

# Analysis Effect of Side Frictions against Vehicles Speed at Ahmad Yani Street Kupang City Using the MKJI and PKJI Formulation Approach

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**Abstract**— Traffic congestion in urban areas has become a national problem in Indonesia, as well as Kupang City, especially on the Ahmad Yani Street. On this road there are commercial activities such as shops, shopping centers and there are also favorite schools on this road so traffic congestion is difficult to avoid. One of the triggers of traffic congestion is side frictions, where parking vehicles are increasing, vehicles are in/out, vehicles are slow and pedestrians are crossing the road which causes a decrease in vehicle speed so that time is wasted on roads. However, how the influence of side frictions against vehicle speed has not been formulated through mathematical models, so this research is needed. The aim of this research was to determine the road performance of existing conditions and find models of the effect of side frictions against vehicle speed, especially on the Ahmad Yani Street, Kupang City. To achieve this aim, the primary data collection method uses observations through traffic surveys while the data analysis method uses MKJI and PKJI formulations which are coupled with regression analysis. The results showed that the regression equation model of the effect of side frictions against the average speed of the vehicle with the MKJI 1997 formulation was  $y = 19,228-0.0369x$ . The regression equation model of the effect of side frictions against the average speed of the vehicle using the 2014 PKJI formulation is  $y = 19.472-0.0431x$

**Keywords**— Models, effect, side frictions, regression, vehicle speed.

## I. INTRODUCTION

Somewhere in the downtown section developed into a trade area is due to the factors supporting the existence of the site, including proximity, convenience, availability and the convenience factor, but it is also determined by the increase in the sheer number of people around the area as well as an increase in per capita income of the people and the facilities that support the region, and increasing development in various fields, thus increasing transportation needs. Increased transportation facilities resulted in the flow of traffic on a road section to be increasing.

Ahmad Yani Street is one of the roads have traffic flow dense fairly in Kupang City. These roads are in the trading business location (BPSKK, 2018). Side friction was on the road very disrupt the smooth flow of traffic. The road is supposed to be used for traffic flow consumed for the vehicle to stop. Besides the sidewalk should be used for pedestrian transformed to enable, and the number of vehicles out access of land along the road adds to the density on these roads. This condition causes Ahmad Yani Street is becoming more narrow, so the speed is reduced, the travel time increases,

Level progressively higher vehicle ownership are the main problems that lead to the traffic flow is not a stable and low level of public awareness in obeying traffic rules causing conflict-prone traffic and decrease speed. Their business activities directly adjacent to roads also indirectly influence the traffic flow on the road (Widari et al. 2015).

Side friction can cause a decrease in the speed of traffic so that the side barrier is one of the causes of traffic congestion. Decrease the speed of the vehicle due to traffic density impact on the time of travel time should be. When there is a traffic density in a row, then the travel time losses experienced by the rider. Barriers side also proved to be very influential on the performance and capacity include pedestrian, public transport stops, and other vehicles as well as vehicles out of the land next to the road (Funan et al. 2014).

Based on the number of vehicles is growing every year resulting in the use of the road is increasing so that the traffic flow is increasing. Two categories of traffic flow namely interrupted the flow and the uninterrupted flow. If the traffic characteristics approach optimum side friction coupled with increased density will tend to occur congestion. Provisional estimates in addition to increasing the number of vehicles, the side frictions also affect traffic congestion, however the extent of the side frictions affect the average speed of vehicles resulted in traffic congestion have not known, so the studies need to be done and hope the results of this study can be used at Kupang City government in making decisions, whether for modeling the transport system management and traffic engineering. So that is the purpose of this study was to determine the condition of the existing road performance and find models effect of side friction against the vehicle's speed, especially on Ahmad Yani Street in Kupang City.

