includes the number of motorcycles (MC), light vehicles (LV), and heavy vehicles (HV): 1) Side obstacle data, which includes pedestrians (PED), stopped vehicles (PSV), vehicles entering and exiting the side of the road (EEV), and slow vehicles (UM), namely bicycles, carts, and others; 2) Land use data is needed to determine the conditions of land use and activities in the study; 3) Road geometric data, which includes road sections, approach widths, types of pavement, and others.

Primary traffic flow data collection is carried out by a clarified traffic flow recording method starting from traffic volume data which includes the number of motorcycles (MC), light vehicles (LV) and heavy vehicles (HV) and also takes side obstacle data which includes pedestrians (PED), stopped vehicles (PSV), vehicles entering and exiting from the side of the road (EEV), and slow vehicles (UM), namely bicycles, carts and others. Meanwhile, secondary data collection can be obtained from related agencies.

Data Seconds

The collection of secondary data includes literature reviews, previous research related to the research to be carried out, population data from the Central Statistics Agency (BPS), land-use data, and the 1997 Indonesian Road Capacity Manual (MKJI) guidelines.

Similarly, for the analysis of signaled intersection performance, the procedure for calculating signal time, capacity, and intersection performance level is in accordance with the Indonesian Road Capacity Manual (MKJI) (1997).

After the data is analyzed, alternative measures to improve road performance can be implemented to address traffic problems. After that, conclusions can be drawn, and alternative suggestions for improving road performance can be made to address problems at the location.

RESULTS

Surveys and Data

Based on previous studies, the busiest working day was Tuesday, so the collection of research data was carried out on Tuesday during the morning peak hour at 6.30 – 10.30 and in the afternoon at 14.00 – 18.00, for 4 hours per session.

- 1) Traffic Data for Emmy Saelan – Anoa – Lalove.

Table 1. Traffic Volume Data at Emmy Saelan Road Junction – Anoa – Lalove for All Arms (at Morning)

Peak Hours Period	Traffic Volume Per Arm (pcu/hour)				Intersection Traffic Volume Σ (pcu/hour)
	North	South	East	West	
Morning					
06.30 - 07.30	672.59	446.71	295.37	460.10	1874.78
06.45 - 07.45	773.78	499.31	379.65	579.57	2232.30
07.00 - 08.00	857.04	551.37	436.95	689.65	2535.01
07.15 - 08.15	932.09	617.55	452.80	773.60	2776.04
07.30 - 08.30	1008.20	679.20	462.21	778.14	2927.75
07.45 - 08.45	1013.76	697.67	433.31	730.59	2875.34
08.00 - 09.00	1005.74	696.81	403.19	656.21	2761.96
08.15 - 09.15	971.26	675.39	366.61	576.11	2589.37
08.30 - 09.30	900.74	622.09	311.57	519.34	2353.75
08.45 - 09.45	878.46	588.65	263.14	486.61	2216.85
09.00 - 10.00	859.83	565.48	230.56	448.46	2104.34
09.15 - 10.15	859.49	545.10	216.11	409.80	2030.50
09.30 - 10.30	814.74	533.79	207.41	358.07	1914.01
Afternoon					
14.00 - 15.00	605.94	623.62	124.51	141.73	1495.81
14.15 - 15.15	660.94	664.73	138.96	172.02	1636.65
14.30 - 15.30	717.01	714.89	163.34	203.18	1798.42
14.45 - 15.45	773.96	754.79	184.42	240.80	1953.97
15.00 - 16.00	819.78	797.11	210.20	286.97	2114.06
15.15 - 16.15	859.70	836.82	243.12	333.83	2273.47
15.30 - 16.30	899.25	871.64	269.77	389.04	2429.69
15.45 - 16.45	947.50	929.44	299.37	447.71	2624.02
16.00 - 17.00	1015.58	993.68	330.02	495.78	2835.06
16.15 - 17.15	1084.03	1071.01	340.65	540.36	3036.05
16.30 - 17.30	1142.57	1160.00	336.47	543.15	3182.19
16.45 - 17.45	1146.62	1139.64	297.46	507.46	3091.18
17.00 - 18.00	1111.13	1086.37	244.87	448.26	2890.63

From the traffic fluctuation graph above, it is found that peak hours at the intersection of Emmy Saelan Street – Anoa Street – Lalove Street occur in the morning, namely from 07.30 – 08.30 with a traffic volume of 2928 pcu/hour, and peak hours in the afternoon occur at 16.30 – 17.30 with a traffic volume of 3182 pcu/hour.

