

The effect of industrial vehicles on the road's level of service of industrial area in Malang City

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Abstract. Malang was a great city that has the characteristics of diverse industries and it was spread in each district. Industry was one of the activities that have the characteristics of the movement with the goal of shipping and distribution. The vehicles used are large vehicles such as trucks and trailers. Problems related to the road's performance that is the emergence of several points of delay and congestion due to the movement and the volume of vehicles as well as the limited capacity of existing roads. It encourages researchers to do research related to the effect of the industrial vehicle movements on the performance of existing roads in the city of Malang. The main purpose of the research is to analyze the effect of industrial vehicles movement on the road's level of service of industrial area and to find out alternative solutions to improve the road's level of service of industrial area. The research used multiple linear regression and do something analysis. The results showed that the types of industry in the city of Malang are ILMETTA, IATT, Agrokim, Sentra and Large Industries. Determining the location of the main observation based on the distribution of industry, have a major impact directly on the street, and the class of the national road are located in Sunandar Priyo Sudarmo Street. Existing land use in Sunandar Priyo Sudarmo Street are industrial, healthcare, office and it dominated by trade and services. Related to the variables that affect the movement of industrial vehicles are the number of employees (X3) and the delivery frequency (X6). The road's level of service of Sunandar Priyo Sudarmo Street are D and E. While the effect of industrial vehicles movement on the road's level of service which ranged from 13.77 per cent to 22.13 per cent of the total volume of vehicles on the road. Some referrals will be used to handle the problems that the road widening and the selection of alternative routes for the industrial vehicles.

1. Introduction

Good transport planning is the planning of transport in accordance with the conditions of the existing land use. Types of land use covering trade, services, industry, public facilities and other land uses. The linkage between land use and transportation is how much the generation and pull on the land use. The increase of the generation make the greater burden of the existing road around the land use [1]. According to the Spatial Plan in East Java (RTRW) in 2011 to 2031, the establishment of Malang as the Center of National Activities (PKN) encourage the development of economic activities in the services sector, trade and industry which became pattern of economic activity. It makes Malang City has a wide variety of industries that are part of the economic system, both engaged in small-scale (in the city) and large scale (inter-provinces). Industry sectors in Malang City control of 35.61 per cent of economic activity in the city of Malang, with the largest contributor to the local government in the amount of 5.14



Trillyun per year [2]. The existence of the industry can not be separated from the transport groove distribution of raw materials and finished goods because it requires a means of transport to be brought to their destination. The shipping of goods by four-wheeled vehicles accounted for 15 per cent to 25 per cent of the volume of vehicles that overload the street [3]. Of course, if it is not managed properly then it can cause traffic problems are quite severe, such as traffic jams. Transportation problems began in the 1960s and 1970s, some of the problems associated with transport is congestion, air and noise pollution, accidents and delays [4]. The source of the cause of problems that occur in transport comes from several things, one of which is the activity of the Industry. Industry in Malang quite a lot lead to some impacts associated with transportation. One of the effects caused by that activity of loading and unloading of goods or raw materials that occur can lead to delays up to congestion. In addition, the activity of industrial workers in the morning (it comes) and afternoon (return) that uses the vehicle caused delays on roads. Therefore, this study was conducted to identify the impact of the movement of large and medium industrial vehicles on the road's service of level of existing roads in Malang City, which is expected to be used as material for evaluation in the planning of industry in Malang City related to transportation and the completion of the problem.

2. Methods

The research location is in Malang with a focus on Sunandar Priyo Sudarmo Road, it was determined by:

- Class national roads.
- The amount of the distribution of large and medium industries most.
- Industry is located near the highway, and it has a direct impact on the way.

This study consists of several stages for the solution of problems in the study area. Firstly, identify and classify industries in Malang City. Secondly, determine the road with some consideration. Thirdly, calculate and analyze the trip generation / attraction model. Finally, analyze the road's level of service and calculate the effect of industrial movement on the road capacity. The first paragraph after a heading is not indented (Bodytext style).

