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Calculation of Trip Generation of Industrial Activities Around Legok Street in Tangerang District

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Currently the industrial activities are the main sector in supporting the Indonesian economy. The trend of development of industrial estates is very high in Indonesia, and has been responded to positively by respective local governments who have provided locations for the industrial estates. However, there are still many industrial estates that have locations mixed with other activities, even those located on the main road. As a consequence, not only does it impact the surrounding economy and environment, but it also impacts the surrounding traffic. Considering industrial activities are trip generators, they cause traffic jams, delays, air pollution and noise. To date there has not been any reference for trip generation or the overall land usage for various types of activities, including trip generation of industrial activities in which their locations are mixed with other activities such as industrial activities located on Legok Street. Based on the results of traffic counting analysis in the busy hours, the level of service (LOS) of Legok Street is in the D classification (bad) with the value of 0.89 marked by unstable traffic. One of the causes of the bad level of service is the very high number of vehicles of the industrial activities e.g. 239 pcu/hour. That number is far above Industrial Ministry predictions as written in the Minister of Industry Regulation No. 40, 2016 regarding Technical Guidance for Industrial Estate Development. Therefore, supporting road services is required. Although the research survey was during peak hours, the results can be used as consideration in spatial planning. Results of this research in general may be used as reference in planning an industrial estate in other locations with similar characteristics, and may also be used to solve the transportation problems in the Legok main road.

Keywords: *Calculation, Trip Generation, Traffic Counting, Land Use, Industrial Activities.*

Introduction

Currently industrial activities are the primary sector supporting the Indonesian economy. This has been the case since 1980, when agricultural activities shifted from being the main economic activities (Efendi, T, 2006). Development of industrial estates was considered to be able to distribute welfare more evenly to the whole of Indonesia (Kemenperin, 2016). Data from the Central Statistic Bureau noted that in 2017 economic activities in Indonesia grew by 5.07% with a Gross Domestic Product (GDP) value of RP 13,588.8 trillion. From this number, the processing industry contributed RP 2,739.4 trillion, or around 20.16% of GDP value. In spite of the decline, in 2019 the processing industry managed to contribute 19.70% of GDP. The principle business of the processing industry in Indonesia is manufacturing. This sector is the main supporting sector of current national economic growth (Kemenperin, 2018). Besides food and drink, there are seven primary manufacturing sectors which are base metal, transportation means, engine and equipment, chemical, pharmaceutical and electronic.

Many industrialised countries in the world have a high Gross Domestic Product (GDP), such as China, USA, India, Japan, Germany, Russia and Indonesia (IMF 2019 in CNBC Indonesia, 2019). To elevate GDP, every country is keen to develop their industry. Indonesia, having abundant natural resources, is very eager to develop its industry. Indonesia, which previously was an agricultural country, has shifted to being an industrial country. Compared to industry, agriculture contributes less to GDP. In 2017 agriculture contributed 13.16% to the GDP and this was down to 12.72% in 2019.

So far natural resources in Indonesia tend to be exported as raw materials, thus do not give any added value to Indonesia nor to the local government where the natural resources are located. Currently the investor interest to develop local industrial estates is significantly high. This trend is greeted by the local governments by providing locations for the industrial estates. However, there are still many industrial estates that have locations mixed with other activities, even located on the main road. As a consequence, not only does it impact the surrounding economy and environment, but it also impacts to the surrounding traffic. Considering industrial activities are trip generators, they cause traffic jams, delays, air pollution and noise (Patel, 2017). Therefore, in industrial estate development, analysis of trip generation is required.

Trip generation depends on two aspects, e.g. type of land use, and the number and intensity of activities on the concerned land (Tamin, 2000). Trip generation caused by land use activities and the number of movements is affected by the land use intensity (Iriawan, 2015). Further, Escamilla et al., (2016) stated that trip generation has a strong relationship with type of land use.

There are various types of land use that generate trips. Industrial activity is one of the activities that generates a high amount of trips. The industrial sector can provide more added value to the business and investment opportunities, therefore its activities can generate movement and affect traffic volume. (Feby, 2014). In Indonesia, industrial activities are divided into six groups of activities e.g agro industry; chemical, textile and various industries; metal, machinery, transportation and electronics industries; small and medium industries; industrial estate; intellectual property industry, living environment and standardisation (Permenparin, 2017). To date there has not been any reference in regard to trip generation of various types of activities and land use, including trip generation of industrial activity. This condition is caused by the many types of industry and levels of intensities, not to mention that trip generation calculation of industrial activities is greatly required as it can help to predict the number of vehicles generated by industrial activities (Patel, 2017).