2) Traffic data at the Jati Street - Lalove Street intersection

Table 2. Traffic Volume Data at Jati Street Junction – Lalove Road for All Arms (at Morning)

Peak Hours Period	Traffic Volume Per Arm (pcu/hour)			Intersection Traffic Volume Σ (pcu/hour)
	North	South	East	
Morning				
06.30 – 07.30	611.50	572.80	434.00	1618.30

06.45 – 07.45	671.20	697.40	463.00	1831.60
07.00 – 08.00	753.40	783.50	465.00	2001.90
07.15 – 08.15	734.30	827.50	539.00	2100.80
07.30 – 08.30	666.90	812.80	589.00	2068.70
07.45 – 08.45	639.70	736.40	614.00	1990.10
08.00 – 09.00	549.90	680.30	637.00	1867.20
08.15 – 09.15	457.40	644.10	618.00	1719.50
08.30 – 09.30	442.80	605.70	589.00	1637.50
08.45 – 09.45	411.90	571.20	563.00	1546.10
09.00 – 10.00	413.20	542.20	525.00	1480.40
09.15 – 10.15	423.70	508.30	491.00	1423.00
09.30 – 10.30	430.60	481.40	471.00	1383.00

Table 3. Traffic Volume Data at Jati Street Junction – Lalove Road for All Arms
(at Afternoon)

Peak Hours Period	Traffic Volume Per Arm (pcu/hour)			Intersection Traffic Volume Σ (pcu/hour)
	North	South	East	
Afternoon				
14.00 - 15.00	566.50	467.20	476.00	1509.70
14.15 - 15.15	615.50	520.90	560.00	1696.40
14.30 - 15.30	652.90	531.10	617.00	1801.00
14.45 - 15.45	711.20	493.20	668.00	1872.40
15.00 - 16.00	732.50	516.50	692.00	1941.00
15.15 - 16.15	767.00	552.80	745.00	2064.80
15.30 - 16.30	788.40	600.10	806.00	2194.50
15.45 - 16.45	849.70	694.10	868.00	2411.80
16.00 - 17.00	914.90	780.30	944.00	2639.20
16.15 - 17.15	966.10	829.00	995.00	2790.10
16.30 - 17.30	998.30	886.40	1010.00	2894.70
16.45 - 17.45	916.50	815.40	980.00	2711.90
17.00 - 18.00	822.30	720.30	885.00	2427.60

Traffic Light Time Data at the intersection of Emmy Saelan – Anoa – Lalove

Table 4. Traffic Light Time			
Traffic Light Time	North Emmy Saelan Street (sec)	East / West Anoa Street / Lalove Street (sec)	South Emmy Saelan Street (sec)
Red	82	97	85
Yellow	3	3	3
Green	44	29	41
All Red Time	2	2	2
Sum	129	129	129

Intersection Performance Analysis After the Operation of the Palu V Bridge

1) Junction of Emmy Saelan Street- Anoa Street – Lalove Street

The composition and proportions of movement data for each intersection approach are presented in Table 5.

Table 5. Traffic Composition Volume for Each Approach			
Arm	Anoa Street		
Composition	MC	LV	HV
	199	134	4
		336	
	59.01	39.75	1.24
		100.00	
Arm	Emmy Saelan Street, North Arm		
Composition	MC	LV	HV
	610	508	25
		1143	
	53.37	44.45	2.18
		100.00	
Arm	Emmy Saelan Street, South Arm		
Composition	MC	LV	HV
	672	464	24
		1160	
	57.97	40.00	2.03
		100.00	
Arm	Emmy Saelan Street, West Arm		
Composition	MC	LV	HV
	341	188	14
		543	
	62.82	34.63	2.55
		100.00	

Table 6. Intersection Traffic Proportions			
Intersection	Emmy Saelan – Anoa - Lalove		
Composition	MC	LV	HV
	1822	1294	67
		3182	
	57.25	40.65	2.09
		100.00	

2) Junction of Jati – Lalove Street

The composition and proportion of movement data of each intersection approach are presented in Table 7.