2.1. The Road's Level of Service Analysis

The road's level of service in this study only calculated traffic volume and road capacity. Based on the Highway Capacity Manual Indonesia in 1997 [5], the road capacity is the amount of vehicle traffic maximum that can be accommodated on the roads during certain conditions (design of geometry, environment, and traffic composition) can be specified in the passenger car unit (pcu per hour). The degree of saturation is defined as the quotient of traffic flow on the road section to capacity of the point of saturation degree can be used as a measure to indicate whether a particular road segment will meet the capacity problem or not. The degree of saturation equation is as follows:

$$DS = \frac{V}{C} \quad (1)$$

Notes:

DS = Degree of Saturation

V = Volume of traffic flow (pcu / h)

C = capacity of the road (pcu / h)

Calculation of the performance conducted in Sunandar Priyo Sudarmo Road which is the location chosen by the consideration that has been done.

2.2. Multiple Linear Regression Analysis

Linear regression analysis is a statistical method used to find linkage of more than one independent variable [6]. The first step in this regression analysis phase is the selection of variables that serve as the independent variable or dependent variable. Here is the independent variable of industry are used:

$Y1$ = Number of Movements

$X1$ = Building

$X2$ = Area Parking

$X3$ = Number of Employees

$X4$ = Number of Visitors

$X3$ = Number of Shift

$X4$ = Frequency Delivery

$$Y = a + b_1x_1 + b_2x_2 + \dots + b_nx_n \quad (2)$$

Notes:

Y : The dependent variable in this study is the amount of movement

A : Constanta parameters which means that if all independent variables ($X1$ through $X4$) remained unchanged or equal to zero, then $Y1$ would be equal to a constant

b_n : Coefficient parameters are: the value of which will be used to determine the effect of variables on the amount of movement

X_n : Independent variables such as all factors are included in the model and that may affect the amount of movement.

3. Results

3.1. Characteristics of Industries in Malang City

Malang has the characteristics of the industry, namely the classification types Agrokim, Metal, Machine Textiles, and Miscellaneous (ILMETTA), Transport Equipment and Telematics (IATT), Sentra and Large Industries. A description of the classification can be seen as follows:

1. ILMETA

Divided into three classifications, namely basic materials industry of metal, Manufacture of material machinery and agricultural machinery, Textile and Miscellaneous.

2. Transport Equipment and Telematics (IATT).

The division of the classification of industries Transportation Equipment and Telematics (IATT) is a combination of several types of industries such as industrial land transportation and Electronics and Telematics.

3. Agrochemicals industry

Agrochemical industry is an industries classification types engaged in food processing, beverages, forest products, up to cigarettes and tobacco.

4. Industrial centers

Industrial centers is a collection of several small industries or households are clustered in a region with the same characteristics. Industrial centers are generally engaged in the production of small and medium scale.

