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Effect of Toll Road Construction on Local Road Level of Service in Gandus Sub-District, Palembang City

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ABSTRACT

Construction of road infrastructure in South Sumatra Province is an effort to improve the economy and accessibility. One of the infrastructure constructions is Kayu Agung-Palembang-Betung Toll Road along 111.69 Km and consists of three segments. The second segment is between Musi Landas-Betung, has an exit and entrance ramps in Gandus Sub district. The toll road has an impact on the performance of local roads such as Jl. Lettu Karim Kadir in Gandus sub-district, because the road will be the main access road from toll road to Palembang outer ring roads such as Jl. Soekarno Hatta and Jl. Mayjend Yusuf Singadekane. The purpose of this study is to identify the conditions of Jl. Lettu Karim Kadir traffic performance in 2020 and after the operation of toll roads in 2024. Traffic simulation using VISSIM program is carried out to process data, meanwhile the prediction number of travel demand is based on the VISSIM Simulation travel demand forecasting. The results showed that there was a decrease in the traffic performance of main road Jl. Lettu Karim Kadir. The decreasing in traffic performance is estimated from queue length and delay time parameters which means that after the operating of toll road, the condition of several roads in Gandus sub-district will be overcrowded and have the potential to occur delays and queues. This is because the division of traffic flow from Jl. Lettu Karim Kadir to local roads as well as increasing population growth in Gandus Sub-District due to the increasing construction of land use in this sub-district.

Keywords— traffic performance, traffic microsimulation, travel demand forecasting

1. INTRODUCTION

Palembang City is the capital city of South Sumatra Province which is also the second largest city in Sumatra after Medan City. Palembang is divided into 18 sub-districts and 107 sub-districts where in 2019, the population is 1,662,893 people, an area of 400.61 km² and population distribution of 4,151 people / km² [1]. As the capital, the city of Palembang is very strategic because it is on the national trade route. This is supported by the location of the city that is traversed by the Trans Sumatra Road that connects cities of Sumatra, making Palembang City have access space and high mobility to accelerate growth and equitable development. Palembang is also passed by the Musi River, which is the longest river on the island of Sumatra, which divides Palembang into two parts, namely, Seberang Ilir in the north and Seberang Ulu in the south. The two areas are connected by several bridges, one of which is the Ampera Bridge which is an icon of Palembang.

A large number of toll road infrastructure developments currently in Indonesia, especially in the Province of South Sumatra, needs to be balanced with increased road network accessibility to and from these toll roads. One of the toll roads in South Sumatra Province that crosses Palembang City, is the Kayu Agung-Palembang-Betung (Kapal Betung) toll road with a length of 111.69 km which is divided into 3 segments, namely segment 1: Kayu Agung-Jakabaring, segment 2: Jakabaring-Musi Landas and segment 3: Musi Landas-Betung. In segment 2 the toll road will pass through Gandus Subdistrict in Pulokerto Urban Village and Gandus Village, where in these areas there are mixed land uses for housing, trade, services and industry. Some of the roads in the area are local roads with various surface and geometric conditions and their current traffic performance is still relatively good. In addition to access to residential areas in Gandus District, after the Kapal Betung toll road operates, the road also becomes a connecting road from the toll road to national roads including Jl. Soekarno Hatta, Jl. By-pass Alang-Alang Lebar and Jl. Mayjend Yusuf Singadekane. Increasing volume of traffic on these roads can occur due to the construction of the Kayu Agung-Palembang-Betung toll road with one of the interchanges being located in Gandus District. To anticipate a decrease in service levels on these road sections, a road network improvement plan in Gandus District is needed due to toll road construction. Based on this, this research will identify level of service of Jl.Lettu Karim Kadir in Gandus Sub District, because the road will be