Table 7. Traffic Composition Volume for Each Approach			
Arm	Anoa Street		
Composition	MC	LV	HV
	411	229	14
		654	
	62.89	34.97	2.14

100.00			
Arm	Emmy Saelan Street, North Arm		
	MC	LV	HV
Composition	642	323	34
		998	
	64.26	32.36	3.39
100.00			
Arm	Emmy Saelan Street, South Arm		
	MC	LV	HV
Composition	620	256	10
		886	
	69.95	28.88	1.17
100.00			

Table 8. Intersection Traffic Proportions

Intersection	Emmy Saelan - Anoa - Lalove		
	MC	LV	HV
Composition	1673	808	58
		2538	
	65.89	31.82	2.29
100.00			

Analysis of Section Performance After the Operation of the Palu V Bridge

1) A Brief History of the North Arm of the Emmy Saelan Street

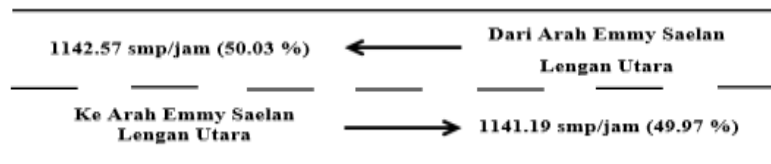


Figure 1. Proportion of Movement of Emmy Saelan North Arm Road Section

Using the same calculation method as in the previous calculation, the results of the analysis of the Street Segment's performance after the Palu V Bridge's operation are presented in Table 9.

Table 9. Recapitulation of Section Performance After Operation of the Palu V Bridge

No.	Road Sections	Traffic Volume (V)	Capacity (C)	Performance (DS)	Speed (Km/hour)	Los
1	Anoa East Arm Street	1477.65	3288.44	0.45	36.50	A
2	Emmy Saelan North Arm Street	1796.33	5548.79	0.32	42.00	A
3	Emmy Saelan South Arm Street	1491.24	4274.70	0.35	42.00	A

4	Lalove Street	1825.30	2405.12	0.76	30.00	A
5	Jati North Arm Street	1891.86	2697.13	0.70	28.00	B
6	Jati South Arm Street	1761.97	2657.96	0.66	28.50	B

The composition and proportion of movement data of each intersection approach are presented in Table 10.

Table 10. Traffic Composition Volume of Each Approach			
Arm	Anoa Street		
	MC	LV	HV
	199	134	4
Composition		336	
	59.01	41.89	1.24
		100.00	
Arm	Emmy Saelan Street, North Arm		
	MC	LV	HV
	610	508	25
Composition		1143	
	53.37	44.45	2.18
		100.00	
Arm	Emmy Saelan Street, South Arm		
	MC	LV	HV
	672	464	24
Composition		1160	
	57.97	40.00	2.03
		100.00	

Table 11. Intersection Traffic Proportions			
Intersection	Emmy Saelan – Anoa		
	MC	LV	HV
	1481	1106	53
Composition		2639	
	56.11	41.89	2.00
		100.00	

Using the same calculation method as in the previous calculation, the results of the performance analysis of the road section before the Palu V bridge's operation are presented in Table 12.

Table 12. Recapitulation of Section Performance Before the Operation of the Palu V Bridge

Road Sections	Traffic Volume (V)	Capacity (C)	Performance (DS)	Speed (Km/hour)	Los
Anoa Street East Arm	504.53	2359.14	0.21	27.81	A

Emmy Saelan Street, North Arm	2281.15	3222.85	0.71	27.00	C
Emmy Saelan Street, South Arm	2492.39	3222.85	0.77	26.20	C
Jati Street	1115.40	2653.07	0.42	33.00	A

Based on the traffic performance analysis results, the impact on traffic performance before and after the Palu V bridge operation was determined and presented in Table 13.

