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Cost Analysis of Road Congestion Losses on Road Construction (Rigid Pavement) Judging From the Travel Delay Time

Misbakhul Hamdi, Zulkifli Lubis*

Universitas Islam Lamongan

Corresponding author: zulkifli.lubis@unisla.ac.id

Abstract: Along the duduksampeyan highway there is road construction (rigid pavement) so that the road section has narrowed, which originally had 4 two-way lanes reduced to 2 two-way lanes along 1.5 km so that traffic became paralyzed and caused long queues of vehicles. This results in a significant delay that can harm transportation users who cross the road. The purpose of this study was to determine the length of queues and travel delay times. Then the data that has been obtained from the field is then analyzed based on technical aspects based on the Indonesian road capacity guidelines in 2014 (PKJI, 2014). From the analysis of the queue length above, the longest queue with a length of 2481.3 meters from the direction of Lamongan - Surabaya and the shortest queue with a length of 1187.1 meters in the direction of Lamongan - Surabaya. The results of the delay time analysis found that the highest delay time occurred on Monday at 07:00 – 08:00 with a delay time of 26,26 minutes from the direction of Lamongan - Surabaya and on Wednesday at 08:00 – 09:00 was the lowest delay time with a delay time of 0,1 minutes from the direction of Lamongan - Surabaya.

Keywords: traffic, performance, delay, queue.

INTRODUCTION

Background

Traffic jams are common in every transport driver's experience. Congestion can be called paralyzed traffic flow caused by obstruction of vehicle movement. The problem of congestion seems to have become a kind of oddity in big cities in developing countries, as well as in Indonesia (Tamin, 1992) in (Asset &; Sugiyanto, 2021). There are several factors that cause traffic congestion including the number of private vehicles or traffic that continues to increase, side obstacles, suboptimal use of public transportation, traffic accidents or road repairs or reservations. In addition, drivers who are not disciplined in traffic or do not obey traffic rules can also cause traffic jams to increase.

Transportation problems are increasing in both developed (industrial) and developing countries. The shortage of temporary fuel availability is not a big problem, but increased traffic flow and transportation demand have led to congestion, delays, accidents, and environmental problems that are already out of bounds (Tamin, 2000).

Over time, congestion has become a major problem. The reason is, congestion brings various negative impacts such as wasted time, wasted fuel, potential accidents, and increased air pollution. In addition, the emergence of congestion slows down operations, causing delays in the delivery of goods, reducing the income of transporters, and causing inconvenience to motorists and other financial losses.

The existence of road maintenance activities resulted in the paralysis of the road and narrowing the original four two-way lanes to two two-way lanes in one lane. When using a two-lane two-way system, long traffic jams are inevitable. The congestion path that occurred during the initial observation was very long about 2 km to 4 km.

The resulting congestion caused severe damage to many public transport vehicles, workers commuting to work were delayed, and traders operating around the congestion also lacked space.

Research Objectives

The research objectives achieved from this study are as follows.

a. Knowing the length of queues that occur on that segment of the road.
b. Knowing the value of delay time borne by road users on the segment.

Research Benefits

The benefits obtained from this study are as follows.

a. For researchers to add insight in the development of academic science and knowledge in the field of traffic, especially transportation losses due to road congestion.
b. For academics, it is hoped that this research can be used as a reference for researchers who want to study more in the case of time losses caused by traffic jams.
c. For the government and related agencies to be the subject of study or consideration before planning road construction so as to minimize the number of losses that occur.

METHODOLOGY

Data Collection

The data collection stage is intended to obtain the data needed as input material for the analysis stage. In this study there are two data that must be met to analyze the problems that occur, namely:

1. Primary data

   Primary Data Collection, which is data obtained directly from the source or from the field. Primary data collection is carried out by surveying in the form of traffic volume and vehicle travel time.

2. Secondary data

   Secondary data, namely data obtained from research results, seminar results, articles, literature searches and official documents or manuals from the Public Works Office or from other related agencies.