## II. LITERATURE REVIEW

Research on side frictions is quite interesting for researchers, especially in the field of transportation, this is evidenced by the number of researchers who examine the side frictions to analyzing qualitatively based on the required quantitative formulations, as well as in the form of mathematical models based on regression analysis. Tataming et al. (2014), conducted a study on the large contribution of side frictions to speed using the MKJI 1997 formulation with multiple linear regression models. The results of this study

state that the contribution of side frictions to speed is 83.03%. Marunsenge et al. (2014), conducting research on the effect of the side frictions to the performance on Panjaitan Street (Ban Hing Kiong Temple). The results of this study indicate that side friction factors affect the speed of the flow of traffic where vehicles slow 12.1%, 7.6% factor pedestrian, vehicle entry and exit factors 5.5%, 4.3% factor to stop the vehicle. This study also used the formulation MKJI 1997 with a multiple linear regression model. Syaputra et al. (2015), conducting research on the effect of the side frictions on the performance of the National Street Traffic (Case Study Proclaimers Street Bandarjaya Plaza). The results showed that the degree of saturation high of 1:01, the traffic volume of 1,395 smp/hour, the capacity of roads in 1,384 smp / hour. This research has not shown any effect is based on a model. Himanudin and Farida (2016), conducting research on the analysis of side frictions of the road performance (Case Study Thunder Street Garut). The results of this study indicate that the effect of the side frictions on the capacity seen from the decline in the capacity before the side barriers of 3,107.64 smp / hour and with a side barrier into 2,865.20 smp / hour. The level of service B, DS = 0:48 at the service level C. Assessment side friction conditions in this study was limited to a comparison of road capacity has yet to show a mathematical equation that can prove the effectiveness of the side frictions on the capacity of the road, so this research also needs to be developed. Permana et al. (2016), conducted a study of the effects of side barriers on-road performance, Vehicle Operating Costs and Congestion Costs of Gatot Subroto Street Malang City. The results of this study indicate that the VCR value is influenced by vehicles coming/out, vehicles entering and slow vehicles with a regression model  $Y = 0.244 + 0.003 X1 - 0.001 X2 + 0.001 X6$ . This research has shown the effect of side friction on VCR but still needs to be improved to other variables such as the average speed of vehicles.

Based on previous research conducted in the development of this study is to present analysis road performance coupled with a model of the effect of side frictions against the vehicle speed by using formulations MKJI 1997 and PKJI 2014 include with simple regression analysis. Road performance is a quantitative measurement which describes specific conditions that occur on a road section. Performance road segments can be defined as the extent of the ability to function. According to MKJI 1997 which is used as a parameter is the degree of saturation (DS). MKJI (1997) also explains that the level of service can also be calculated based on the limit the scope of Q/C of these roads.

Indonesian Highway Capacity Guidelines 2014 (PKJI 2014) arranged in an effort to update the Indonesian Highway Capacity Manual 1997 (MKJI 1997) which has been used for more than 12 years since publication. PKJI 2014 establishes provisions concerning the calculation of capacity for planning and performance evaluation of urban road traffic, including road capacity (C) and road traffic performance as measured by the degree of saturation (DJ), travel speed (VT), and travel time (TT). These guidelines can be used on segments that are

common in urban environments with the type of road 2 / 2TT, 4 / 2TT, and Highways type 4 / 2T and 6 / 2T.

The main characteristics of the road segment which affects the capacity and performance of the road according to PKJI 2014, namely: 1) The geometry of the road that influence the capacity and 2) performance of the road where the type of road that determine differences in the loading traffic, width of traffic lanes that can affect the value of free flow speed and capacity curb and the shoulder of the road that have an impact on the side barriers on the side of the road, the median affecting the direction of traffic movement. Most capacity occurs when the flow both directions on the type of road 2 / 2TT equally (50% -50%), hence the separation in this direction needs to be determined in the determination of the value of the capacity to be achieved, while the composition of the traffic affected when converting vehicles to Light vehicle (KR), the unit used in the analysis of capacity and traffic performance.

### III. RESEARCH METHODOLOGY

The secondary data collection method uses the literature study while obtaining primary data uses the observation method by conducting traffic surveys. The method of data analysis uses the MKJI 1997 and PKJI 2014 formulations which are equipped with regression analysis to analyze the effect of side frictions against vehicle average speed (Vr). The flow chart of the research is presented in Figure 1.