Table 13. Recapitulation of Section Performance Before and After the Operation of the Palu V Bridge

Road Sections	Traffic Volume (V)	Capacity (C)	Performance (DS)	Speed (Km/hour)	Los
Before the Operation of the Palu V Bridge					
Anoa Segment East Arm	504.53	2359.14	0.21	27.81	A
Segment Emmy Saelan North Arm	2281.15	3222.85	0.71	27.00	C
Segment Emmy Saelan South Arm	2492.39	3222.85	0.77	26.20	C
Jati Segment	1115.40	2653.07	0.42	33.00	A
After the Operation of the Palu V Bridge					
Anoa Segment East Arm	1477.65	3288.44	0.45	36.50	A
Segment Emmy Saelan North Arm	1796.33	5548.79	0.32	42.00	A
Segment Emmy Saelan South Arm	1491.24	4274.70	0.35	42.00	A
Lalove Segment	1825.30	2405.12	0.76	30.00	A
Jati Segment North Arm	1891.86	2697.13	0.70	28.00	B
Jati Segmen South Arm	1761.97	2657.96	0.66	28.50	B

Table 14. Recapitulation of Intersection Performance Before and After the Operation of the Palu V Bridge

Road Sections	Traffic Volume (V)	Capacity (C)	Performance (DS)	Average Delay (sec/pcu)	LOS	Information
Before the Operation of the Palu V Bridge						
Intersection of Emmy Saelan - Anoa	2639.04	3455.57	0.76	12.26	D	Unsignaled
After the Operation of the Palu V Bridge						
Intersection of Emmy Saelan - Anoa - Lalove						Unsignaled

Emmy Saelan Street, North Arm	776.72	2254.34	0.34	65.98	F	
Emmy Saelan Street, South Arm	756.52	1991.57	0.38	65.70	F	
Anoa Street East Arm	296.76	278.88	1.06	250.88	F	
Lalove Street West Arm	474.91	298.17	1.59	1163.57	F	
Intersection of Jati - Lalove	2538.43	2509.41	1.01	19.55	F	Unsignaled

DISCUSSION

Scope of Research Area

The study area is located in the city of Palu, South Palu District, and the scope of the traffic research includes intersections and sections in the Palu area and its surroundings, as shown in Figure 2.



(Source: Google Earth, 2022)

Figure 2. Scope of Study Area

The study of segments and intersections includes road sections and junctions. The road sections are Emmy Saelan (North Arm), Anoa (East Arm), Emmy Saelan (South Arm), Lalove (West Arm), Jati (North Arm), Lalove (East Arm), and Jati (South Arm). So, the junctions are the junction of Emmy Saelan - Anoa - Lalove, and the junction of Jati - Lalove.

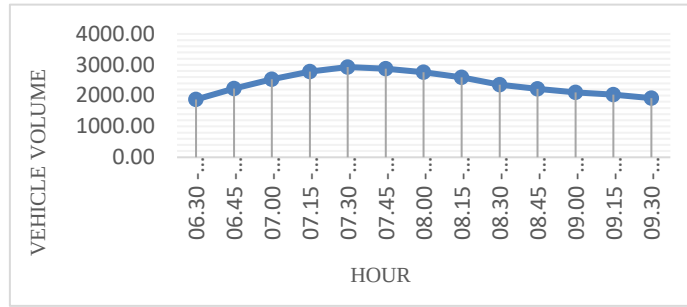


Figure 3. Fluctuations in Morning Peak Hour Periods

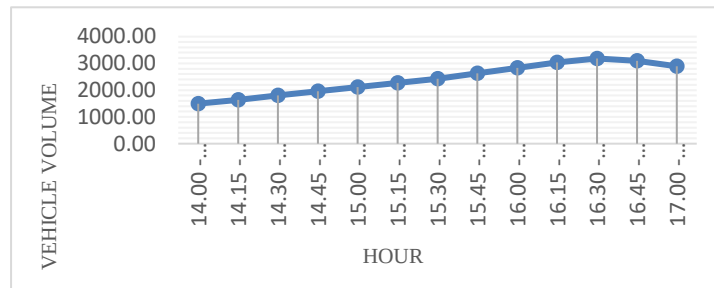


Figure 4. Fluctuations in Afternoon Peak Hour Periods

The vehicle fluctuations/hours for the intersection of Jati Street – Lalove Street are presented in Figures 5 and 6.