The research flowchart used in this research is pictured as figure 1 below.

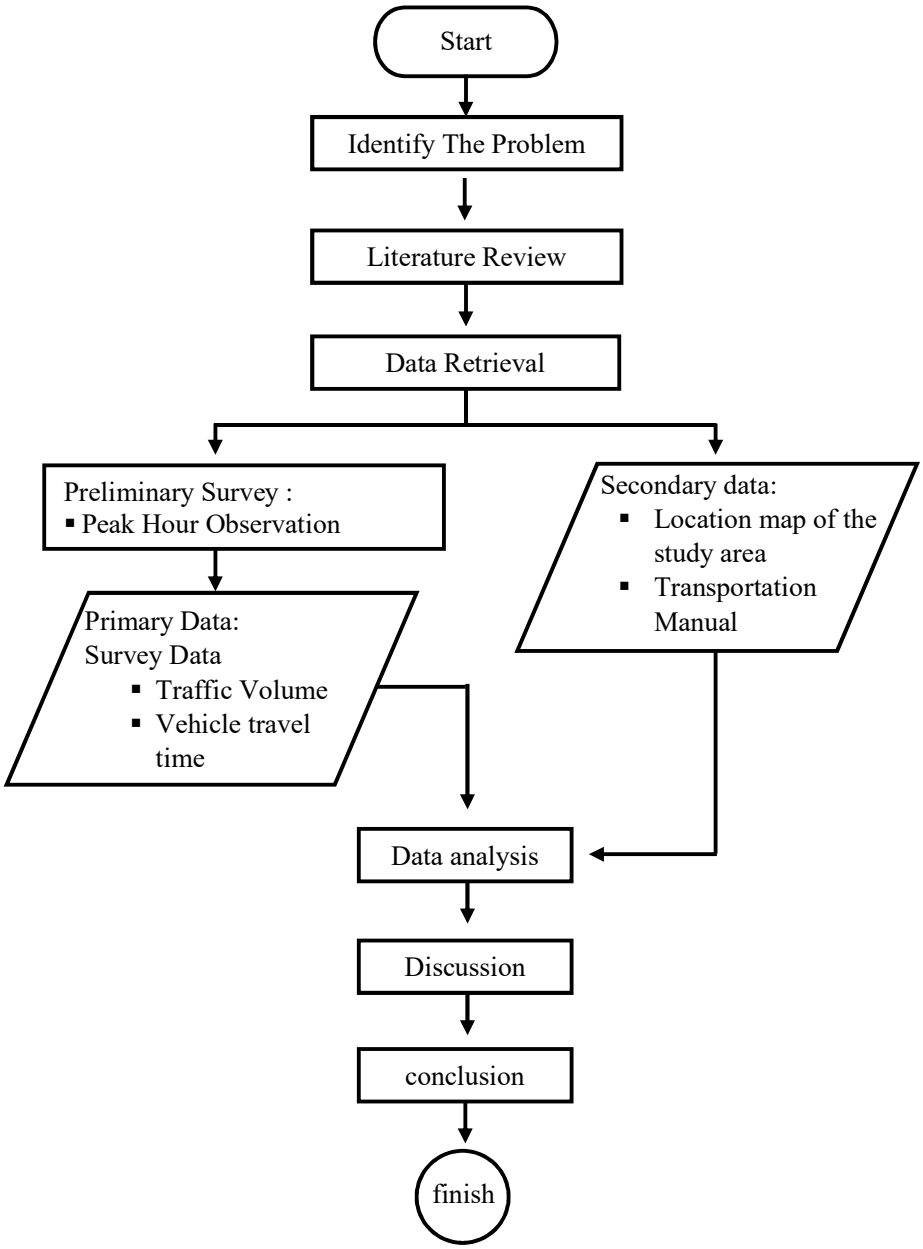

Figure 1 Research Flow Chart

RESULTS AND DISCUSSION

Duduksampeyan Highway Performance Analysis

The days and hours of observation are determined based on peak traffic volume corresponding to the results of initial observations on November 07, 2022. So that the days and hours of observation are set for 3 (three) days on Monday, Tuesday, Wednesday during peak hours, namely in the morning at 07.00 – 09.00 WIB, noon at 12.00 – 14.00 WIB, and in the afternoon at 16.00 – 18.00 WIB.

