Analysis of the Impact of Palembang-Indralaya (Palindra) Toll Road to Palembang – Indralaya National Road Service Levels

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ABSTRACT
The Traffic jams are an issue that still an important concern in the world of transportation. The problem which was occurs in Palembang-Indralaya national road section, as it is often experiencing traffic jams on each part of the road. Besides breaking down the jams, Palembang-Indralaya toll road which is part of the Trans Sumatra Toll Road program that having an aim to accelerate the mobility of goods and services between the centers of economic growth. The purpose of this study is to determine the effect of toll roads and show the capacity of national roads before and after toll roads having been operated. This study uses Indonesian Road Capacity Manual method to analyze toll road. Whereas, to analyze national road use Indonesian Road Capacity Guidelines.
The analysis results obtained the level of national road service before the construction of the highest toll road which was occurred in 2017 in the F category is the current obstruction, low-speed, and over capacity volume and many stops. After the development of toll road in 2019, the greatest level service in category C is stable flow, the speed having been affected by traffic and volume which is suitable for city road. Therefore, Palembang – Indralaya toll road can reduce the level of road service. The capacity of the national road before and after toll road is acquire the same value. This is caused by the road handling has not yet been done. The value of capacity in the first segment (KM7-KM29) is 1805 smp/hour, while second segment (KM24-KM25) is 3007 smp/hour and the third segment (KM28-KM29) is 1401 smp/hour.

Keywords: *Road Capasity, Level of Service, PKJI'14*

1. INTRODUCTION

Traffic jams are an issue that still an important concern in the world of transportation. [1], [5],[7],[8] The problems which occurred in the Palembang-Indralaya National Road section, as it often experiencing traffic jams on each section of the road and there are still many vehicles that cross the National Road section after the Toll operates. Besides breaking down the traffic [4],[5], Palembang-Indralaya (Palindra) Toll Road is a part of the Trans Sumatra Toll Road Program which having an aims to accelerate the mobility of goods and services between the centres of economic growth .[1],[5],[6]

Traffic jams is caused by the high volume of vehicles that are not suitable for the road capacity, therefore at peak hours, traffic will occur. This study aims to determine how much the capacity of Palembang-Indralaya National Road before and after Palembang-Indralaya (Palindra) Toll Road having been constructed and how the effect to the service level of the Palembang-Indralaya National Road.

Capacity is defined as the maximum current through a point on the road that can be maintained per unit hour under certain conditions. .[3],[4],[5],[7]-[13], [16],[21] For two-way lanes, capacity is determined for two-way flows (two-way combinations), but for multi-lane roads, flows are separated per direction and capacity is determined per lane. [3],[8]-[10] The basic equation for determining capacity is as follows

$$C = C_o x FC_w x FC_{PA} x FC_{HS} \quad (1)$$

Toll Road Capacity Factors
Basic Capacity (Co)

Table 1. Basic Capacity

Road Type	Alignment Type	Basic Capacity (smp / hour / lane)
4/2T	Flat	1900
	Hill	1850
	Mountain	1800
4/2TT	Flat	1700
	Hill	1650
2/2 TT	Mountain Flat	1600
	Hill	3100
	Mountain	3000
		2900

Source: PKJI,2014

Capacity Adjustment Factors Due to Traffic Line Width (FC_w)

Tabel 2. Capacity Adjustment Factors Due to Traffic Line Width (FC_w)

Road Type	Effective lane width (L_{Lj}-E)	Traffic lane width	FC_w
4/2T & 6/2T	Per lane	3,00	0,91
		3,25	0,96
		3,50	1,00
		3,75	1,03
4/2TT	Per lane	3,00	0,91
		3,25	0,96
		3,50	1,00
		3,75	1,03
2/2TT	Two way total	5,00	0,69
		6,00	0,91
		7,00	1,00
		8,00	1,08
		9,00	1,15
		10,00	1,21
		11,00	1,27

Source: PKJI,2014

Kapasitas Capacity Adjustment Factors Due to Direction Separators (FC_{PA})

Table 3. Capacity Adjustment Factors Due to Direction Separators (FC_{PA})