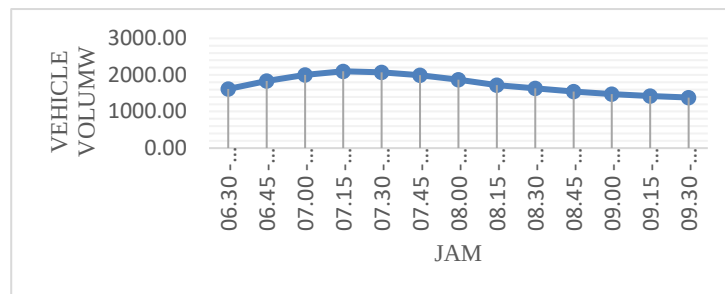


Figure 5. Fluctuations in Morning Peak Hours

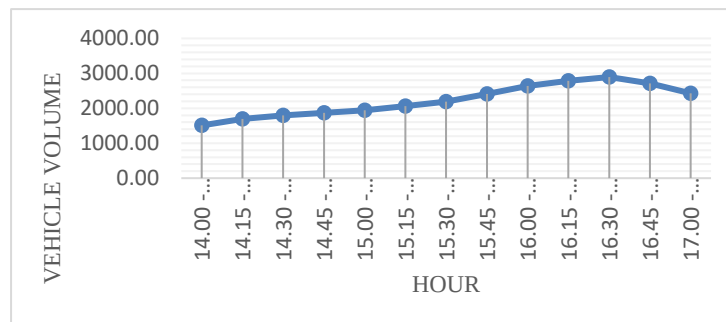


Figure 6. Fluctuations in Afternoon Peak Hour Periods

From the traffic fluctuation in Figures 4 and 5, it is found that the peak hours at the Jati Street – Lalove Street intersection occur in the morning, namely from

07.30 – 08.30, with a traffic volume of 2069 pcu/hour, and the peak hours in the afternoon occur at 16.30 – 17.30 with a traffic volume of 2894 pcu/hour.

Based on the description of fluctuation graph data from the two intersections above, the highest value of passenger car units (junior high school/hour) was obtained, namely at the intersection of Emmy Saelan Street – Anoa Street – Lalove Street, which was 3182 pcu/hour at (16.30 – 17.30) WITA time zone, and the highest value of passenger car units (pcu/hour) at the intersection of Jati Street – Lalove Street, which was 2894 pcu/hour at (16.30 – 17.30) WITA time zone.

Road Geometric Data

1) Geometric intersection of Emmy Saelan Street- Anoa Street – Lalove Street

Table 15. Geometric Data intersection of Emmy Saelan Street- Anoa Street – Lalove Street

Street Name	Hierarchy Functions	Road Type	Road Width (m)	Median (m)	Sidewalk Width (m)	
					Left	Right
Emmy Saelan	Arteri Primer	4/2 UD	14	-	1.5	1.5
Anoa	Secondary Collector	2/2 UD	8	-		
Lalove	Local Seconds	2/2 UD	7	-		

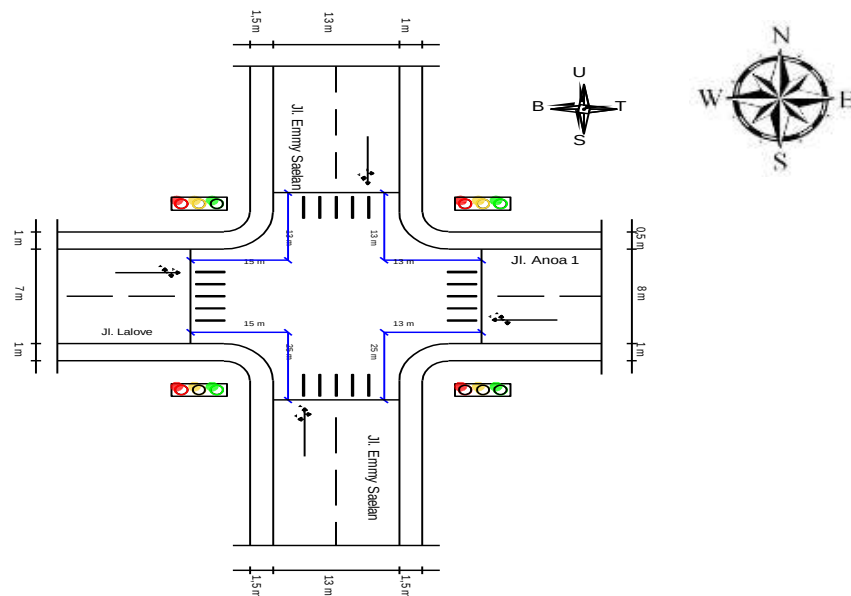


Figure 7. Geometric Sketch of the Intersection of Emmy Saelan Street – Lalove Street