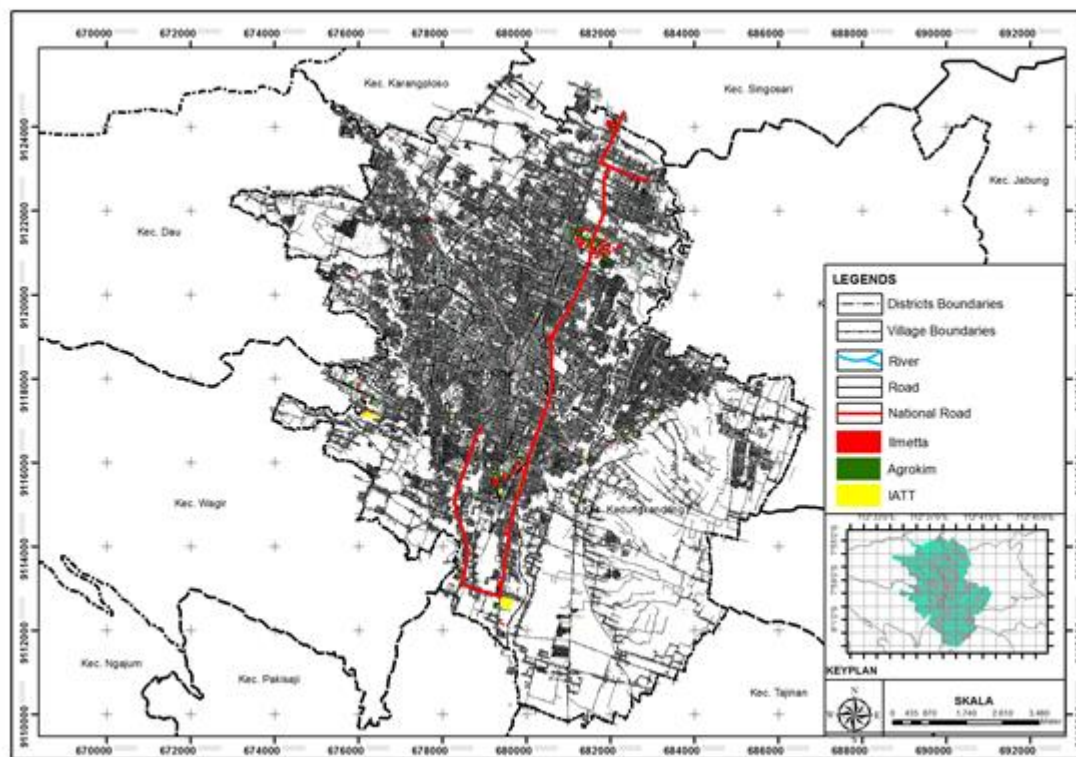
5. Large industry

An industry which has a production performance in a large scale are some examples such as the tobacco and timber.

Small industries in Malang has the largest percentage and spread throughout the district. Total industry in the city of Malang is 617 industrial units. The distribution of industries in Malang (Table 1) separated by district and type of industry. Agrochemical industry is a kind of industry that have a degree of dispersion highly. The highest is located in Klojen with 117 units, while for large industries is only located in Blimbing District and Sukun District (Figure 1).

Table 1. The Distribution of Industries in Malang City

No	Classification	Sukun	Klojen	Lowokwaru	Kedung Kandang	Blimbing
1	ILMETA	30	35	12	12	33
2	IATT	12	10	6	9	11
3	Agrochemicals industry	110	117	53	53	92
4	Industrial Center	2	2	7	2	6
5	Large Industry	2	-	-	-	3

**Figure 1.** The distribution of industries in Malang City.

Distribution of industries in Blimbing District is still relatively evenly for each district is the largest in Bandungrejosari with the type of small industry. As for Kedungkandang District dispersion more centered in Kotalama Village with Agrokim number is 16 units of the industry.

3.2. Characteristics of Industries in Selected Location

Results of identification which have to be got Blimbing District locations that have the largest industrial distribution and in accordance with predetermined criteria (Table 2). Roads are selected in accordance with the consideration that the focus of observation is Sunandar Priyo Sudarmo Road. The function of land use around Sunandar Priyo Sudarmo Road dominated by commercial area which this road is a potential for such activities (Figure 2).