Road Capacity Analysis

Capacity is defined as the maximum current passing through a point on the road that can be sustained per unit hour under certain conditions. For two-lane two-way roads, capacity is separated for two-way current (combination of two directions), but for roads with many lanes, current is separated per direction and capacity is determined per lane, the basic equation of determining capacity is as follows(PKJI, 2014).

$$C = C_0 \times FC_{LJ} \times FC_{PA} \times FC_{HS} \quad (1)$$

C = 1700 x 1,00 x 1,00 x 0,88

C = **1496**

Traffic Volume Analysis

Traffic data was recorded using the mini tally count tool during the observation hour period at 10-minute time intervals every 2 observation hours. The total amount of each vehicle volume is converted into light vehicle units (skr), as seen in table 1 by multiplying the vehicle volume by the light vehicle equivalent (ekr) according to each vehicle type.

Table 1. Light Vehicle Equivalents

No	Vehicle Type	ekr
1	KR (light vehicles)	1,0
2	BB (Big Bus)	1,4
3	TB (heavy trucks)	2,0
4	SM (motorbike)	0,6

Source: PKJI, 2014

Analysis Of Degrees Of Saturation

The degree of saturation (DJ), as seen in table 2 is defined as the ratio of road flow to capacity used as the main factor in determining the level of performance of intersections and road segments. The DJ value indicates whether there are problems in the road segment (PKJI, 2014). The magnitude of the degree of saturation theoretically cannot be more than 1 (one), which means that if the value is close to 1, then traffic conditions are close to saturation, and visually or directly can be seen in the field traffic conditions that occur close to solid at low speed (Muchlisin & Lubis, 2016). The basic equation for determining the degree of saturation is as follows.

$$D_J = \frac{Q}{C} \quad (2)$$

Where
Q = 1654 (skr/hour)
C = 1496 (skr/hour)
D_J = 1,106 (skr/hour)

Table 2. Degree Of Saturation

Surabaya - Lamongan				**Lamongan - Surabaya**			
MONDAY	**Q**	**C**	**DJ**	MONDAY	**Q**	**C**	**DJ**
07.00 - 08.00	1528	1496	**1,022**	07.00 - 08.00	1654	1496	**1,106**
08.00 - 09.00	1537	1496	**1,027**	08.00 - 09.00	1653	1496	**1,105**

12.00 - 13.00	1229	1496	**0,821**	12.00 - 13.00	1013	1496	**0,677**
13.00 - 14.00	1280	1496	**0,856**	13.00 - 14.00	947	1496	**0,633**
16.00 - 17.00	1290	1496	**0,862**	16.00 - 17.00	1057	1496	**0,707**
17.00 - 18.00	1229	1496	**0,822**	17.00 - 18.00	848	1496	**0,567**

TUESDAY	**Q**	**C**	**DJ**	TUESDAY	**Q**	**C**	**DJ**
07.00 - 08.00	964	1496	**0,645**	07.00 - 08.00	1482	1496	**0,991**
08.00 - 09.00	1038	1496	**0,694**	08.00 - 09.00	1197	1496	**0,800**
12.00 - 13.00	1218	1496	**0,814**	12.00 - 13.00	1025	1496	**0,685**
13.00 - 14.00	1266	1496	**0,846**	13.00 - 14.00	906	1496	**0,606**
16.00 - 17.00	1373	1496	**0,918**	16.00 - 17.00	965	1496	**0,645**
17.00 - 18.00	1138	1496	**0,761**	17.00 - 18.00	791	1496	**0,529**