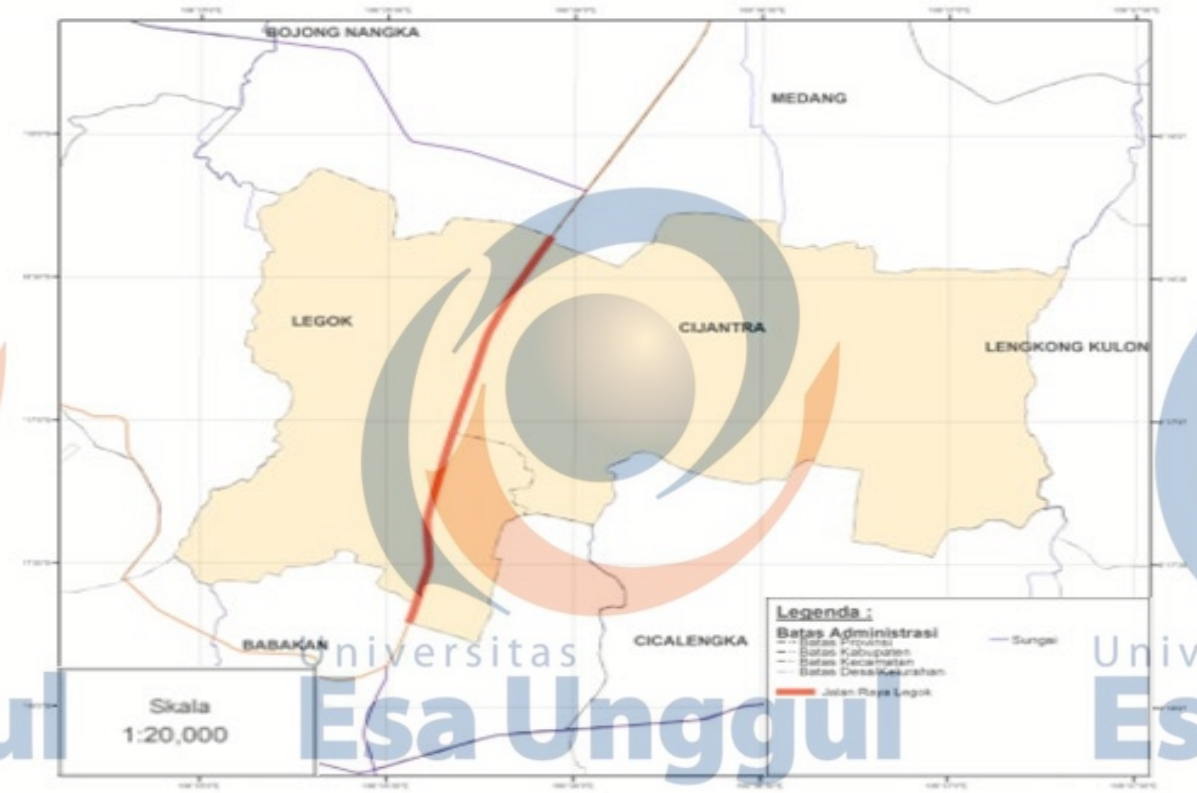
Results of spatial planning, among others, are descriptions of land use Should reference of trip generation for every type of land use be available, especially for existing industrial activity, trip generation of every industrial activity land use plan may be predicted. Volume of vehicles that would take place may be predicted in such that transportation problems that may arise may be anticipated in the early stages. There are industrial estates that are purely for industrial activities, nevertheless there are also industrial activities mixed with other activities (such as trading, education and etc). Trip generation arising from those two conditions will have different impacts on the surrounding traffic conditions.

Tangerang Regency is one of the regencies located in the Banten Province. It is undergoing development of industrial activities in accordance with development of industrial areas in the city of Tangerang. Among others, the considerably dominant developing area is located surrounding Legok Street situated in between two villages and two districts e.g. Legok Village in Legok District and Cijantra Village in Pagedangan District (see Picture 1). Legok Street has two lanes in the section of ± 3km long, with a width of 7m, and roadsides in the right and left of 0.5m each. It is the road connecting Tangerang City and Bogor Regency. There are 16 (sixteen) industrial activities in the form of industrial estates, factories and warehousing with an average space of 2 Ha. They comprise packaging industry, foam factories, concrete prefabrication and paint factories. Those industrial activities located in the area are mixed with residential, trading and educational areas. Every industrial activity generates trips by labour vehicles as well as material transportation by heavy equipment. The resulting vehicles added with other vehicles of other activities in the area, plus through traffic, cause traffic jams on Legok Street.