Table 2. Characteristics of Industries in Selected Location

Location	Type of Industry	Name	Size
Blimbing District	Agrochemicals industry	HM. Sampoerna, Tbk	Large
	Agrochemicals industry	Bronson Prima Industri	Large
	Agrochemicals industry	Nanas	Large
	Agrochemicals industry	Merry May	Medium
	Agrochemicals industry	Naga Laut	Medium
	Agrochemicals industry	Lestari Biscuit Factory	Medium

Location	Type of Industry	Name	Size
	Agrochemicals industry	credo	Large
	ILMETA	panglima alumunium	Medium
	ILMETA	benang merah	Medium
	ILMETA	Mandiri Garmen	Medium
	Agrochemicals industry	CARAGENAN	Medium
	Agrochemicals industry	Heksa Manunggal Jaya	Medium
	Agrochemicals industry	Kharisma Matahari Katulistiwa,PT	Medium
	Agrochemicals industry	PT karya Niaga Bersama	Large
	ILMETA	Palatino	Medium
	Agrochemicals industry	Hollywood system	Medium
	Agrochemicals industry	Gracia	Medium
	ILMETA	Lancar Jaya	Medium

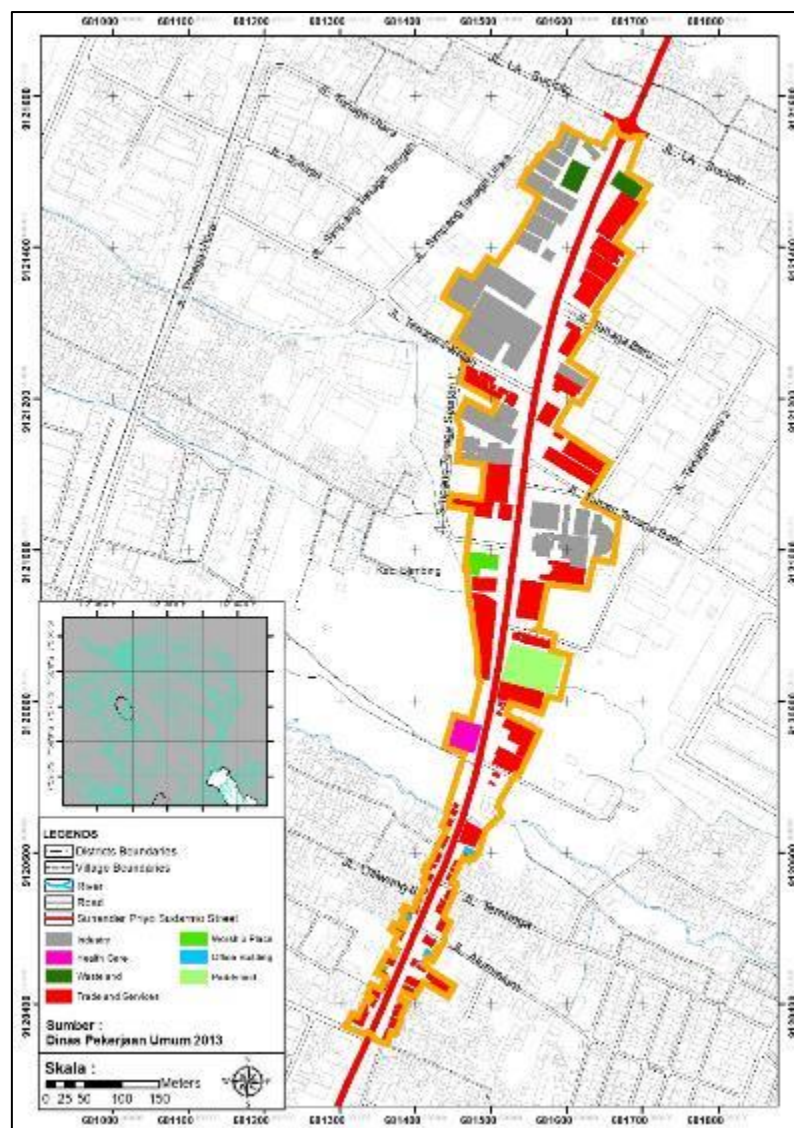


Figure 2. Characteristics of land use in Sunandar Priyo Sudarmo Road.