WEDNESDAY	**Q**	**C**	**DJ**	WEDNESDAY	**Q**	**C**	**DJ**
07.00 - 08.00	1077	1496	**0,720**	07.00 - 08.00	1269	1496	**0,848**
08.00 - 09.00	1084	1496	**0,725**	08.00 - 09.00	1132	1496	**0,756**
12.00 - 13.00	998	1496	**0,667**	12.00 - 13.00	946	1496	**0,632**
13.00 - 14.00	1036	1496	**0,693**	13.00 - 14.00	957	1496	**0,640**
16.00 - 17.00	1219	1496	**0,815**	16.00 - 17.00	914	1496	**0,611**
17.00 - 18.00	1036	1496	**0,693**	17.00 - 18.00	1000	1496	**0,669**

Source: Analysis Results, 2023

Queue Length Analysis

Queue length is defined as the length of vehicles waiting in one group of vehicles and is expressed in meters. The movement of a vehicle in a queue is controlled by movement in front of it or the vehicle is stopped by another part of the traffic system. When measuring the length of the queue, include the number of vehicles in the queuing system at any given time. This can be done by physically counting vehicles or marking roads, indicating that the vehicles in the queue are expressed in units of length. The length of the queue is calculated by multiplying the number of vehicles by the distance between vehicles in this case using a minimum value of 1,5 meters (table 3).

Table 3 Queue Length

Queue Length Surabaya - Lamongan				**Queue Length Lamongan - Surabaya**		
Time	Traffic Volume	Distance Between Vehicles (Meters)	Quantity (Meters)	Traffic Volume	Distance Between Vehicles (Meters)	Quantity (Meters)
07.00 - 08.00	1528,4	1,5	2292,6	1654,2	1,5	2481,3

08.00 - 09.00	1536,8	1,5	2305,2	1653,2	1,5	2479,8
12.00 - 13.00	1228,8	1,5	1843,2	1013	1,5	1519,5
13.00 - 14.00	1280,2	1,5	1920,3	946,8	1,5	1420,2
16.00 - 17.00	1289,8	1,5	1934,7	1057,2	1,5	1585,8
17.00 - 18.00	1229	1,5	1843,5	848,4	1,5	1272,6

Time	Traffic Volume	Distance Between Vehicles (Meters)	Quantity (Meters)	Traffic Volume	Distance Between Vehicles (Meters)	Quantity (Meters)
07.00 - 08.00	964,4	1,5	1446,6	1482	1,5	2223
08.00 - 09.00	1038,2	1,5	1557,3	1197,2	1,5	1795,8
12.00 - 13.00	1218	1,5	1827	1025	1,5	1537,5
13.00 - 14.00	1265,8	1,5	1898,7	906	1,5	1359
16.00 - 17.00	1373,2	1,5	2059,8	965,4	1,5	1448,1
17.00 - 18.00	1137,8	1,5	1706,7	791,4	1,5	1187,1

time	Traffic Volume	Distance Between Vehicles (Meters)	Quantity (Meters)	Traffic Volume	Distance Between Vehicles (Meters)	Quantity (Meters)
07.00 - 08.00	1076,8	1,5	1615,2	1269	1,5	1903,5
08.00 - 09.00	1084	1,5	1626	1131,6	1,5	1697,4
12.00 - 13.00	998,4	1,5	1497,6	946,2	1,5	1419,3
13.00 - 14.00	1036,4	1,5	1554,6	957	1,5	1435,5
16.00 - 17.00	1219,4	1,5	1829,1	913,6	1,5	1370,4
17.00 - 18.00	1036	1,5	1554	1000,2	1,5	1500,3

Source: Analysis Results, 2023

Delay Time Analysis

Delay is the difference in travel time from a trip from one point to the destination point between free current conditions and inhibited current (alamsyah, 2005:177). Procrastination is a very important variable to determine quality rather than traffic. Delays are used as criteria to determine the level of traffic congestion of a road, the greater the value of the delay, the greater the level of congestion on the road section. The value of the delay time is obtained from the result of summing the travel time (traffic jams) minus the travel time (normal conditions). The travel time with a distance of 1.5 km under normal conditions is as table 4 bellow. Time delay on Monday, Tuesday and Wednesday are recorded as on table 5, table 6 and table 7, respectively.