In accordance with the Local Regulation of Tangerang Regency No. 13, 2011 regarding Spatial Planning of Tangerang Regency 2011 – 2031, the industrial area in Legok and Pagedangan is one of the areas to be developed as a medium industrial area. For preparing the concerned

industrial area, calculation of trip generation of the industrial activity of the surrounding Legok Street is greatly required. The purpose of this study is to calculate trip generation of industrial activity, the location of which is mixed with other activities in the surroundings of the Main Road of Legok. The results of which may be used to solve transportation problems of the Main Road of Legok and may also be used as a reference in planning any industrial estate in other location with similar characteristics.

Picture 1. Map of Studied Location



Source: Results of Analysis, 2019

Literature Review

Trip Generation

Trip generation is a modelling stage which predicts the total movements originating from one zone or one land use, or the total movement attracted to one zone or one land use (Tamin, 2000). Trip generation is the total number of trips that take place at a time in one zone of land use (Hobbs, 1995). The traffic problems such as traffic jams and delays are caused by trip generations that take place at the same time, resulting in a high traffic load (Fitira, 2015). To tackle these problems, analysis of the resulting trip generation and trip attraction is required (Hasriani, 2015).

Road performance

According to Manual Kapasitas Jalan Indonesia or MKJI (Highway Capacity Manual Indonesia) 1997, it is stated that calculation for a city road performance indicator covers traffic volume, capacity and level of service. In MKJI 1997, Direktorat Jenderal Bina Marga Direktorat Bina Jalan Kota, stated that traffic volume is the number of vehicles passing a certain point at a section of road in a certain unit. Two-way traffic volume at the busiest time in a day is used as the basis of analysis of performance of the concerned section of road and concerned crossing. Traffic volume (Q) is stated in the equation:

Q = (MC x emp MC) + (LV x emp LV) + (HV x emp HV)

Urban road capacity is obtained by the equation **(Tamin, 2008)**:

$$C = C_O \times FC_W \times FC_{SP} \times FC_{SF} \times FC_{CS}$$

Where
C : Capacity (pcu/hour)
CO : Basic Capacity (pcu/hour)
FCW : Adjustment factor of traffic wide lane
FCSP : Adjustment factor of directional separator
FCSF : Adjustment factor of side barriers
FCCS : Adjustment factor of city size

Level of Service (LOS)

The Transportation Research Board in Khisty and Lall (2005), states that every facilities may be evaluated based on six levels of services from A to F, where A represents the best operational condition whereas F represents the worst. According to Louis J Pignataro (1973), characteristic evaluation of level of service is based on V/C ratio, where V is traffic volume (pcu/hour) and C is capacity (pcu/hour).

Table 2: Characteristic Evaluation of the great of service

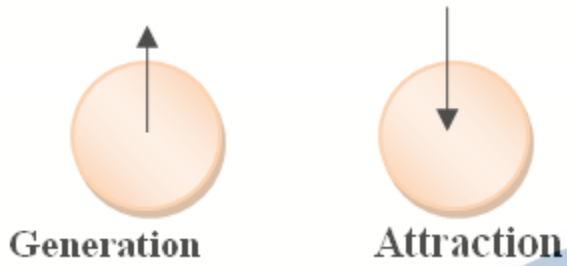
Service Level	Related Operating Characteristics
A	Free flow
B	Stable flow (for intercity road planning)
C	Stable flow (for city road planning)
D	Flow starting unstable
E	Unstable flow
F	Restricted flow

Source: MKJI, 1997

Trip Generation and Trip Attraction

Trip generation is a modelling stage which predicts the total number of movements originating from a zone or a land use and the total number of movements attracting to a zone or a land use. Traffic flow is a function of a land use which generates traffic flow (Tamin, 2008)

Picture 2. Generation and Attraction



Source: Tamin, 1997

Land use and transportation

In its modelling, transportation systems and land use contain two variables, independent variables and dependent variables which can be identified and measured (Black, 1981 in Miro, 2005). Independent variables may be in the form of a transportation system, i.e. travel time, transportation costs, services, convenience, security, reliability, availability, land use i.e industrial estate, housing estate, etc; social variables i.e. total population, employment opportunities, education etc.