2) Geometry of the Intersection Jati Street – Lalove Street

Table 16. Geometric Data of Intersection Jati Street – Lalove Street

Street Name	Hierarchy Functions	Road Type	Wide	Median	Sidewalk Width (m)	Shoulder Width (m)
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			Road (m)	(m)	Left	Right	Left	Right
Teak North & South Arm	Secondary Collector	2/2 UD	7.5	-	-	-	1.2	2.35
Lalove East Arm	Local Seconds	2/2 UD	8	-	-	-	2.8	2.3

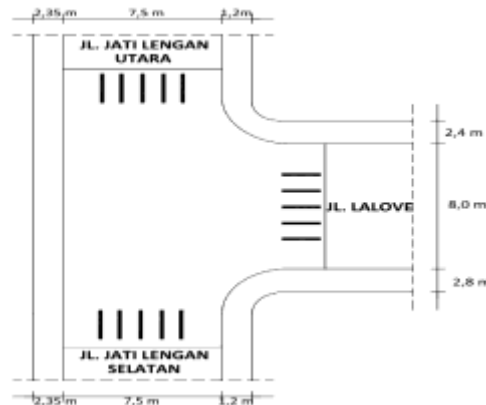


Figure 8. Geometric Sketch of the Junction of Jati Street – Lalove Street

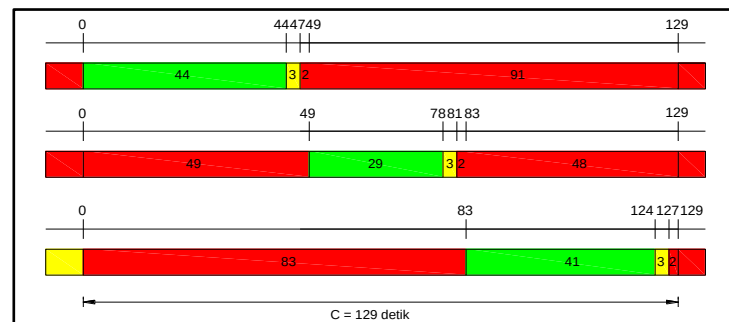


Figure 9. Traffic Light Signal Phase Diagram (Existing Condition)

Based on Table 6, the traffic composition of the intersection of Emmy Saelan, Anoa – Lalove is M 57.25 %, LV 40.65 %, and HV 2.09 %.

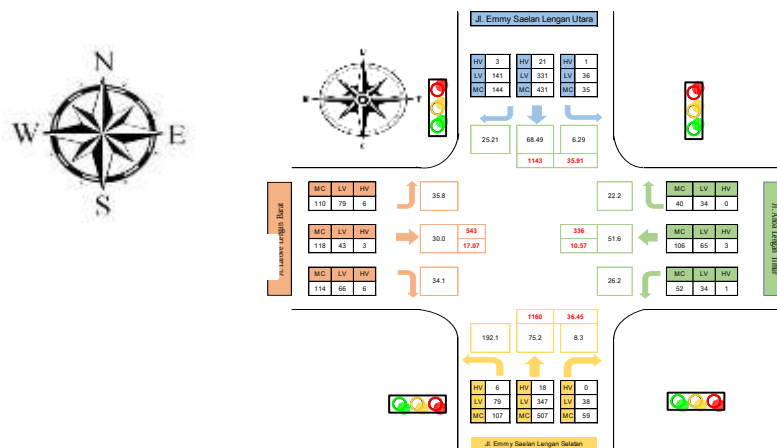


Figure 10. Proportion of Signaled Intersection Traffic Movements

Based on Table 10, it is found that the traffic composition of the intersection of Jati Street – Lalove Street are MC 65.89%, LV 31.82 %, and HV 2.29 %.