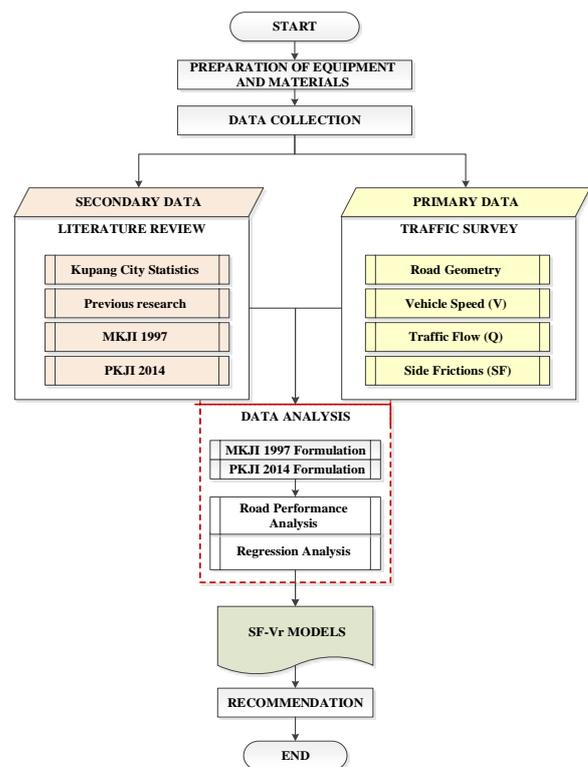


Figure 1. Flowchart of research

#### 3.1. Research Variable

The aim of this research was to determine the condition of the existing road performance and find a model of the effect of

side friction against the vehicle speed in Ahmad Yani Street Kupang. To achieve these objectives, there are five main variables that must be examined in this study include: 1) Geometric Road, 2) Traffic flow (Q), 3) The Capacity of the Road (C), 4) Average Speed of Vehicle (Vr), and 5) Side Friction (SF).

Mathematical models were found from the results of the regression analysis based on relevant variables and independent variables and intermediate variables: 1) Bound variable is the average of vehicle speed (Vr). 2) The free variables are of side friction (vehicle parking, vehicle and out of the access roads, the vehicle stops, crossing the street). 3) The variable of the mediator is traffic flow, road capacity, and geometric road.

### 3.2. Equipment and Materials Research

The tools used in the study consisted of a traffic survey tool items: stationery, a time measuring device (watch and stopwatch), a distance measuring device (meter), a board (clipboard), a documentation tool (video, camera), a handheld tool (handy tally counter), other tools that support surveys (flags, luck band). The tool used for tabulation and processing of data is a laptop equipped with MS Word, MS Excel, and MS Visio software. While the materials used in this study are survey form sheets and reference materials.

### 3.3. Research Procedure

#### 3.3.1. Preparatory research

Before conducting the research, it is necessary to do the preparatory work. The things that need to be prepared include finding and collecting information related to the research topic. Gather supporting literature to be used in the collection, tabulation and analysis of data either manually or using a computerized system. Collecting alternative materials from previous studies that are relevant to the study as a comparison study. At this stage the problem, problem formulation that produces research purposes, especially those related literature review has been conducted reexamined as inputs in conducting a preliminary survey. At this stage also carried out preparatory surveys, such as: choice of location, setting each segment of road, the selection of survey methods, form preparation and equipment surveys and surveyor.

#### 3.3.2. Traffic survey

The data collection is done by measuring through traffic surveys in the field to generate the data required in accordance with the variables that have been determined to achieve the research objectives. Surveys conducted the survey consists of geometric conditions and surveying the road and traffic conditions. The data recorded on the survey form provided.

- Survey conditions and road geometry aims to obtain general data about the condition of a cross section of the road geometry studied.
- Traffic flow condition survey aims to determine traffic flow conditions that exist in the study area.

#### 3.3.3. Tabulation and analysis of data

At this stage the data that has been collected in a form of data tabulated in the form of tables that suit their needs by using MS Excel applications on computer/laptop to be more

easily carried out at the time of data analysis. Further data analysis using within their formulation variables needed to achieve the objectives, namely: 1) Geometric Road, 2) Traffic Flow (Q). 3) The capacity of Road (C). 4) Average of Vehicles Speed (Vr) and 4) Frictions Side (SF).