Criteria of Road Network Serving Industrial Activities

Based on Industrial Minister Regulation No. 40, 2016 regarding Technical Guidance for Developing Industrial Estate, road networks for industrial activities have a vital function facilitating movement mobility and accessibility. A good road network design for industrial activity has to consider capacity and total number of vehicles that would pass the roads in such that it may anticipate in the early stages the risk of road breakage and traffic jams. This is crucial, as based on experience, impacts of industrial activities to local transportation are not easy to be anticipated.

Development of an industrial estate would have a big external impact on the surrounding area. Industrial estate development will generate trips significantly due to labour transportation as well as material freight. Industrial Minister Regulation No. 40, 2016 stated that an industrial estate of the size of 100 HA would generate total passenger trips and freight trips of 450 pcu/day + 100 pcu/day = 550 pcu/day. Therefore, trip generation of total passengers and freight

for 1 hectare would be 5.5 pcu/day/hectare. Even if trip generation of an industrial estate is not that large, available high quality road is needed because the vehicles that would pass the road are heavy vehicles.

Selection of Industrial Types

Prior to conducting the analysis, a sample of industry activities of the whole industry located on Legok Street is determined. Sample taking is done based on the type of existing industry; the results there are 4 (four) industry types that may represent industry activities in that area e.g. packaging industry, concrete pre-fabricating, foam factories and paint factories as seen in Table 3 below.

Table 3: List of Industry Sorrounding Legok Street

No	Company	Industrial Type
1	A	packaging design *
2	B	foam management *
3	C	Molding
4	D	Paint
5	E	Foam
6	F	Foam
7	G	Packaging
8	H	paint production *
9	I	concrete manufacturing *
10	J	Packaging
11	K	Packaging
12	L	Panel
13	M	Concrete prefab

Source: Survey result, 2019. *type of industry used as sample

Following, in Table 4 is use of variable, indicator and parameter

Table 4: Variable, Indicator and Parameter

Variable	Indicator	Parameter
Performance of the road	Volume	The number of vehicles through one observation point during the current time period
	Capacity	Maximum current traffic through a point on the road at a certain time
	Level of service	The ability of roads and / or intersections to accommodate traffic in certain circumstances
Land	Area	The area of sample industrial activity samples

Variable	Indicator	Parameter
Traffic	Generation	Number of vehicles originating by industrial activities
	Attraction	Number of vehicles to industrial activities location

Source: Analysis and literature study, 2019

Description of the Study Area

Legok Street is a main road as a secondary collector road under the authority of the Tangerang Regency Government which is used for various activities such as the movement of people and goods. Legok Street is an industrial estate within Tangerang Regency. Based on the observation, several spots of this main road are cracked and have holes and lose gravel on the road surface which may endanger the passing vehicles (see Picture 3). Besides, when raining the main road of Legok is flooded and the holes are significantly deep. The breakage of the road is caused by heavy vehicles passing on it. Generally, those vehicles carry industry materials and raw materials to the factories as well as products going out of the factories for distribution to the markets.