Table 4 Vehicle Travel Time (normal condition)

Normal Condition Travel Time (minutes)		
KR	BB	TB
1,54	2,11	2,39

Source: Survey Results, 2023

Table 5 Time delay on Monday

Time	Direction of destination	Vehicle Type	Average Travel Time (minutes)	Time Delay		
				Minute	Second	Hour
07.00 - 08.00	L - S	KR	27,8	26,26	1575,6	0,4377
		BB	8,31	6,2	372	0,1033
		TB	24,12	21,73	1303,8	0,3622
	S - L	KR	13,08	11,54	692,4	0,1923
		BB	15,48	13,37	802,2	0,2228
		TB	14,55	12,16	729,6	0,2027
08.00 - 09.00	L - S	KR	12,11	10,57	634,2	0,1762
		BB	7,10	4,99	299,4	0,0832
		TB	7,29	4,9	294	0,0817
	S - L	KR	7,06	5,52	331,2	0,0920
		BB	6,43	4,32	259,2	0,0720
		TB	6,48	4,09	245,4	0,0682
12.00 - 13.00	L - S	KR	5,42	3,88	232,8	0,0647
		BB	5,06	2,95	177	0,0492
		TB	5,54	3,15	189	0,0525
	S - L	KR	5,54	4,00	240	0,0667
		BB	5,38	3,27	196,2	0,0545
		TB	6,14	3,75	225	0,0625
13.00 - 14.00	L - S	KR	6,41	4,87	292,2	0,0812
		BB	7,26	5,15	309	0,0858
		TB	7,13	4,74	284,4	0,0790
	S - L	KR	5,39	3,85	231	0,0642
		BB	4,28	2,17	130,2	0,0362
		TB	5,58	3,19	191,4	0,0532
	L - S	KR	4,17	2,63	157,8	0,0438

16.00 - 17.00		BB	6,06	3,95	237	0,0658
		TB	4,28	1,89	113,4	0,0315
	S - L	KR	6,25	4,71	282,6	0,0785
		BB	8,35	6,24	374,4	0,1040
		TB	6,49	4,1	246	0,0683
17.00 - 18.00	**L - S**	KR	5,56	4,02	241,2	0,0670
		BB	5,27	3,16	189,6	0,0527
		TB	10,33	7,94	476,4	0,1323
	S - L	KR	5,33	3,79	227,4	0,0632
		BB	21,02	18,91	1134,6	0,3152
		TB	7,09	4,7	282	0,0783

Source: Analysis Results, 2023

Table 6 Time delay on Tuesdays

Time	Direction of destination	Vehicle Type	Average Travel Time (minutes)	Time Delay		
				Minute	Second	Hour
07.00 - 08.00	**L - S**	KR	8,59	7,05	423	0,1175
		BB	6,49	4,38	262,8	0,0730
		TB	7,29	4,9	294	0,0817
	S - L	KR	25,38	23,84	1430,4	0,3973
		BB	19,48	17,37	1042,2	0,2895
		TB	25,43	23,04	1382,4	0,3840
08.00 - 09.00	**L - S**	KR	12,1	10,56	633,6	0,1760
		BB	6,13	4,02	241,2	0,0670
		TB	13,04	10,65	639	0,1775
	S - L	KR	16,23	14,69	881,4	0,2448
		BB	16,21	14,1	846	0,2350
		TB	15,38	12,99	779,4	0,2165
12.00 - 13.00	**L - S**	KR	10,39	8,85	531	0,1475
		BB	5,33	3,22	193,2	0,0537
		TB	5,56	3,17	190,2	0,0528
	S - L	KR	13,29	11,75	705	0,1958
		BB	13,17	11,06	663,6	0,1843
		TB	13,32	10,93	655,8	0,1822
13.00 - 14.00	**L - S**	KR	4,24	2,70	162	0,0450
		BB	4,32	2,21	132,6	0,0368