3.3. Trip Attraction Movement Model

Based on movement analysis, it obtained the classification of land use is industrial, healthcare, offices, and commercials. Thus, in the calculation of the regression analysis included variables that affect the land use. So that the results of the regression analysis found that:

1. Trip Attraction Model of Industry

$$Y_{\text{industri}} = 5.104 + 0.736 (X_3) + 1.832 (X_6) \quad (2)$$

Information:

Y_{industri} = dependent variable, the amount of movement

X_3 = independent variable, the number of employees

X_6 = independent variable, frequency of delivery

The amount of R square for the regression model were performed in the amount of 0.941, which means 94.1 per cent of the influence of the independent variables on the dependent variable

2. Trip Attraction Model of Healthcare and Commercial

$$Y_{\text{Health}} = 12.545 + 0.277 (X_{10}) + 0.364 (X_{11}) \quad (4)$$

$$Y_{\text{Office}} = 38.076 + 0.19 (X_{12}) + 0.301 (X_{15}) \quad (5)$$

$$Y_{\text{store}} = 4.766 + 0.445 (X_{16}) + 0.049 (X_{19}) \quad (6)$$

$$Y_{\text{Building and furniture store}} = 37.958 + 0.463 (X_{20}) + 0.14 (X_{23}) \quad (7)$$

$$Y_{\text{Joinery}} = 2.074 + 0.252 (X_{24}) + 0.702 (X_{27}) \quad (8)$$

$$Y_{\text{Restaurants and cafes}} = 1.811 + 1.84 (x_{31}) + 0.443 (X_{32}) \quad (9)$$

$$Y_{\text{Electronics \& electrical stores}} = 4.359 + 0.206 (x_{33}) + 0.459 (x_{36}) \quad (10)$$

$$Y_{\text{Dealership / showroom}} = 13.189 + 0.23 (X_{38}) + 0.392 (x_{42}) \quad (11)$$

$$Y_{\text{Other}} = 7.678 + 0.662 (X_{46}) \quad (12)$$

Tabel 3. Total of Movement based on Land Use according to Operational Time

Operational	Total of Industry Movement	Total of Healthcare Movement	Total of Office Movement	Total of Commercial Movement
08.00-09.00	316.68	2.80	19.32	482.36
09.00-10.00	180.96	6.40	33.12	533.38
10.00-11.00	180.96	5.20	27.60	600.61
11.00-12.00	158.34	2.80	30.36	758.91
12.00-13.00	180.96	4.40	41.40	664.95
13.00-14.00	180.96	4.00	38.64	744.5
14.00-15.00	203.58	1.60	30.36	625.01
15.00-16.00	203.58	4.80	24.84	494.87
16.00-17.00	316.68	4.40	19.32	421.79
17.00-18.00	339.30	3.60	11.04	222.56
TOTAL	2,262.00	40.00	276.00	5,548.94



Figure 3. Sunandar Priyo Sudarmo Road.

3.4. Implementation of Trip Attraction Model in Sunandar Priyo Sudarmo Road

The application of the trip attraction model based on land use aimed to find out how much of the movement of incoming and outgoing vehicles for the land. So with these calculations could be more significant of the magnitude of the movement is in each land use related contributions from existing volumes on the road (Table 3). Calculations performed for industry, healthcare, office buildings and commercials.

$$Y_{\text{industri}} = 5.104 + 0.736 (X3) + 1.832 (X6) \quad (13)$$

$$Y_{\text{industri}} = 5.104 + 0.736 (90) + 1.832 (56) \quad (14)$$

$$Y_{\text{industri}} = 173.936 \approx 174 \text{ pcu/h} \quad (15)$$

3.5. The Road's Level of Service in Sunandar Priyo Sudarmo Road

Class of Sunandar Priyo Sudarmo Road is 1st class hierarchy collector-1 and it has a length of 2.05 kilometers. The road status is a national road and other treatments which are carried out by national (Figure 3 and Table 4). Priyo Sunandar Sudarmo Road has 10 alleys where 5 are the alley that connects them to the land of industry, so that the calculation of the road's level of service of traffic should consider to constant volume, the amount of alleys, and the movement of the industry (Figure 4).