Picture 3. Condition of the Legok Street

Source: Survey Documentation, 2019

Land Use

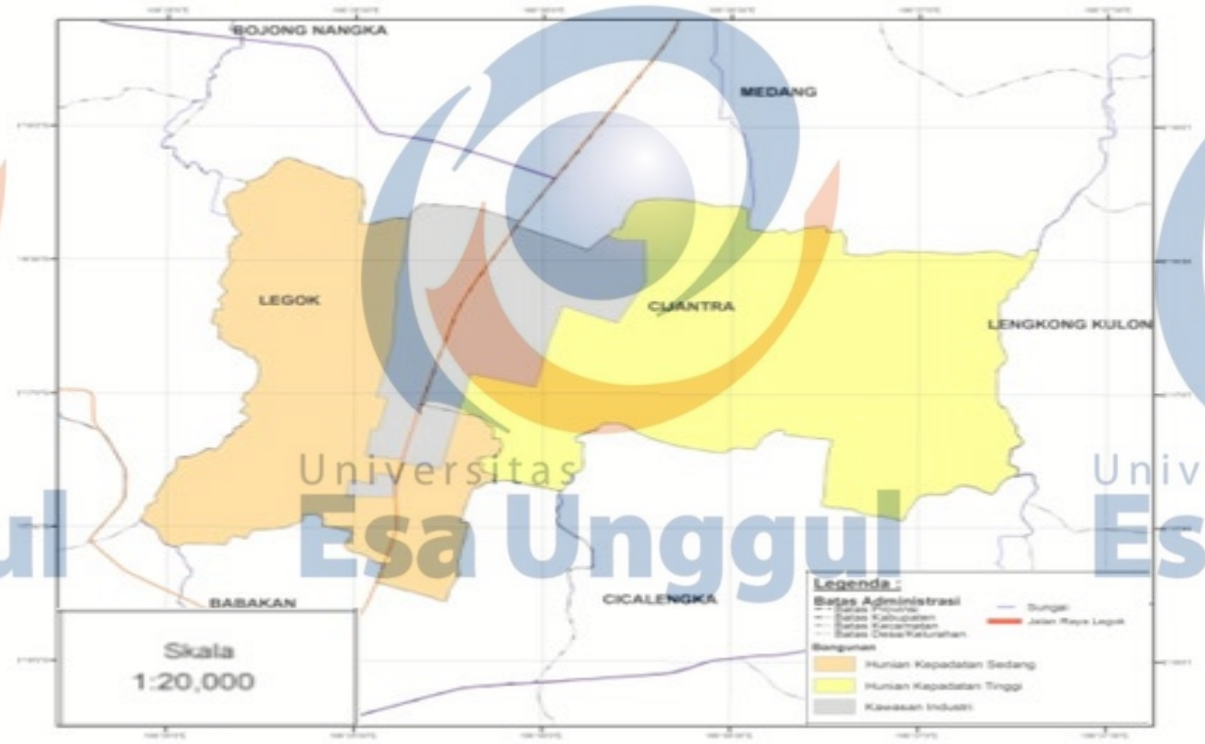
Surrounding Legok Street are 3 (three) types of land use: high density land use, residential with medium density, and industrial area (see Picture 4). Land use for commercial use is mixed with residential. Land use in the studied area is dominated by high density residential use e.g 51% (see Table 5)

Table 5: Size of Land Use

Land Use	Area (Ha)
High Density Residential	7,678.80
Medium Density Residential	7,085.55
Industrial Estate	316.13

Source: Profile of Legok and Cijantra Villages, 2018

Picture 4. Map of Land Use in the Studied Area



Source: Result of Analysis, 2019

Picture 5. Residential and Industry Land Use

Residential

Industry

Source: Survey Documentaion, 2019

Population

In 2018, the total population of the two villages, Legok and Cijantra was 26,292 (see Table 6) and 60% of the population was women. The average growth of the population was 3.62% per year for 4 years in a row from 2014 to 2018. This was partly due to the impact of people moving.

Table 6: Total population in the Studied Location

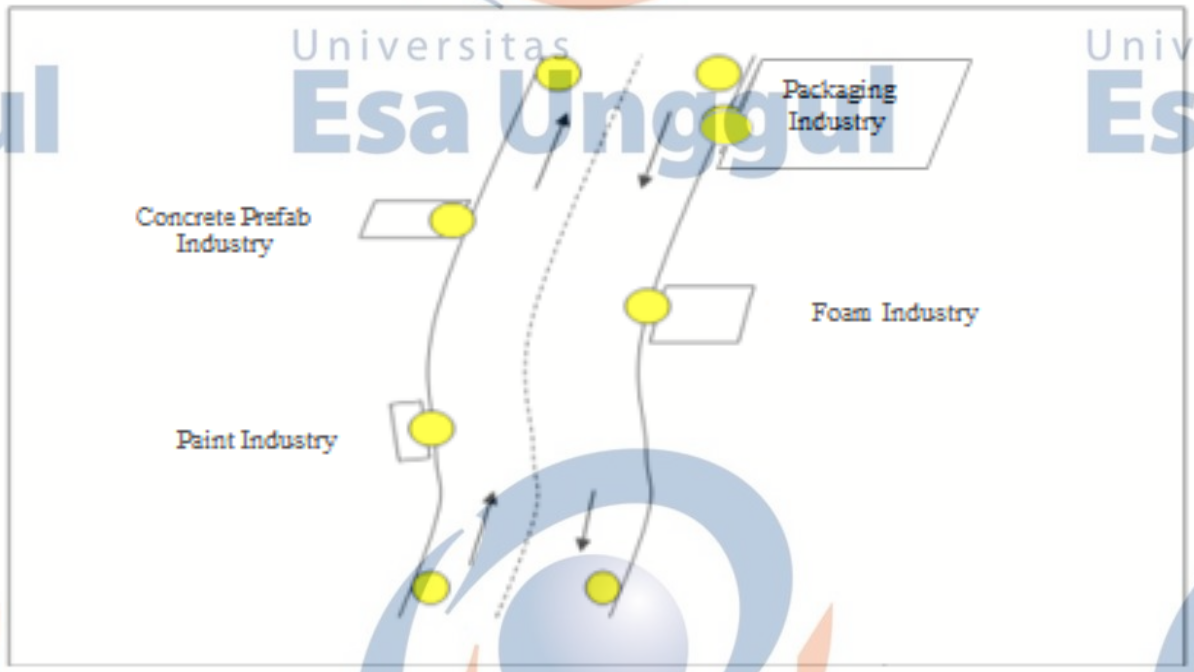
Year	Total Population
2014	22,802
2015	23,706
2016	24,565
2017	25,391
2018	26,292