Directional separator SP % - %		50 - 50	55 - 45	60 - 40	65 - 35	70 - 30
FC_{SP}	Two Lanes 2L2A	1,00	0,97	0,94	0,91	0,88
	Four Lanes 4L2A	1,00	0,975	0,95	0,925	0,90

Source: PKJI,2014

Capacity Adjustment Factors Due to Side Constraints (FC_{HS})

Table 4. Capacity Adjustment Factors Due to Side Constraints (FC_{HS})

Road Type	Class Side Constraints	Adjustment factor due to side barriers (FC_{HS})			
		Effective shoulder width L_{BE}, m			
		≤ 0,5	1,0	1,5	≥ 2,0
4/2T	Very low	0,99	1,00	1,01	1,03
	Low	0,96	0,97	0,99	1,01
	Medium	0,93	0,95	0,96	0,99
	High	0,90	0,92	0,95	0,97
	Very high	0,88	0,90	0,93	0,96
	Very low	0,97	0,99	1,00	1,02
2/2TT & 4/2TT	Low	0,93	0,95	0,97	1,00
	Medium	0,88	0,91	0,94	0,98
	High	0,84	0,87	0,91	0,95
	Very High	0,80	0,83	0,88	0,93

Source: PKJI,2014

Degree of Saturation (D_j)

The degree of saturation (DJ) is defined as the ratio of road current to capacity, which is used as the main factor in determining the level of performance of intersections and road segments.

The DS value indicates whether the segment has a capacity problem or not. The basic equation for the degree of saturation is: [8]-[21]

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

Level of National Road and Toll Road Services

While the level of service is determined on an interval scale consisting of six levels, it can be seen in table 5.

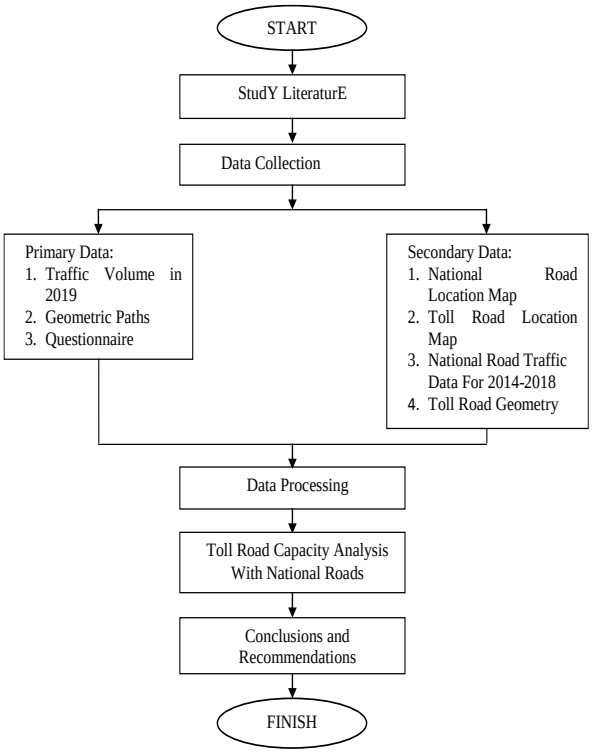
Table 5. *Characteristics of Road Service Levels*

VCR	Service Level	Information
< 0.60	A	Current smooth, low volume, high speed
0,60 – 0,70	B	Stable current, limited speed, volume suitable for roads outside the city
0,70 – 0.80	C	The flow is stable, the speed is influenced by traffic, the volume is suitable for city roads
0,80 – 0,90	D	Current approaching unstable, low speed
0,90 – 1,00	E	Current unstable, low speed, solid volume or near capacity
>1,00	F	Stopped current, low speed, volume above capacity, many stops

Source: PKJI, 2017

2. RESEARCH METHODS

The methodology of this research is shown in Figure 1.



Study Literature

This section contains literature related to the research title.

Data Collection

Dividing data into primary and secondary data. Primary data namely data taken directly at the research site and secondary data namely data obtained from related agencies.

Data Processing

Process data using the Indonesian Road Capacity Manual for toll road data. Indonesian Road Capacity Guidelines for national road data.

Toll Road Capacity Analysis With National Roads

Analyze and compare the results of the calculation of toll road capacity with national roads.