the main access road from toll road to Palembang outer ring roads such as Jl. Soekarno Hatta and Jl. Mayjend Yusuf Singadekane in 2020 and after the toll road operation is estimated to be in 2024. Besides, it will also explain some alternatives improvements that need to be made based on community movement patterns and prediction of traffic volume in the future due to the construction of the Kayu Agung-Palembang-Betung Toll Road. Traffic simulation using VISSIM program is carried out to process data and the prediction number of travel demand based on the VISSIM Simulation travel demand forecasting. The result of the study are the prediction of traffic volume after toll road operation and some suggestions traffic engineering management on Jl.Lettu Karim Kadir that can improve road network performance in Gandus District due to the construction of the Kayu Agung-Palembang-Betung toll road.

The difference between this research and several previous researches with almost the same topic regarding the analysis of traffic performance on roads is that this research examines the impact of toll roads on the performance of local roads, which generally have geometric conditions of small road width and dense land use. This research used VISSIM method so that the parameters for assessing the performance of the roads that are assessed represent the actual conditions and the simulation results can be visualized with 3-dimensional animated images. This research also analyze and alternative road improvement solutions. Previous research has conducted to analyze national road performance using the 2014 PKJI method [2]. The other research has analyzed the performance of roads using the MKJI 1997 method and the VISSIM simulation method [3].

2. THEORETICAL FRAMEWORK

2.1. Transportation System

In transportation system theory, road construction will affect increasing the number of movements and increasing the number of activities on land use which have increased due to road construction [4]. The components in the transportation system influence each other, so that the construction of the road network is also influenced by land use as a generator of traffic movement [5]. The construction of housing, schools and other land uses is a form of change in the activity system, which will increase the activity of human movement that affects the use of the existing transportation network system. In theory, major investments in transport infrastructure have both direct and indirect effects on local transport systems. Direct effects of major transport investments, such as a redistribution of traffic and congestion effects are directly related to the investments and happen directly after opening.

2.2. Traffic Simulation Using the VISSIM Program

In assessing the Level of Service of road sections (LOS) in the VISSIM program, there are parameters as vehicle behavior to be used in the traffic simulation modeling process [6], [7]. The parameters chosen in the modeling include:

1. Standstill distance in front of obstacle, which is the parameter of the safe distance when the vehicle is about to stop due to a vehicle stopping or decelerating due to obstacles in units of meters (m).
2. Observed vehicle in front, which is the parameter of the number of vehicles observed by the driver when he wants to make a movement or reaction. The default values for this parameter are one, two, three, and four with vehicle units.
3. Minimum Headway, which is the minimum distance available for the vehicle in front to make lane shifts or prepare. Default values range up to 0.5−3 meters.
4. Lane Change Rule, namely the mode of driver behavior when passing, for heterogeneous traffic it is very suitable to use the Free Lane Change mode which allows the vehicle to prepare freely.
5. Overtake at Same Line is the behavior of vehicle drivers who want to be on the same lane from both the right and the left.
6. Desired Lateral Position, which is the position of the vehicle while in the lane, meaning that the vehicle can be on the left or right side of another vehicle.
7. Lateral Minimum Distance is the safe distance for the driver when he is next to another vehicle. This parameter is divided into two parts, namely the distance of the vehicle when it is at a speed of 0 km / h and 50 km / h, which means that the parameter value for this parameter is different, the default value for this parameter ranges from 0.2 to 1 m.
8. Safety Distance Reduction, the safe distance between vehicles in front and behind or the gap and clearing distance between vehicles, this is a very determining parameter because each traffic condition has a different safety distance value

VISSIM can simulate similar to the real transportation conditions. The advantage of VISSIM is that it has quite complete parameters, such as calibration of the driving behavior which can resemble the characteristics of the driver in each area. The steps of modeling analysis using VISSIM software generally include input, running, and output. Input parameters from VISSIM modeling are obtained from the observation location in the form of road networks, travel routes and types of vehicles. Examples of input to the VISSIM program can be seen in Fig. 1 to Fig. 4. The output of VISSIM modeling used in the study of queue length, degree of saturation, delay and roads level of service.