Source: Legok District in Figure and Pagedangan District in Figure

Traffic Counting

Prior to conducting trip generation calculation and investigating its level of service, traffic counting was done to investigate types of vehicles passing Legok Street. A traffic survey is conducted by calculating the total number of vehicles during peak hours of 08.00am – 11.00am assuming that this time represents the problematic traffic conditions, Picture 6 illustrates the traffic counting positions; whereas results of the traffic survey of Legok Street are shown in Table 7.

Picture 7. Illustration of Locations of Traffic Counting



Source: Result of Analysis, 2019

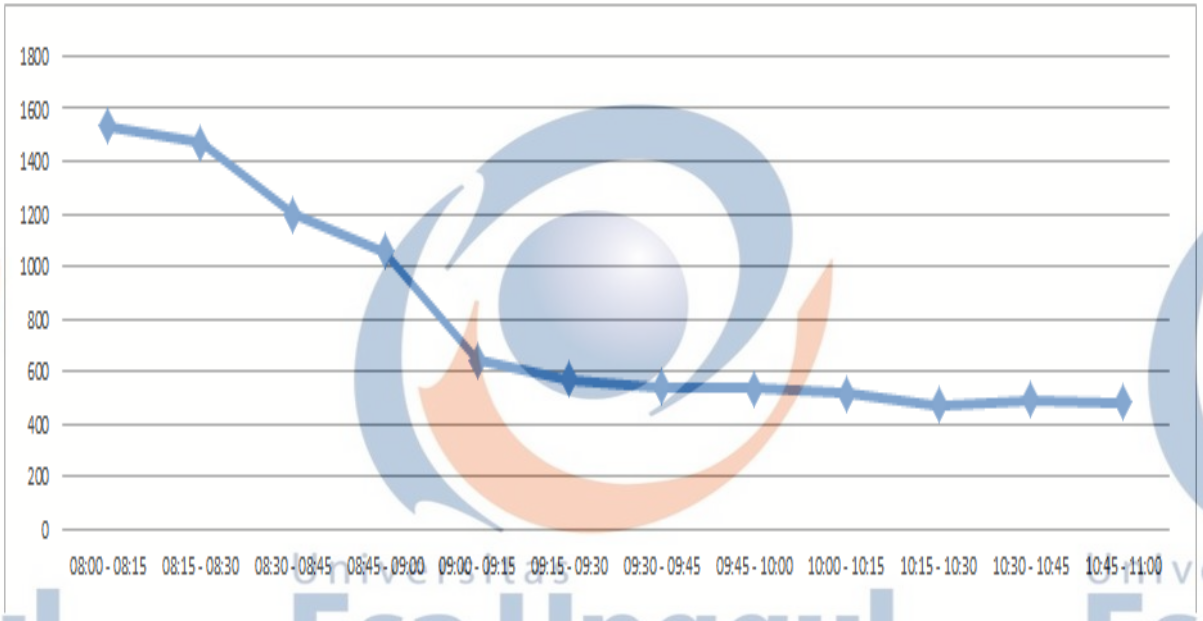
Table 7: Traffic Counting at Legok Street

Time	Karawaci – Legok			Legok – Karawaci		
	MC (Motorcycle)	LV (Light Vehicle)	HV (Heavy Vehicle)	MC (Motorcycle)	LV (Light Vehicle)	HV (Heavy Vehicle)
08:00 - 08:15	508	141	64	607	158	54
08:15 - 08:30	493	134	57	578	158	52
08:30 - 08:45	422	126	68	392	130	58
08:45 - 09:00	334	99	48	426	103	46
09:00 - 09:15	261	48	17	249	55	14
09:15 - 09:30	197	22	32	215	73	29
09:30 - 09:45	135	40	41	211	80	33
09:45 - 10:00	148	41	41	200	70	35

10:00 - 10:15	174	47	37	175	56	28
10:15 - 10:30	147	44	36	177	46	21
10:30 - 10:45	126	51	37	197	58	23
10:45 - 11:00	113	46	40	182	75	26

Source: Result of Survey, 2019

Picture 7. Chart of Traffic Counting in the Study Area at 8:00am to 11:00am



Performance Analysis of the Road

Peak hours in Legok Street at 08:00 – 09:00 in the morning are the time people start their activities. Traffic volume at peak hours in Legok Street is 4,270 pcu/hour.