#### 3.3.4. Data analysis method

Methods of data analysis using quantitative methods with an MKJI 1997 and PKJI 2014 formulation approach for all variables needed are 1) Geometry Road, 2) Traffic Flow (Q). 3) Capacity Road (C). 4) Speed (V), 5) Degree of Saturation (DS) and 6) Side Frictions (SF). The results of quantification using both formulations are taken as variable regression analysis to find a mathematical model of the effect of the side friction against the Average vehicle speed. The mathematical model as one outcome/product end of this study is expected to be used as a local policy recommendations Kupang City in traffic engineering system forward so that traffic congestion can be reduced.

##### 1) Geometry road

Survey conditions and road geometry aims to obtain general data about the condition of a cross section of the road geometry studied. Road geometry data analysis by counting the number of lanes, lane width (m), class / function, shoulder road, median and type of road.

##### 2) Traffic flow (Q)

Traffic flow (Q) is the number of vehicles that Traffic flow (Q) is the number of vehicles that pass a point per unit time in a particular location. In measuring the amount of traffic flow, it is usually stated in vehicles per day, passenger car units per hour (pcu/hour), and vehicles per minute (MKJI 1997). Traffic flow is calculated based on equation (1).

$$Q = N / T \tag{1}$$

Where:

Q: Traffic flow (pcu/hour)

N: Number of Vehicles (Vehicles)

T: Observation Time (Hours)

##### 3) Speed (V)

Formula for calculating the average speed (Vr) of a vehicle using equation (2)

$$V = L / TT \tag{2}$$

Where:

V: Average speed (km/h)

L: Road length (km)

TT: The average travel time of a LV vehicle along a segment (hour)

##### 4) Capacity (C)

Capacity is defined as the maximum current through a point on the road that can be maintained per unit hour under certain conditions. Determine the capacity using equation (3) as the basic equation.

$$C = Co + FCw + FCSP + FCSF + FCcs \tag{3}$$

Where:

C: Capacity (pcu / hour)

CO: Basic capacity (pcu / hour)

FCw: Road width adjustment factor

FCSP: Direction separator adjustment factor

FCSF: Factors adjusting side obstacles and road shoulder

FCcs: City size adjustment factor

5) Degree of saturation

Degree of saturation (DS) is a comparison of the value of traffic flow to its capacity. DS is a description of whether a road has a problem or not, based on the assumption that the road segment is getting closer to its capacity to facilitate movement, is increasingly limited. Based on the definition of degree of saturation, DS is calculated using equation (4).

$$DS = Q / C \tag{4}$$

Where:

DS: Degree of Saturation

Q: Maximum traffic flow (pcu / hour)

C: Capacity (pcu/hour)

6) Side frictions

Side frictions are the effect of activities in addition to the performance of traffic roads (MKJI, 1997). According to (PKJI, 2014), side friction is beside the road segment activities that affect traffic performance. Criteria Class Barriers (CCB) side is determined from the total of the frequency of occurrence of each type of side frictions, each of which had been multiplied by its weight. The frequency of side frictions are calculated based on observations in the field for a period of one hour along the segment were observed. Results of side friction survey will get street-side activity data occurring during the observation period. After the data of the frequency of occurrence for each type of side friction obtained, then the calculation of the frequency weighted by means of multiplying the frequency of occurrence for each type of events friction with a weighting factor of each type of incident side frictions, then add them up to get the total frequency weighted incident. Of the total weighted frequency can be determined the class of side friction on the side friction weighting coefficient table, then we will get the data of side friction for each road segment were observed. Side frictions were analyzed by calculating the frequency of occurrence of each type.

IV. RESULTS AND DISCUSSION

4.1. Results

Observations made through traffic survey on the road Ahmad Yani Kupang city is divided into three segments. Each segment has a length of 200m observation Ahmad Yani Street Kupang including type 2 lane road undivided 2-way (2 / 2UD). The road has a shoulder of the road and has no median. The survey results of side frictions frequency (SF) is calculated using the formula MKJI 1997 and PKJI 2014 to find the results weighted frequency of side frictions. The results of the analysis of the frequency of SF-weighted through a calculation using the formula MKJI 1997 at the Ahmad Yani Street on Mondays and Fridays are the class of Very High (VH), while on Sunday is in a class of High (H), but the use of formulations PKJI 2014, on Mondays and Fridays are in the Medium class (S), while on Sunday is at Low class (R). Summary of frequency Ahmad Yani Street frictions side Kupang three road segments is presented in Table 1.