Fig. 1. Road network input

Fig. 2. Travel route input

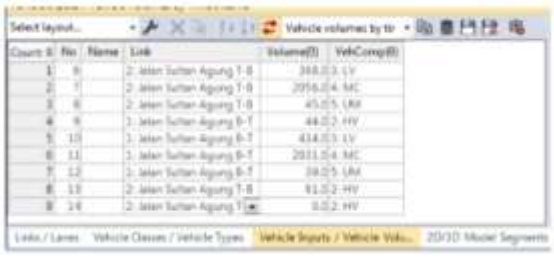

Fig. 3. Vehicle type input

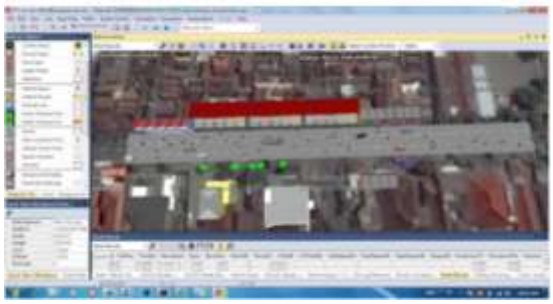

Fig. 4. Running Process

After the parameters are adjusted to the existing conditions, then the next step is comparing the number of vehicles crossing the local roads in the existing conditions and number of vehicles output from VISSIM using the model calibration formula as follows:

$$\text{Percentage of Validation} = \frac{\textit{Number of Vehicle out put from Vissim}}{\textit{Number of Vehicle based on survey result}} \text{x}100\% \quad (1)$$

2.3. TRANSPORATION MODELLING USING THE VISSIM PROGRAM

In this study, a transportation model was made to predict traffic volume on the road network in Gandus District using the VISSIM macrosimulation program. The modeling steps are described as follows:

1) First step is to click on the VISSIM Program. Then input the background with the background maps input based on open street map.
2) After the open street map has been displayed, the next step is to create a base map to display the road network, and validate the base map by adding to the existing road network in the background by creating points or nodes.
3) The next step is to define zones
4) Between zones and nodes on the road network, will be connected by a connector (connector).
5) The next step is inputting the Origin Destination Matrix data.
6) After inputting the Origin Destination Matrix data, the next step is to input the type of vehicle
7) Running the Procedure Sequence as follows:
   a) After the previous steps have been completed, the next step is to run the procedure sequence.
   b) Click Procedure sequence.
   c) Make a sequence of procedures with the trip generation model operation, then the trip distribution model operation and finally the trip assignment model as can be seen in Figure 3.17 by clicking create in the Operation window according to the model to be reviewed.
   d) For each procedure, define the respective parameters that will be reviewed the operation.
   e) Run the procedure sequence by clicking on all procedures or just want to review some procedures and then press the green arrow button to run the procedure as shown in Figure 3.17. The results will be displayed in tabular form.
8) Editing Demand from standard 4-stage transportation modeling, at this stage a procedure will be carried out to obtain a model of the amount of generation and attraction.
9) Calculate Trip Distribution
10) The trip distribution is calculated from the help of a uniform model which can be calculated manually beforehand.
11) Calculate route assignment (trip assignment) using the equilibrium assignment model.

3. METHODOLOGY AND DATA

The purpose of the research is to identify the current road level of service in 2020 and after the operation of toll road in 2024. Traffic simulation using VISSIM program is carried to identify road level of service and VISSIM Simulation travel demand forecasting is carried to forecast traffic volume in 2024 due to the construction of the Kayu Agung-Palembang-Betung Toll Road. To achieve the purpose, the analysis follow the framework as shown in the Fig. 5.