Table 8: Traffic Volume at 8.00 – 9.00

Type of Vehicles	Volume (pcu/hour)
Motorcycle	1880
Car	955
Public Transport	94
Heavy Vehicles	1341
Total	4270

Source: Result of Analysis, 2019

The level of service of Legok Street at peak hour is calculated by 4270/4756, and the result is 0.89. This level of service is in category D which is an unstable traffic condition.

Calculating Trip Generation Industrial Activity in Legok Street

For calculation of trip generation of industrial activities mixed with other activities, traffic counting is done at the entrance gate of the respective factories for vehicles that enter and exit all the factory samples, which were a packaging factory, a foam factory, concrete fabrication and a paint factory. The results are shown in table 9 to 12.

Table 9: Results of TC in Packaging Industry

Time	Type of Vehicles					
	Motorcycle (MC)		Light Vehicle (LV)		Heavy Vehicle (HV)	
	Exit	Entry	Exit	Entry	Exit	Entry
08:00 - 08:15	48	67	5	2	9	6
08:15 - 08:30	35	32	3	4	14	9
08:30 - 08:45	27	10	4	5	15	13
08:45 - 09:00	13	10	6	3	16	8
09:00 - 09:15	6	9	2	0	10	11
09:15 - 09:30	5	3	1	1	6	6
09:30 - 09:45	7	5	3	0	11	11
09:45 - 10:00	5	3	1	4	10	9
10:00 - 10:15	2	1	2	0	7	5
10:15 - 10:30	5	0	1	3	5	3
10:30 - 10:45	4	0	7	1	10	5
10:45 - 11:00	9	1	0	0	5	4

Source: Result of Survey, 2019

Table 10: Results of TC at Foam Factory

Time	Type of Vehicles					
	Motorcycle (MC)		**Car (LV)**		**Heavy Vehicle (HV)**	
	Exit	Entry	Exit	Entry	Exit	Entry
08:00 - 08:15	35	38	7	10	3	1
08:15 - 08:30	27	29	4	6	4	2
08:30 - 08:45	12	14	2	1	7	5
08:45 - 09:00	8	13	1	1	6	8
09:00 - 09:15	2	3	4	1	8	2
09:15 - 09:30	4	3	4	0	4	5
09:30 - 09:45	0	1	1	0	4	3
09:45 - 10:00	3	1	2	1	3	2
10:00 - 10:15	4	5	5	3	7	2
10:15 - 10:30	3	3	3	2	2	5
10:30 - 10:45	2	1	6	2	7	1
10:45 - 11:00	5	3	4	1	4	6

Source: Result of Survey, 2019

Table 11: Results of Traffic Counting at Concrete Fabrication Industry

Time	Type of Vehicles					
	Motorcycle (MC)		**Car (LV)**		**Heavy Vehicle (HV)**	
	Exit	Entry	Exit	Entry	Exit	Entry
08:00 - 08:15	9	11	4	3	2	1
08:15 - 08:30	8	4	3	5	4	0
08:30 - 08:45	3	2	2	0	3	1
08:45 - 09:00	2	3	2	0	3	0
09:00 - 09:15	3	1	1	0	2	1
09:15 - 09:30	1	0	0	0	8	3
09:30 - 09:45	5	2	3	1	6	4
09:45 - 10:00	4	3	1	1	3	1
10:00 - 10:15	8	2	2	1	5	2
10:15 - 10:30	2	1	2	0	6	4
10:30 - 10:45	4	2	1	1	4	3
10:45 - 11:00	6	3	1	1	2	0