Maximum traffic flow Mondays to Fridays wherein different on Monday, the highest peak traffic flow is at 10: 00-11: 00 pm, while on Friday is at 08: 00-09: 00 pm. On Sunday peak traffic flows are at hour 09: 00-10: 00 pm, which is 2,989

pcu/hour. Traffic lows are lowest on weekdays Friday amounted to 1,459 pcu/hour. The traffic characteristics with respect to time in Jalan Ahmad Yani Kupang presented in Figure 2.

TABLE 1. Summary of frequency of side frictions weights Ahmad Yani Street

Hari	Weighted SF Frequency MKJI 1997					
	PED	PSV	EEV	SMV	Total	Kelas
Monday	93	103	249	23	469	VH
Friday	85	107	256	35	483	VH
Sunday	63	87	140	27	317	H
	Weighted SF Frequency PKJI 2014					
	PED	PSV	EEV	SMV	Total	Kelas
Monday	78	129	174	23	404	S
Friday	71	134	179	35	419	S
Sunday	53	108	98	27	286	R

The result of the calculation of capacity road (C) Ahmad Yani Street uses slightly different formulations MKJI 1997 with the formulation of PKJI 2014, due to the determination of side frictions class. In MKJI 1997 type of the two-lane undivided two directions indicated by the 2 / 2UD, whereas in 2014 PKJI indicated as 2 / 2TT. Road capacity calculation using the formula MKJI 1997 and PKJI 2014 are presented in Table 2.

TABLE 2. Capacity of road Ahmad Yani Street					
Capacity of Road Uses MKJI 1997					
Co	FC <sub>CW</sub>	FC <sub>SP</sub>	FC <sub>SF</sub>	FC <sub>CS</sub>	C
pcu/hour					pcu/hour
2,900	1	1	0.92	0.9	2,401
Capacity of Road Uses PKJI 2014					
Co	FC <sub>LJ</sub>	FC <sub>PA</sub>	FC <sub>HS</sub>	FC <sub>UK</sub>	C
lvu/hour					lvu/hour
2,900	1	1	0.95	0.9	2,480
pcu	: Passenger Car Unit				
lvu	: Light vehicle unit				

The degree of saturation calculation using the formula MKJI 1997 is 3% higher compared to using formulations PKJI 2014. The average degree of saturation in Ahmad Yani Street Kupang City has reached 1.02, which means that traffic flows that pass this way has exceeded the capacity of the road. The highest degree of saturation of 1.27 is on Monday from 09:00-10:00 am, while the lowest saturation of 0.74 is on Monday from 17: 00-18:00 pm. Characteristics of the degree of saturation versus time are presented in Figure 3.

Average vehicle speed highest is 13.07 Km/h on Sunday from 06:00-07:00 am, while the average speed of the lowest vehicle is 3.83 km/h is at 11: 00-12: 00 pm on Monday, Characteristics of the average vehicle speed (Vr) is presented in Figure 4.

Side Friction (SF) was 79% negatively correlated against the average speed of the vehicle (Vr) using MKJI 1997 formulations, while using the PKJI 2014 formulation, SF

correlated negatively by 83% against Vr. Correlation of SF against Vr is presented in Table 3.

TABLE 3. Correlation of SF against Vr

Days	Time	Vr y	SF	
			PKJI 2014 x1	MKJI 1997 x2
M	06:00-07:00	5	260	302
o	07:00-08:00	4	360	419
n	11:00-12:00	4	379	441
d	12:00-13:00	4	369	430
a	16:00-17:00	5	301	350
y	17:00-18:00	6	249	290
F	06:00-07:00	5	312	360
r	07:00-08:00	4	378	435
i	11:00-12:00	4	366	421
d	12:00-13:00	4	365	420
a	16:00-17:00	5	276	318
y	17:00-18:00	5	271	313
S	06:00-07:00	13	209	233
u	07:00-08:00	10	252	281
n	11:00-12:00	9	278	309
d	12:00-13:00	9	273	305
a	16:00-17:00	11	254	283
y	17:00-18:00	10	250	278
Correlation			-79%	-83%

4.2. Discussion

The analysis results of side frictions (FS) against the average speed of the vehicle (Vr) uses regression analysis to

the formulation MKJI 1997 states that any increase in FS by 1 frequency then Vr will decrease by 0.0369 Km/h, with the regression model  $y = 19.228 - 0.0369x$  at  $R^2 = 68\%$ , meaning 68% decrease in the average speed of vehicles affected by the side barriers and 32% are affected by other variables. The affected of Side Frictions (FS) against the average vehicle speed (Vr) is presented in Figure 5.