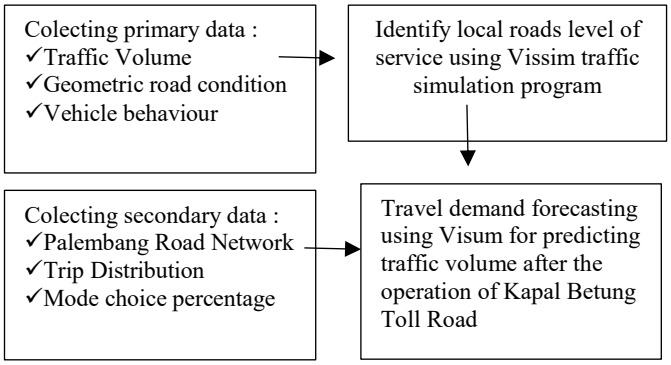

Fig. 5. Analysis Framework

The location of data collection was carried out on Jl. Lettu Karim Kadir in Gandus sub-district. The local road is the main access road to and from Kapal Betung toll road. The location of traffic volume data collection on Jl Lettu Karim Kadir in Gandus sub-district is described in Fig. 6. There are four road segments of Jl. Lettu Karim Kadir based on number of intersection on the road.

The survey was conducted by counting the number of vehicles passing the road and based on the type of vehicle in 15-minute intervals recorded on the survey form. The types of vehicles calculated are motorbikes, cars, public transportation, puck-ups, 2 axles' trucks, 3 axles' trucks, micro buses and large buses. Data processing with the VISSIM simulation model begin by entering local roads geometric data, vehicle type data and traffic count data, so that the queue length, delay time and traffic volume based on simulation results will be obtained. VISSIM Simulation travel demand forecasting is carried to forecast traffic volume in 2024 due to the construction of the Kayu Agung-Palembang-Betung Toll Road. Input data for VISSIM Simulation are Palembang road network, trip distribution obtained from upgrading Origin-Destination Matrix 2016 and mode choice percentage obtained from previous research.

Fig. 6. Jl Lettu Karim Kadir as Local observed road in Gandus Sub-district

Explanation :

: Segment 1 (Musi II Bridge - Perumahan Mitra Permai)
: Segment 2 (Jl.Perumahan Mitra Permai – Jl. M.Amin Fauzi)
: Segment 3 (Jl. M.Amin Fauzi – Jl. TPH Sofyan Kenawas)
: Segment 4 (Jl. TPH Sofyan Kenawas – Jl. Sosial)

4. DATA PROCESSING AND ANALYSIS

This section will explain the data that has been collected, the processing methods and the analysis of data processing result.

4.1. Data Collection

The primary data collected are:

1) Geometric and road conditions are:
   a) Jl. Lettu Karim Kadir has two lane and two line undivided (2/2 UD)
   b) Road width 6 meters,
   c) Pavement type is concrete
   d) Jl. Lettu Karim Kadir has good pavement condition.

2) Recapitulation o f maximum traffic volume on the observed road sections.

Traffic count survey was conducted during morning, afternoon and evening peak hours. Recapitulation of maximum traffic volume on the observed road sections is explained in Table I.

Table I. Recapitulation of Traffic Count Based On Survey Results

No	Name	Volume (Vehicle/Hour)		
		Motor Cycle	Passenger Car	Heavy Vehicle
1	Musi II Bridge - Perumahan Mitra Permai (Segment I)	2217	311	35
2	Jl. Perumahan Mitra Permai – Jl. M.Amin Fauzi (Segment II)	1966	278	34
3	Jl. M.Amin Fauzi – Jl. TPH Sofyan Kenawas (Segment III)	2067	199	46
4	Jl. TPH Sofyan Kenawas – Jl. Sosial (Segment IV)	776	43	5

4.2. Identify Existing Local Roads Level of Road Service in 2020 and After the Toll Road Operation in 2024

Number of vehicles data on local roads is then inputted into VISSIM Microsimulation Program and simulation is carried out by entering parameters such as road geometry and local vehicle speed. From the simulation results, the output will be in the form of the number of vehicles on each road, the length of the queue, and the delay time. However, the most important thing that must be seen first is the suitability of the input and output data for the number of vehicles. The process of suitability of data to produce output is done by calibration. Calibration in traffic simulations with

the VISSIM Program is carried out by several times a trial and error process by changing the parameter values in the driving behavior menu until a traffic simulation is obtained that is close to the existing conditions. Meanwhile, to ensure that the traffic simulation in the existing conditions is suitable, a validation process is carried out.