Conclusions and Recomendation

The final of the research that outlines the conclusions from the analysis results and suggestions for further research.

3. RESULTS AND DISCUSSIONS

A. National Road Traffic Volume Before Toll Road

The highest traffic volume of the National Road before the Toll Road occurred in 2017. The maximum vehicle volume data is shown in table 1.

1. Maximum Vehicle Volume in 2017

Table 6. *Maximum Vehicle Volume in 2017*

Day of Observation	Peak Hour (smp/hour)					
	First Segment		Second Segment		Third Segment	
	Normal	*Opposite*	Normal	*Opposite*	Normal	*Opposite*
Monday	2789	3250	2660	3060	2745	2126
Tuesday	3138	3138	2801	3006	3380	3082
Wednesday	3151	3110	2940	3055	3591	3119
Thursday	2893	2994	2715	2928	2782	2967
Friday	2766	2775	2569	2673	2662	2760
Saturday	2375	2735	2307	2626	2375	2706
Sunday	2527	2542	2055	2538	2352	2607

Graph of Maximum Vehicle Volume in 2017 can be seen in figure 2

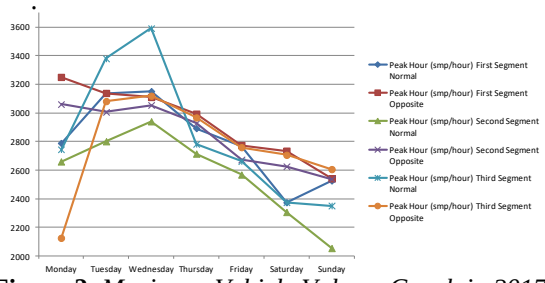


Figure 2. *Maximum Vehicle Volume Graph in 2017*

From Figure 2. The highest vehicle volume on the National Road Before the 2017 Toll Road occurred in the third segment on the normal lane of 3591 kend / hour.

2. Maximum Vehicle Volume in 2019

Table 7. Maximum Vehicle Volume in 2019

Day of Observation	Peak Hour (smp/hour)					
	First Segment		Second Segment		Third Segment	
	Normal	*Opposite*	Normal	*Opposite*	Normal	*Opposite*
Monday	1184	1240	1170	1230	1168	1232
Tuesday	1034	1133	1029	1057	1029	1047
Wednesday	1126	1108	1116	1097	1116	1104
Thursday	1101	1165	1091	1156	1091	1156
Friday	1169	1244	1023	1244	1025	1244
Saturday	1042	1075	1036	1065	1030	1069
Sunday	1247	1218	1766	1220	1237	1219

The following graph is the Maximum Vehicle Volume in 2019 presented in figure 3.

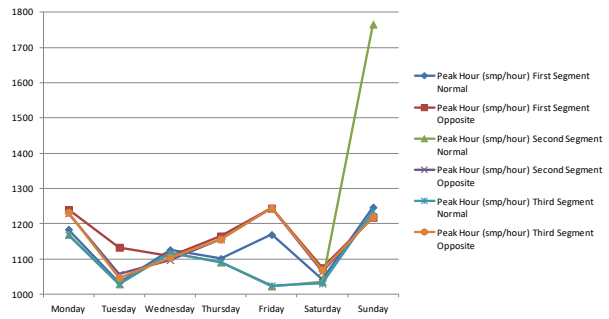


Figure 3. *Graph of National Road Traffic Volume Before the 2019 Toll Road*

Based on Figure 3. Shows the highest vehicle volume on the National Road After the 2019 Toll Road occurred in the second segment on the normal lane of 1766 kend / hour.

3. Side Barriers

Calculation of side barriers can be seen in table 3.

Table 8. *National Road Side Obstacles Before and After Toll Roads*

	Weighted Frequency of Events on Both Sides of The Road	Typical Conditions	Side Obstacle Class
First Segment	>250 - 350	Village, Several Market Activities	High (H)
Second Segment	> 50 - 150	Countryside, Some Buildings and Road Side Activities	Low (L)
Third Segment	> 350	Almost Urban, Market/Trading Activities	Very High (VH)

4. Capacity Analysis

Calculation of road capacity is presented in table 4.