The analysis results of side friction (FS) against the average speed of the vehicle (Vr) uses regression analysis to the formulation PKJI 2014 states that every increase FS by 1 frequency then Vr will decrease by 0.0431 Km / h, with the regression model  $y = 19.472 - 0.0431x$  and  $R^2 = 63\%$ , meaning 63% decrease in the average speed of vehicles affected by the side barriers and 37% are affected by other variables. The affected of Side Friction (SF) of the average vehicle speed (Vr) is presented in Figure 6.

V. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusion

The average degree of saturation in Ahmad Yani Street Kupang City has reached 1.02, which means that traffic flows that pass this way has exceeded the capacity of the road. The highest degree of saturation of 1.27 is on Monday at 09:00-10:00 am, while the lowest degree of saturation of 0.74 is on the same day at 17:00-18:00 pm. The degree of saturation calculation using the formula MKJI 1997 is 3% higher compared to using formulations PKJI, 2014.

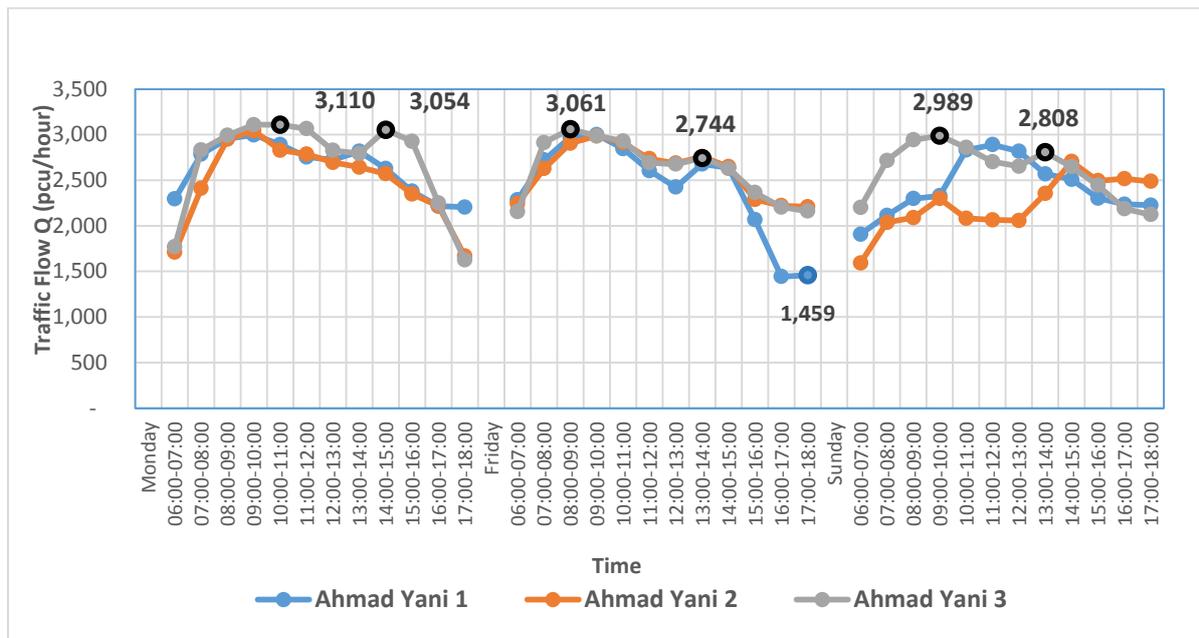


Figure 2. Traffic characteristics Ahmad Yani Street

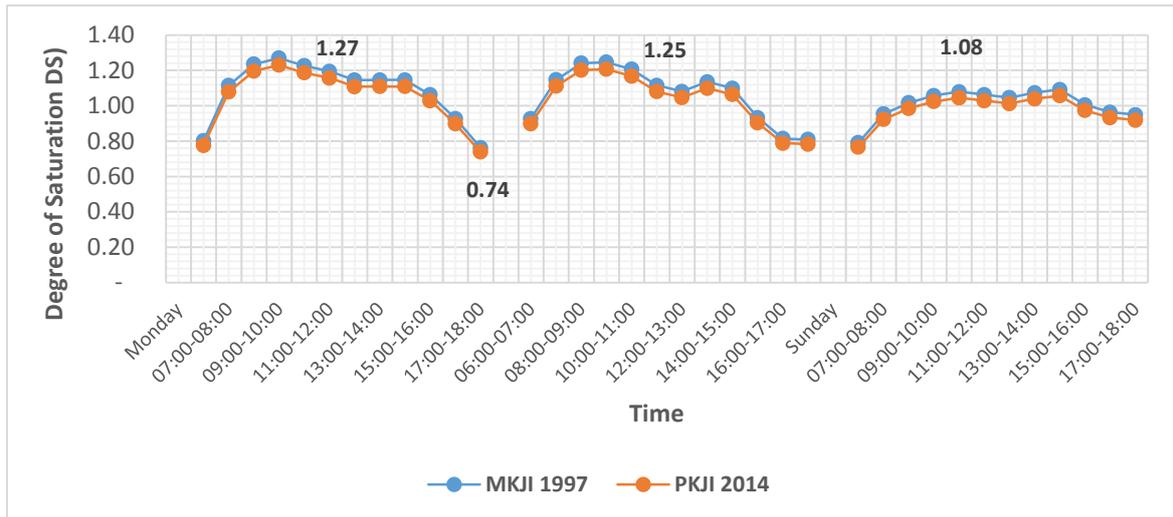


Figure 3. Characteristics of the degree of saturation Ahmad Yani Street

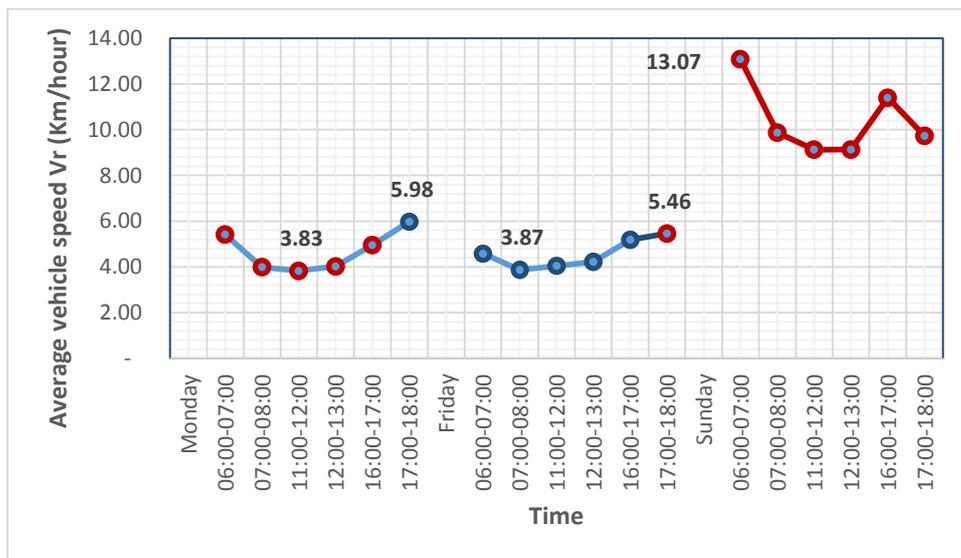


Figure 4. Characteristics of the average vehicle speed (Vr) Ahmad Yani Street

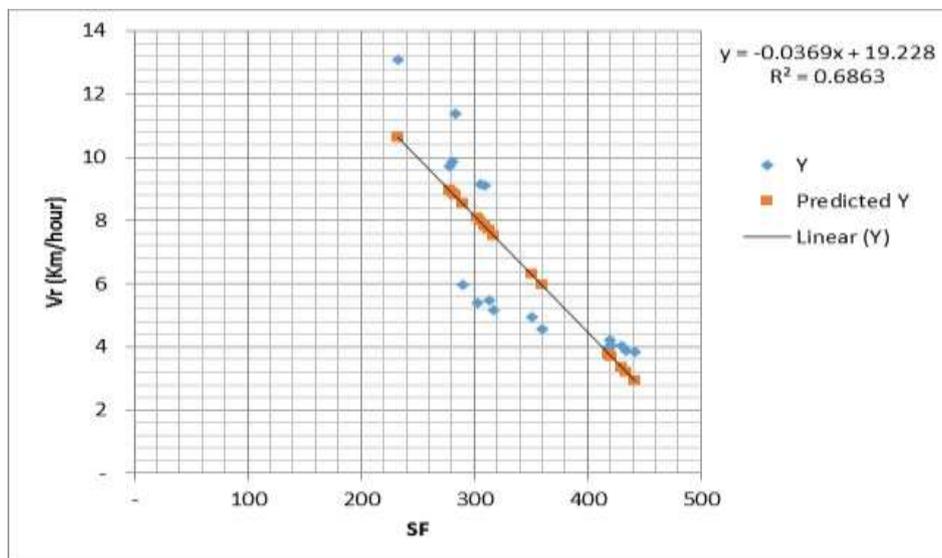


Figure 5. Effect of FS against Vr using MKJI 1997 formulation

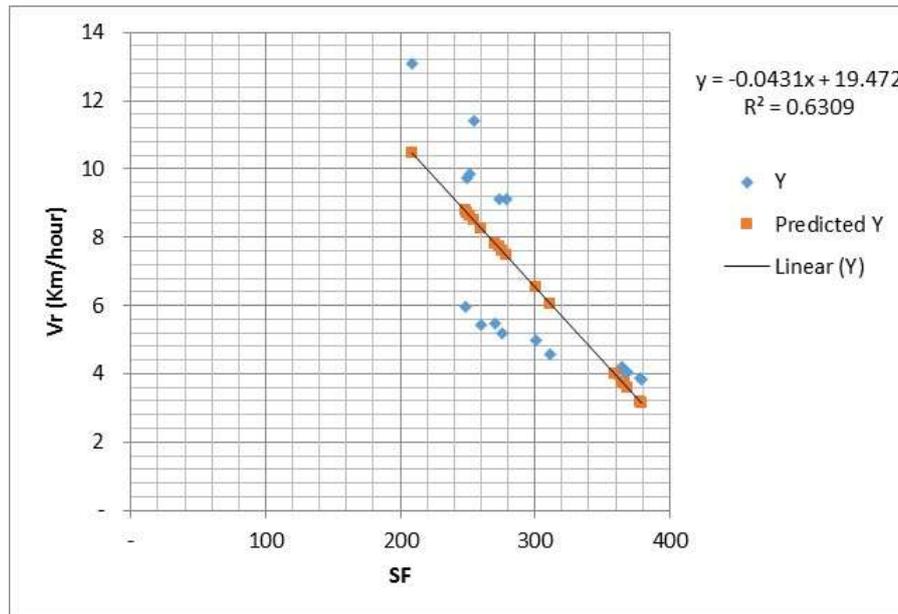


Figure 6. Effect of SF against Vr using PKJI 2014 formulation

Average Vehicle Speed highest is 13.07 Km/h, is on Sunday at 06: 00-07: 00 am, while the average speed of the lowest vehicle is on Mondays. 3.83 km/h is at 11:00-12:00 am.

Regression model the affected of side frictions (SF) against the average vehicle speed (Vr) with formulations MKJI 1997 is  $y = 19.228 - 0.0369x$  at  $R^2 = 68\%$  of the meaning, 68% decrease in the average vehicles speed affected by of side frictions and 32 % affected by other variables. Regression model the effect of Side Frictions (SF) against the average vehicle speed (Vr) using the PKJI 2014 formula is  $y = 19.472 - 0.0431x$  at  $R^2 = 63\%$ , the meaning of 63% decrease in the average speed of vehicles affected by the side friction and 37 % affected by other variables.

### 5.2. Recommendation

The performance review should be held at least one year all the way to get the data series so that the future can do dynamic modeling and performance of road transport system for projecting the model transport system in the city of Kupang for ahead.

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