Comparison between traffic count survey and simulation results with VISSIM describe in Table II. It is showed that if the percentage value is greater, the better the validation value.

Table II. Comparison between Traffic Count Survey and Simulation Results

No	Name	Number of vehicle Vehicle/Hour		Percentage of Validation (%)
		Traffic Count Survey	VISSIM Program	
1	Musi II Bridge - Perumahan Mitra Permai (Segment I)	2563	2528	98.63
2	Jl. Perumahan Mitra Permai – Jl. M.Amin Fauzi (Segment II)	2278	2249	98.73
3	Jl. M.Amin Fauzi – Jl. TPH Sofyan Kenawas (Segment III)	2312	2255	97.53
4	Jl. TPH Sofyan Kenawas – Jl. Sosial (Segment IV)	824	650	78.88

In addition to calculating the percentage of validation values, statistical tests were also performed using the Geoffrey E.Havers (GEH) formula to determine whether the simulation model using VISSIM software was acceptable. Based on the statistical value, the simulation model using VISSIM is acceptable.

To determine level of service of Jl. Lettu Karim Kadir, there are two parameters queue length and delay time as explained in Table III. Queues and time delays occur due to side obstacles and there is a conflict in the direction of vehicle movement at several intersections on Jl. Lettu Karim Kadir. The highest delay time and the longest queue is in segment I around 33.1 seconds and 7.18 meters. The lowest delay time and the longest queue is in segment IV around 3.38 seconds and 0.18 meters... Table 3 shows queue length and delay time on Jl. Lettu Karim Kadir segment I to segment IV.

Table III. Queue Length and Delay Time on Jl. Lettu Karim Kadir

No	Name	Direction	Delay time (seconds)	Queue length (meters)
1	Musi II Bridge - Perumahan Mitra Permai (Segment I)	To Musi II Bridge	41.22	25.19
		To Perumahan Mitra Permai	16.65	10.22
2	Jl. Perumahan Mitra Permai – Jl.M.Amin Fauzi (Segment II)	To Perumahan Mitra Permai	14.04	35.96
		To Jl.M.Amin Fauzi (Segment II)	6.89	32.54
3	Jl. M.Amin Fauzi – Jl. TPH Sofyan Kenawas (Segment III)	To Jl. M.Amin Fauzi – Jl. TPH Sofyan Kenawas	11.40	128.78
		To Jl. TPH Sofyan Kenawas	9.53	8.4
4	Jl. TPH Sofyan Kenawas – Jl.Sosial (Segment IV)	To Jl. TPH Sofyan Kenawas	1.19	0
		To Jl.Sosial	3.62	0

4.3. Prediction Local Roads Level of Road Service in 2020 and After the Toll Road Operation in 2024

To determine level of service on Jl. Lettu Karim Kadir after Kapal toll road is operating, it is necessary to know in advance the prediction of traffic volume on Jl. Lettu Karim in 2024. VISSIM Simulation travel demand forecasting is used to perform four-stage transportation modeling so that the predicted traffic volume in 2024 is obtained. The prediction of traffic volume on Jl. Lettu Karim are explained in Table IV.