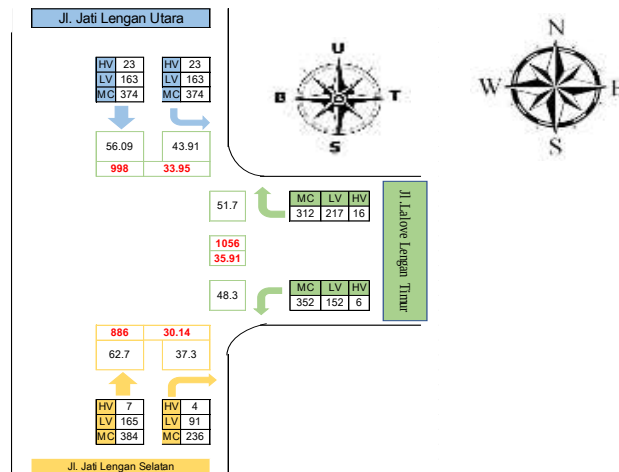


Figure 11. Proportion of Traffic Movements

To know the Signal Junction Performance Analysis, the data is shown in Table 17 (Othayoth, Rao, & Bhavathrathan, 2020).

Table 17. The level of service	
Level of Service	Delayed Delay (sec/pcu)
A	< 5
B	5.1 - 15
C	15.1 - 25
D	25.1 - 40
E	40.1 - 60
F	> 60

So that the level of service at the intersection of Jati Street – Lalove Street is C.

Using formulas and input data, the performance of the existing intersection of Jati Street – Lalove Street is described in Table 18.

Table 18. Recapitulation of the Performance of the Existing Junction Jati Street– Lalove Street

No.	Description	Peak Hours Afternoon (16.30 - 17.30)
1	Capacity (C)	2509.41
2	Traffic Flow (Q)	2538.43
3	V/C	1.01
4	Average Delay	19.55
5	LOS (Level of Service)	C

Based on the results of the recapitulation of the performance of the section after the existence of the Palu V bridge in Table 9, it can be known, Anoa East Arm Street Segment: Capacity (C) = 3288.44, Traffic volume (V) = 1477.65 pcu/hour, Degree of Saturation (DS) = 0.45 (< 0.85), Speed = 36.5 km/hour. This shows that the performance condition of the Anoa Street Segment in the east arm can still support good traffic flow. Emmy Saelan North Arm Street Section: Capacity (C) = 5548.79, Traffic volume (V) = 1796.33 pcu/hour, Degree of Saturation (DS) = 0.32 (< 0.85), Speed = 42.00 km/hour. This shows that the performance condition of the North Arm Emmy Saelan Street Segment can still support free-flowing traffic.

Emmy Saelan South Arm Street Segment: Capacity (C) = 4274.70, Traffic volume (V) = 1491.24 pcu/hour, Degree of Saturation (DS) = 0.35 (< 0.85), Speed = 42.00 km/hour. This shows that the South Arm Emmy Saelan Street Segment can still handle traffic well. Lalove Street Segment: Capacity (C) = 2405.12, Traffic volume (V) = 1825.30 pcu/hour, Degree of Saturation (DS) = 0.76 (< 0.85), Speed = 30.00 km/hour. This shows that the performance condition of the Lalove West Arm Street Segment can still flow traffic well. Jati North Arm Street Segment: Capacity (C) = 2697.13, Traffic volume (V) = 1891.86 pcu/hour, Degree of Saturation (DS) = 0.70 (< 0.85), Speed = 28.00 km/h. This shows that the North Arm Jati Street Segment can still handle traffic well. Jati South Arm Street Segment: Capacity (C) = 2657.96, Traffic volume (V) = 1761.97 pcu/hour, Degree of Saturation (DS) = 0.66 (< 0.85), Speed = 28.50 km/h. This shows that the South Arm Jati Street Segment can still handle traffic well.

Performance Analysis Before Operation of the Palu V Bridge

1) Performance Analysis of Emmy Saelan Street – Anoa Street Intersection

In the analysis of traffic performance before the operation of the Palu V bridge, it is assumed that the condition of the traffic intersection:

- i. The type of intersection is 324, which is an intersection with 3 arms consisting of the Emmy Saelan North arm and the Anoa arm.
- ii. The data on the volume of traffic entering and exiting Lalove Street was distributed to North Emmy Saelan Street and South Emmy Saelan Street.
- iii. Composition and Proportions of Movement

The Lalove Street access is assumed to be non-existent. So that the flow of vehicles heading towards the Palu V bridge is distributed to other roads:

- i. The flow of vehicles from the direction of Emmy Saelan North Arm, which was originally heading to the Palu bridge, was moved to Jl—I Gusti Ngurah Rai (Emmy Saelan South Leng).
- ii. The flow of vehicles from the direction of Emmy Saelan South Arm, which was originally heading to the Palu V bridge, was moved to Jl. KH. Wahid Hasyim (Emmy Saelan North Arm).
- iii. The flow of vehicles from the direction of Anoa, which was originally heading to the Palu V bridge, was moved to I Gusti Ngurah Rai Street (Emmy Saelan South Arm).