Table 9. *National Road Capacity Before and After Toll Road Construction*

Road Capacity (smp/hour)			
	First Segment	Second Segment	Third Segment
Capacity of National Road Before Toll Road	1805	3007	1401
Capacity of National Road After Toll Road	1805	3007	1401

National Road Capacity Before and After the Toll Road has the same value. This is because road handling has not yet been done. The value of capacity in the first segment is 1805 pcu / hour, while the second segment is 3007 pcu / hour and the third segment is 1401 pcu / hour.

5. Degree of Saturation (Dj)

The degree of saturation of the National Road before and after the construction of the Toll Road is presented in table 5.

Table 10. Degree of Saturation of National Roads Before and After Toll Road Construction

	Day of Observation	Level of Service				Explanation
		2017		2019		
		Normal	Opposite	Normal	Opposite	
First Segment	Monday	F	F	B	B	F = Current blocked, low speed, volume above capacity and many stops
	Tuesday	F	F	A	B	
	Wednesday	F	F	B	B	
	Thursday	F	F	B	B	
	Friday	F	F	B	B	
	Saturday	F	F	A	A	E = Unstable current, low speed, solid volume or near capacity
	Sunday	F	F	B	B	
Second Segment	Monday	E	F	A	A	
	Tuesday	F	F	A	A	
	Wednesday	F	F	A	A	
	Thursday	E	F	A	A	D = Current approaches unstable and low speed
	Friday	E	E	A	A	
	Saturday	D	E	A	A	
	Sunday	C	E	B	A	C = Flow is stable, speed is affected by traffic and volume is suitable for city road
Third Segment	Monday	F	C	D	D	
	Tuesday	F	F	C	C	
	Wednesday	F	F	C	C	B = Stable current, limited speed, volume suitable for road outside city
	Thursday	F	F	C	D	
	Friday	E	F	C	D	
	Saturday	D	E	C	C	A= Current smooth, low volume and high speed
	Sunday	D	E	D	D	

The highest level of service of National Roads before Toll Roads occurred in 2017. In the first, second and third segments included in category F. After the construction of Toll Roads in 2019 the level of road services declined, in the first segment included in category B, the second segment included in category A and in the third segment included in category C. Thus, the construction of the Palembang - Indralaya Toll Road (Palindra) was able to reduce the level of road services (LoS) on the Palembang - Indralaya National Road Section.

B. Traffic Composition

1. Traffic Composition of National Roads Before Construction of Toll Roads in 2017

Calculation of the composition of traffic on the National Roads Before the 2017 Toll Road can be seen in table 11.

Table 11. *Composition of National Road Traffic Before Toll Roads in 2017*

No	Transportation Type	Traffic Composition (%)	Emp	LHR Volume	
				Kend/day	Smp/day
1	Ligt Vehicle	57	1	118648	118648
2	Medium Heavy Vehicle	23	1.2	71331	85597
3	Large Bus	7	1.6	12231	19570
4	Large Truck	4	1.8	29554	53197
5	Motorcycle	9	0.5	103112	51556
		100		**334876**	**328568**

From the results of the analysis in table 6 the highest traffic volume in units of junior high school / hour is 118648 with the type of vehicle that is Light Vehicles (KR) and the lowest LHR volume in units of junior high school / hour is 19570 included in the type of Big Bus vehicles (BB). The percentage diagram of the traffic composition of the National Road Before the Toll Road in 2017 is presented in Figure 4.

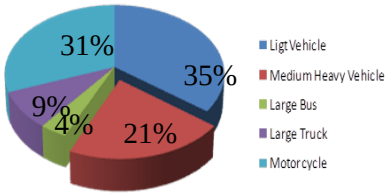


Figure 4. *Percentage of National Road Traffic Composition Before 2017 Toll Roads*

Figure 4. shows that vehicles that pass a lot are dominated by Light Vehicles (KR) at 35%, then Motorbikes (SM) by 31%, Medium Heavy Vehicles (KBM) by 21%, Large Trucks (TB) by 9% and Large Bus (BB) as much as 4%

2. The composition of national road traffic after the construction of a toll road in 2019

Calculation of the composition of traffic on the National Road after the 2019 Toll Road.