Table IV. Prediction of Traffic Volume Based On Vissim Simulation Results

No	Name	Volume (Vehicle/Hour)		
		Motor Cycle	Passanger Car	Heavy Vehicle
1	Musi II Bridge - Perumahan Mitra Permai (Segment I)	4223	621	59
2	Jl. Perumahan Mitra Permai – Jl. M.Amin Fauzi (Segment II)	4191	595	75
3	Jl. M.Amin Fauzi – Jl. TPH Sofyan Kenawas (Segment III)	4372	340	70
4	Jl. TPH Sofyan Kenawas – Jl. Sosial (Segment IV)	4212	232	27

After prediction of traffic volume in 2024 was obtained, the next step is to use VISSIM Program to determine level of service of Jl. Lettu Karim Kadir section after the toll road operates. The results of prediction of queue length and delay time at Jl. Lettu Karim Kadir are explained in Table V. It can be seen in Table 5 that the increasing number of queues and delay times are significantly different before and after operation of Kapalk-Betung toll roads. This is because there was no development on Jl. Lettu Karim Kadir such as

remove side obstacles and road widening. Jl. Lettu Karim Kadir is relatively has small width, only 6 meters, and the road will be traversed by heavy vehicles entering or leaving the toll road.

Table V. Queue Length and Delay Time on Jl. Lettu Karim Kadir after Toll Road Kapal-Betung Operates

Name	Direction	After Toll Road Operates		The Difference Between Before and After The Toll	
		Delay Time (Sec)	Queue Length (m)	Delay Time (Sec)	Queue Length (m)
Musi II Bridge - Perumahan Mitra Permai (Segment I)	To Musi II Bridge	66.44	76.97	27%	63%
	To Perumahan Mitra Permai	12.64	76.97	15%	87%
Jl. Per Mitra Permai – Jl. M.Amin Fauzi (Seg ment II)	To Perumahan Mitra Permai	24.08	133.18	42%	56%
	To Jl. M.Amin Fauzi	16.90	53.72	59%	39%
Jl. M.Amin Fauzi – Jl. TPH Sofyan Kenawas (Segment III)	To Jl. M.Amin Fauzi	24.28	165.12	53%	21%
	To Jl. TPH Sofyan Kenawas	11.12	9.68	14%	13%
Jl. TPH Sofyan Kenawas – Jl. Sosial (Segment IV)	ToJl. TPH Sofyan Kenawas	11.52	7.18	90%	100%
	To Jl. Sosial	16.68	32.2	90%	100%

The percentage difference in queue length and delay time on Jl.Lettu Karim Kadir is quite significant, especially for segment 4 which is the closest road to access / entry of vehicles from and to toll roads in Gandus District. Based on the data processing results, increasing number of queues and delay times are significantly different before and after operation of Kapalk-Betung toll road. Some effort to Increasing Level of Service Jl. Lettu Karim Kadir after the Toll Road Operation in 2024 are:

1) Reduce side barriers by constructing warning signs such as no stopping or no parking.
2) Improving geometric road condition such road widening.
3) Conducting several alternative travel routes so as to reduce traffic flow on Jl. Lettu Karim Kadir.

The research results obtained are in line with previous research [8] that toll road construction will impact local road development. Both the toll roads that have been or will be built will have a direct or indirect impact on local roads. Local road development is carried out to anticipate movement from and to toll roads as well as growth in land use and population around toll roads.

5. CONCLUSION AND RECOMMENDATION

This research identify local road level of service before and after the construction of toll road in Palembang City. Some conclusion from the research are as follow:

1) The construction of Kapal Betung toll road infrastructure has an impact to Jl. Lettu Karim Kadir, which is a local access from national road such as Jl. Soekarno Hatta and Jl. Mayjend Yusuf Singadekane the toll road and vice versa.

2) Decreasing on level of service on Jl. Lettu Karim Kadir after toll road operates which is indicated by the parameters of queue length and delay time. That occur due to conflicts at intersections and side barriers on Jl. Lettu Karim Kadir.

3) Efforts that can be made to improve the road performance of Jl. Lettu Karim Kadir are, reduce side barriers, improving geometric road condition and conducting several alternative travel routes.

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