$$V_{\text{sunandar}} = V_{\text{continuous}} + V_{\text{tenaga baru}} + V_{\text{tenaga Selatan}} + V_{\text{taman Tenaga Baru}} + V_{\text{Simpang Tenaga Selatan}} + V_{\text{S.P.Sudarmo A}} \quad (16)$$

$$+ V_{\text{gg. Settlement A}} + V_{\text{gg Settlement B}} + V_{\text{Ciliwung II}} + V_{\text{Tembaga}} + V_{\text{Aluminium}} \quad (17)$$

$$V_{\text{sunandar}} = 1337.8 + 108.45 + 90.1 + 107.15 + 24.40 + 10.80 + 3.75 - 0.75 - 2.50 + 0.5 - 9.00 \quad (18)$$

$$V_{\text{sunandar}} = 1670.7 \text{ pcu/hour} \quad (19)$$

So that the total volume of vehicles at 9:00 to 10:00 o'clock in the amount of 1670.7 pcu/hour. Based on the calculation of volume, capacity and the road's level of service, the road's level of service affected by the amount of movement of land use and alleys. The road's level of service at operational hours of land at 8:00am to 18:00pm on the road's level of service is D and E (Table 4).

Table 4. Characteristic of Sunandar Priyo Sudarmo Road

Road Characteristics	Sunandar Priyo Sudarmo
Type	2/2 UD
Current direction	North-South South-North
Lanes	4
Direction system	2 ways
Effective width (m)	10.5
Material	Asphalt
Bandwidth (m)	5.25
Sidewalk (m)	-

Road Characteristics	Sunandar Priyo Sudarmo
Kerb	-
Roadside	1 m and 1 m
Median (m)	-
Parking	available
Land use	commercials
City size	0,5-1 million population

3.6. The Influence of Industry Movement to Road's Level of Service in Sunandar Priyo Sudarmo Road

The movement of the vehicle industry to the overall volume of vehicles in Sunandar Priyo Sudarmo Road ranged at 13 per cent to 22 per cent. Which at certain hours has a different contribution. The contribution of the vehicles by the industry that occur at 14.00 pm to 15.00 pm in which the vehicle industry has a number of moves by 22.13 per cent. This is because it is during these hours many industrial vehicles coming out of an industrial site. In addition, during the early morning at 09.00 am to 10.00 am contribution vehicle that is equal to 21.52 per cent (Table 5).

Table 5. The Road's Level of Service in Sunandar Priyo Sudarmo

Time	$V_{\text{continuous}}$	V_{industry}	$V_{\text{non-industry}}$	$\sum V_{\text{industry}}^{\text{gg}}$	$\sum V_{\text{Settlement}}^{\text{gg}}$	V_{TOTAL}	C	DS	LOS
08.00-09.00	1623.80	316.68	504.48	263.20	8.75	2,716.91	3235.22	0.85	E
09.00-10.00	1337.80	180.96	572.90	340.90	8.00	2,424.56	3235.22	0.75	D
10.00-11.00	1158.35	180.96	633.41	259.00	10.25	2,241.97	3235.22	0.76	D
11.00-12.00	1595.80	158.34	792.07	226.95	25.50	2,798.66	3235.22	0.87	E
12.00-13.00	1451.45	180.96	710.75	323.10	1.00	2,665.26	3235.22	0.82	E
13.00-14.00	1842.95	180.96	787.14	278.35	5.00	3,094.40	3235.22	0.96	E
14.00-15.00	1346.15	203.58	656.97	356.75	7.00	2,581.25	3235.22	0.80	D
15.00-16.00	1511.05	203.58	524.51	238.95	2.25	2,475.84	3235.22	0.77	D
16.00-17.00	1772.55	316.68	445.51	234.75	6.75	2,774.74	3235.22	0.86	E
17.00-18.00	1911.50	339.30	237.20	169.00	26.00	2,683.00	3235.22	0.85	E