Source: Result of Survey, 2019

Table 12: Results of Traffic Counting at Paint Factory

Time	Type of Vehicles					
	Motorcycle (MC)		**Car (LV)**		**Heavy Vehicles (HV)**	
	Exit	Entry	Exit	Entry	Exit	Entry
08:00 - 08:15	22	24	5	7	1	2
08:15 - 08:30	11	17	6	9	4	2
08:30 - 08:45	6	12	2	4	3	1
08:45 - 09:00	8	6	1	2	5	2
09:00 - 09:15	3	2	2	1	4	3
09:15 - 09:30	9	5	4	3	6	5
09:30 - 09:45	2	3	4	2	5	2
09:45 - 10:00	1	4	3	1	5	7
10:00 - 10:15	7	2	5	2	9	2
10:15 - 10:30	6	4	7	3	5	1
10:30 - 10:45	3	1	2	3	4	2
10:45 - 11:00	7	3	6	5	5	2

Source: Result of Survey, 2019

Table 13: Total Number of Movement and Land Size at Industrial Activities at Shift Hours

No	**Industry**	**Total Movement (Pcu/hour)**		**Shift Hours**	**Land Size (Ha)**
1	**Packaging Industry**	**423**		08:00am – 09:00am	22.76
	Exit		241,5		
	Entry		181,5		
2	**Foam Industry**	**228**		08:00am – 09:00am	3.37
	Exit		115		
	Entry		113		
3	**Concrete Fabrication Industry**	**82**		08:00am – 09:00am	0.59
	Exit		57		
	Entry		25		
4	**Paint Industry**	**149**		08:00am – 09:00am	0.69

No	Industry	Total Movement (Pcu/hour)		Shift Hours	Land Size (Ha)
	Exit		76,5		
	Entry		72,5		
Total		**882**	**882**		**27.41**

Source: Result of Survey, 2019

Table 14: Total Number of Movement and Land Size at Industrial Activities at Operating Hours of Heavy Vehicles

No	Industry	Total Movement (Pcu/Hour)		Operating Time of Heavy Vehicles	Size of Land (Ha)
1	Packaging Industry	**335**		08:30 – 09:30	22.76
	Exit		184		
	Entry		151		
2	Foam Factory	**179**		08:30 – 09:30	3.37
	Exit		99		
	Entry		79,5		
3	Concrete Fabrication	**118**		08:30 – 09:30	0.59
	Exit		81		
	Entry		36,5		
4	Paint Factory	**165**		08:30 – 09:30	0.69
	Exit		100		
	Entry		65		
Total		**797**	**797**		**27.41**

Source: Result of Survey, 2019

Table 15: Total Number of Vehicle Movements per hectare at Labour Shifting Time

Type of Industry	Total Number of Movement on Shifting Time	Size of Land Use (Ha)	Total Movement (PCU /Ha)
Packaging Industry	423	22.76	18
Foam Factory	228	3.37	67
Concrete Fabrication	82	0.59	138
Paint Factory	149	0.69	215

Source: Result of Calculation 2019

Table 13 shows that trip generation resulting from labour vehicles of the paint factory have the biggest total number, e.g. 215 pcu/hour; whereas those of the packaging industry are the smallest, e.g. 15 pcu/hour

Table 16: Number of Total Movements per hectare at The Time Heavy Vehicle Operating

Type of Industry	Number of Total Movements When Heavy Vehicle Operating	Size of Land Use (Ha)	Total Number of Movements /Ha
Packaging Industry	335	22.76	15
Foam Factory	179	3.37	53
Concrete Fabrication	118	0.59	200
Paint Factory	165	0.69	239

Source: Result of Calculation 2019

Table 14 shows that trip generation of heavy vehicles of the paint factory is the biggest, e.g. 239 pcu/hour; whereas those of the packaging industry are the smallest, e.g. 15 pcu/hour.

It is noticeable that trip generation during labour shifting time, from 8.00am to 8.30am, is the highest in every type of industry. In relation to the results of the traffic counting above, where the highest traffic volume is from 8.00am to 8.30am, trip generation by the factories have a large impact onthe traffic.

Conclusion

- Having conducted direct observation in the study area and having processed and analysed the obtained data, it is found that performance of Legok Street is bad. This fact is proved by the calculated value of level of service of 0.89
- Trip generation of the sample industrial activities is very high, reaching a high value of 239 pcu/hour at the time of heavy vehicle operation.

- The high numbers of trip generation influence the level of service of the road section. As time goes by population increases, so does the level of activities, therefore it will influence the level of movements. Bad quality road may not support industry activities as well, therefore action needs to be taken to the concerned section of road in such that it may support industry activities optimally.

Suggestion

Based on the conclusions above, suggestions forwarded are as follows:

- Upgrading the road capacity on Legok Street;
- Reducing the volume of vehicles by providing labour buses;
- Improving traffic condition through a Transportation Management System;
- Considering relocation of any activity that generates high trips.

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