		TB	8,12	5,73	343,8	0,0955
	S - L	KR	9,57	8,03	481,8	0,1338
		BB	10,33	8,22	493,2	0,1370
		TB	11,56	9,17	550,2	0,1528
16.00 - 17.00	**L - S**	KR	4,35	2,81	168,6	0,0468
		BB	17,08	14,97	898,2	0,2495
		TB	6,07	3,68	220,8	0,0613
	S - L	KR	18,21	16,67	1000,2	0,2778
		BB	15,13	13,02	781,2	0,2170
		TB	15,55	13,16	789,6	0,2193
17.00 - 18.00	**L - S**	KR	12,51	10,97	658,2	0,1828
		BB	12,12	10,01	600,6	0,1668
		TB	12,06	9,67	580,2	0,1612
	S - L	KR	19,55	18,01	1080,6	0,3002
		BB	20,15	18,04	1082,4	0,3007
		TB	20,45	18,06	1083,6	0,3010

Source: Analysis Results, 2023

Table 7 Time delay on Wednesdays

Time	Direction of destination	Vehicle Type	Average Travel Time (minutes)	Time Delay		
				Minute	Second	Hour
07.00 - 08.00	**L - S**	KR	18,22	16,7	1000,8	0,2780
		BB	17,33	15,22	913,2	0,2537
		TB	17,10	14,71	882,6	0,2452
	S - L	KR	24,03	22,49	1349,4	0,3748
		BB	21,59	19,48	1168,8	0,3247
		TB	23,52	21,13	1267,8	0,3522
08.00 - 09.00	**L - S**	KR	2,24	0,7	42	0,0117
		BB	3,12	1,01	60,6	0,0168
		TB	2,45	0,06	3,6	0,0010
	S - L	KR	13,03	11,5	689,4	0,1915
		BB	12,17	10,06	603,6	0,1677
		TB	13,25	10,86	651,6	0,1810
12.00 - 13.00	**L - S**	KR	10,07	8,5	511,8	0,1422
		BB	7,56	5,45	327	0,0908
		TB	10,17	7,78	466,8	0,1297
	S - L	KR	10,38	8,8	530,4	0,1473

		BB	11,18	9,07	544,2	0,1512
		TB	10,54	8,15	489	0,1358
13.00 - 14.00	**L - S**	KR	8,20	6,7	399,6	0,1110
		BB	8,47	6,36	381,6	0,1060
		TB	7,13	4,74	284,4	0,0790
	S - L	KR	9,20	7,7	459,6	0,1277
		BB	9,45	7,34	440,4	0,1223
		TB	10,15	7,76	465,6	0,1293
16.00 - 17.00	**L - S**	KR	13,35	11,8	708,6	0,1968
		BB	11,53	9,42	565,2	0,1570
		TB	14,25	11,86	711,6	0,1977
	S - L	KR	8,55	7,0	420,6	0,1168
		BB	8,49	6,38	382,8	0,1063
		TB	8,14	5,75	345	0,0958
17.00 - 18.00	**L - S**	KR	9,13	7,6	455,4	0,1265
		BB	9,37	7,26	435,6	0,1210
		TB	10,32	7,93	475,8	0,1322
	S - L	KR	10,18	8,6	518,4	0,1440
		BB	9,12	7,01	420,6	0,1168
		TB	10,02	7,63	457,8	0,1272

Source: Analysis Results, 2023

CONCLUSION

Based on the results of the data analysis above, the following conclusions are drawn. From the analysis of the queue length above, the longest queue with a length of 2481,3 meters from the direction of Lamongan - Surabaya and the shortest queue with a length of 1187,1 meters in the direction of Lamongan - Surabaya.

The results of the delay time analysis found that the highest delay time occurred on Monday at 07:00 – 08:00 with a delay time of 26,26 minutes from the direction of Lamongan - Surabaya and on Wednesday at 08:00 – 09:00 was the lowest delay time with a delay time of 0,1 minutes from the direction of Lamongan - Surabaya.

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