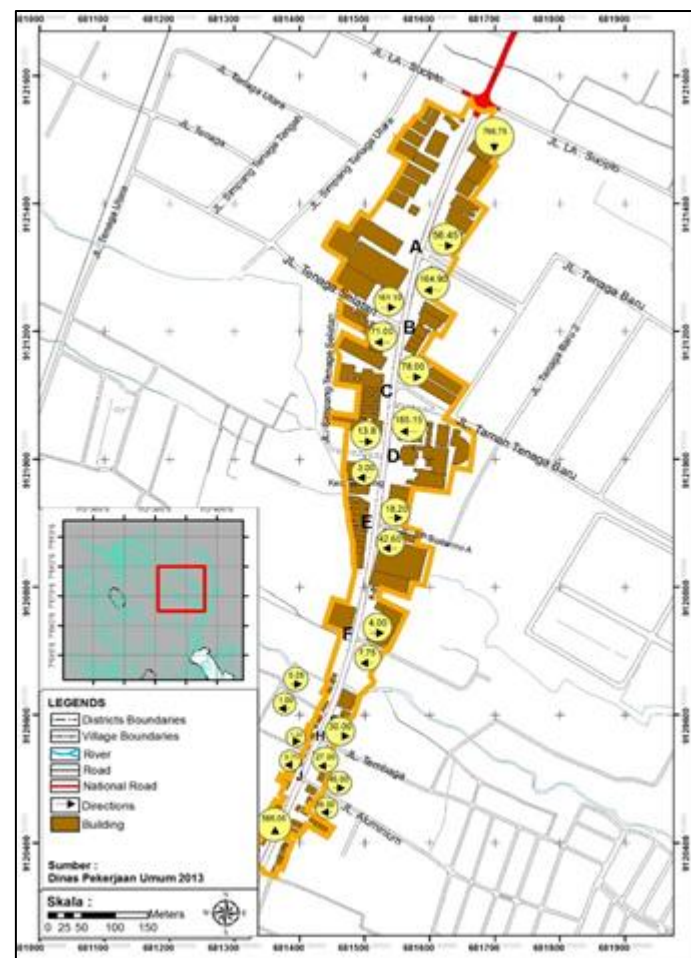


Figure 4. Volume of alley in Sunandar Priyo Sudarmo Road.

Table 6. Influence of Vehicles Movement of Industry to The Road's Level of Service of Sunandar Priyo Sudarmo

Time	V_{industry}	$\sum V_{\text{gg industry}}$	V_{Total}	Contribution (%)
08.00-09.00	316.68	263.20	2,716.91	21.34
09.00-10.00	180.96	340.90	2,424.56	21.52
10.00-11.00	180.96	259.00	2,241.97	19.62
11.00-12.00	158.34	226.95	2,798.66	13.77
12.00-13.00	180.96	323.10	2,665.26	18.91
13.00-14.00	180.96	278.35	3,094.40	14.84
14.00-15.00	203.58	356.75	2,581.25	22.13
15.00-16.00	203.58	238.95	2,475.84	17.87
16.00-17.00	316.68	234.75	2,774.74	20.31
17.00-18.00	339.30	169.00	2,683.00	18.95

4. Conclusion

The road's level of service in Sunandar Priyo Sudarmo is C, D and E. The road's level of service has a difference every time, and the effect of the volume of industrial vehicles in Sunandar Priyo Sudarmo amounting to 4.57 per cent to 21.51 per cent. Which is where the highest peak is the greatest contribution

at 14.00 pm to 15.00 pm. The influence of the volume of industrial vehicle to vehicle volume is 13.77 per cent with total lowest at 11.00 am to 2.00 pm and the highest at 14:00 to 15:00 of 22.13 per cent.

5. Acknowledgement

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