Based on Table 11, the traffic composition of the Emmy Saelan – Anoa intersection before the operation of the Palu V bridge is MC 56.11%, LV 41.89 %, and HV 2.00 %.

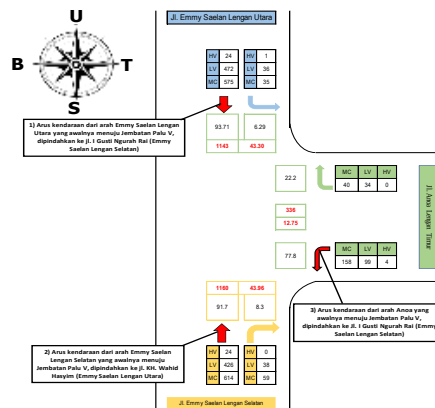


Figure 13. Proportion of Traffic Movements

a) Signal Junction Performance Analysis

Based on the type and volume of traffic at the intersection of Emmy Saelan Street – Anoa Street before the operation of the Palu V bridge, traffic performance was analyzed and obtained in Table 19.

Table 19. The level of service

Level of Service	Delayed Delay (sec/pcu)
A	< 5
B	5.1 - 15
C	15.1 - 25
D	25.1 - 40
E	40.1 - 60
F	> 60

So that the level of service at the intersection of Emmy Saelan Street – Anoa Street is B.

Based on the results in Table 12, Anoa Street East Arm Segment: Capacity (C) = 2359.14, Traffic volume (V) = 504.53 pcu/hour, Degree of Saturation (DS) = 0.21 (< 0.85), Speed = 27.81 km/hour. This shows that the East Arm Anoa Street Segment's performance condition still supports good traffic flow. Emmy Saelan Street North Arm Segment: Capacity (C) = 3222.85, Traffic volume (V) = 2281.15 pcu/hour, Degree of Saturation (DS) = 0.71 (< 0.85), Speed = 27.00 km/hour. This shows that the performance condition of the North Arm Emmy Saelan Street Segment can still support free-flowing traffic.

Emmy Saelan Street South Arm Segment: Capacity (C) = 3222.85, Traffic volume (V) = 2492.39 pcu/hour, Degree of Saturation (DS) = 0.77 (< 0.85), Speed = 26.20 km/hour. This shows that the South Arm Emmy Saelan Street Segment can still handle traffic well. Jati Street Segment: Capacity (C) = 2653.07, Traffic volume (V) = 1115.40 pcu/hour, Degree of Saturation (DS) = 0.42 (< 0.85), Speed

= 29.00 km/hour. This shows that the performance condition of the Lalove West Arm Street Segment can still flow traffic well.

CONCLUSIONS AND RECOMMENDATIONS

The data reveals a variety of traffic circumstances at intersections following the Palu V Bridge's operation. Despite mild delays, the Emmy Saelan Street north and south arms continue to function well, with saturation levels within the permissible limit. On the other hand, due to conflicting traffic flows, the Anoa Street east arm and the Lalove Street west arm experience significant congestion, extremely long delays, and lengthy lines. Congested operating circumstances are evident at the unsignalized Jati Street-Lalove Street intersection, where capacity has been surpassed. Overall, major new movements and traffic flow diversions between Emmy Saelan Street and Jati Street are responsible for the increase in traffic volume on Lalove Street.

Recomendations

Based on the research results, it is recommended to evaluate traffic performance on I Gusti Ngurah Rai Street and Gajah Mada Street due to Lalove Street operations and to implement a four-phase signal system at the Emmy Saelan-Anoa-Lalove intersection to reduce opposing traffic conflicts.

FURTHER STUDY

To lessen traffic at the Anoa Street east arm and Lalove Street west arm, more research is advised to assess alternate traffic management techniques. Future studies should examine geometric enhancements and signal time optimisation to solve delays brought on by conflicting traffic patterns.

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