Table 7. *Composition of National Road Traffic After Toll Roads in 2019*

No	Transportation Type	Traffic Composition	Emp	LHR Volume	
				Kend/day	Smp/day
1	Ligt Vehicle	57	1	52725	52725
2	Medium Heavy Vehicle	23	1.2	16515	19818
3	Large Bus	7	1.6	789	1262
4	Large Truck	4	1.8	2656	4781
5	Motorcycle	9	0.5	92944	46472
Jumlah		**100**		**165629**	**125058**

In table 7 the highest LHR volume in units of junior high school / hour is 52725 with the type of vehicle that is Light Vehicles (KR) and the lowest LHR volume in units of junior high school / hour is 1262 included in the type of Big Bus vehicles (BB). The following is a diagram of the percentage of the composition of national road traffic after the 2019 toll road.

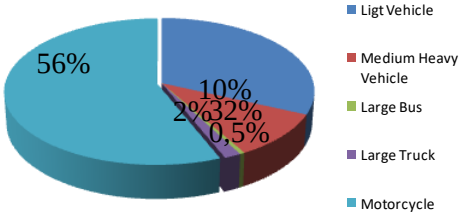


Figure 5. *Percentage of Composition of National Road Traffic After Toll Roads in 2019*

Figure 5. shows the many vehicles that pass on the Palembang - Indralaya National Road Section after Toll Roads are dominated by Motorcycles (SM) as much as 56%, Light Vehicles (KR) as much as 32%, Medium Heavy Vehicles (KBM) as much as 10%, Large Trucks (TB) 2% and Large Bus (BB) 0.5%.

C. Performance Analysis of National Roads After Toll Roads

Road performance analysis is carried out to determine the level of service of the road under study. The level of service of the National Road After the Construction of the Toll Road in the first segment with categories B and A. In the second segment included in category A. Whereas, in the third segment included in categories C and D.

Based on the results of the analysis it is known that the performance of the Palembang - Indralaya National Road after the Toll Road Development has decreased. The maximum limit value of the National Road - Indralaya before the toll road construction is> 1.00 with the highest VCR value of 1.841. After the existence of the Toll Road the VCR value decreased with a Dj value of 0.80 to 0.90 and the highest VCR value of 0.888.

D. Characteristics of Toll Roads and National Roads Based on Questionnaire Results

From the results of the questionnaire, 63% of the 30 respondents stated (yes) that the construction of the Toll Road could reduce congestion on the National Road and could accelerate mileage. And 37% stated (No). The percentage of questionnaire results can be seen in Figure 6.

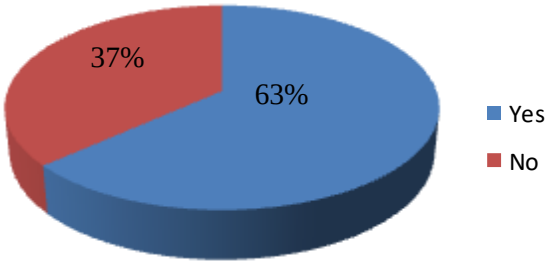


Figure 6. *Percentage Diagram Based on Questionnaire Results*

4. CONCLUSION

Based on the results of research showed that the traffic volume of the National Road before the Toll Road was highest in 2017 at 3591 pcu / hour. After the construction of the Toll Road in 2019 the traffic volume will be 1766 pcu / hour. It can be concluded

that the construction of the Palembang - Indralaya (Palindra) Toll Road was able to reduce the volume of traffic that occurred on the Palembang - Indralaya National Road.

The service level of the National Road before the Toll Road was highest in 2017 with category F which is the current that is obstructed, low speed, volume above capacity and many stops. After the construction of the Toll Road in 2019 the highest level of road service is included in category C, namely stable flow, speed affected by traffic and volume suitable for city roads. From the results of the analysis, the construction of the Palembang - Indralaya (Palindra) Toll Road was able to reduce the level of road services.

AUTHOR'S CONTRIBUTIONS

Author 1: Sartika Nisumanti
- Analyze and compare the results of the calculation of toll road capacity with national roads.
- Wrote the paper

Author 2: Sri Mulyaningsih
- Traffic collection the data

Author 3: Norma Puspita
- Traffic collection the data

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