INDONESIAN JOURNAL OF MULTIDISCIPLINARY SCIENCE

P-ISSN: 2808-5957
E-ISSN: 2808-6724
ijoms.internationaljournallabs.com

THE TRAFFIC CHARACTERISTIC ANALYSIS OF JALAN CIATER RAYA SOUTH TANGERANG, INDONESIA

Achmad Oktobrianto[1], Andri Irfan Rifai[2*], Adinda Fajarika Akhir[3]

[1]Faculty of Engineering, Universitas Mercubuana Jakarta, Indonesia
[2]Faculty of Civil Engineering and Planning, Universitas Internasional Batam, Indonesia
[3]Graduate School, Universitas Mercu Buana Jakarta, Indonesia
**e-correspondence: andri.irfan@uib.ac.id*

ARTICLE INFO

Published: January 17th, 2023

Keywords: *Greenshield, greenberg, volume, traffic characteristics,*

This work is licensed under CC BY-SA 4.0

ABSTRACT

Jalan Ciater Raya Serpong, South Tangerang City, has criteria for a 4/2 D road with a width of 3.5 m per lane. During peak hours, this road experiences congestion with a length of more than 1.5 km. LHR Jalan Ciater Raya = 25296 pcu/day with peak peak peak hours at 07:00-08:00 am and 6:00 pm-8:00 pm. The research data were obtained from surveys and direct traffic observations. By analyzing road characteristics using the Greenshield and Greenberg models, the relationship between the volume, speed, and density of road traffic can be found, so optimal values of Vm, Qm, and Dj can be found.

INTRODUCTION

Highways in metropolitan cities and their surroundings have different traffic flow densities depending on the region. A severe problem in urban areas is the high population density which causes traffic conditions to become congested/saturated in critical areas of a city, which increases driving travel time. In addition, the need for mobility in a city will increase in line with a state's development. While policy responses typically prioritize reducing delays under normal conditions to improve the efficiency of urban road systems, analytics support for resilience-enhancing investments (defined as system recovery from additional disruptions) is still scarce (Martinez, et al., 2019); (Prakoso & Rifai, 2018); (Ganin, et al., 2017).

The behavior of users of transportation and road infrastructure, especially users of motor vehicles, dramatically affects the volume, speed, and density of the traffic on municipal highways. Research on the relationship of such parameters has been widely carried out, mainly in the regions of Europe and America, since traffic conditions are primarily homogeneous, which is close to the theory. Therefore, the assessment of the intensity and structure of the flow of motor vehicles will allow to carry out of more accurate forecasts for the control and prevention of extreme and hazardous technogenic vulnerability factors of the urban population around the highway (Nurinda, Priyanto, & Malkamah, 2019); (Kosovets, Lozhkin, & Lozhkina, 2021).

In developing countries such as Indonesia, the population tends to urbanize, so transportation users in urban areas increase rapidly. Transportation needs are derivative needs due to economic, social, and so on activities. Developing countries' growing economies positively affect people's ability to travel from one place to another. Significant and minor disturbances can have a considerable impact on the performance of the road network. The two should not be considered entirely separate since local interference affects network flow and network flow, affecting local conditions. Traffic conditions in Indonesia tend to be

heterogeneous, namely, various types of vehicles with driver behavior and roadside developments in Indonesia that differ from countries in Europe and America. Especially the driving pattern of two-wheeled vehicles is stochastic in the absence of lane discipline or turning motion discipline at intersections in traffic conditions, which affects the safety and overall characteristics of traffic flow. Arbitrary placement of traffic signs is becoming more common as a result of the acceleration of road construction and the increasing congestion of the road network (Yunita & Rifai, 2019); (Calvert & Snelder, 2018); (Nurinda, Priyanto, & Malkamah, 2019); (Singh, Barhmaiah, Kodavanji, & Santhakumar, 2020); (Han, Wang, & Chen, 2022).

A road can be in a congested/congested condition if the traffic flow makes the average vehicle speed lower than the optimal speed (Vm) or plan speed (Vr) of the road. In general, congestion occurs during peak hours. Traffic jams cause delays, inconvenience and economic losses to drivers, and air pollution. The Jalan Ciater Raya section is one of the connecting collector roads between the Serpong and Pamulang districts in South Tangerang City. Jalan Ciater Raya often experiences queues of vehicles for more than 1.5 km during peak hours, especially in the morning. As one of the cities directly adjacent to the Metropolitan city of Jakarta, South Tangerang is one of the choices to be used as a domicile city. The large number of property areas, such as BSD and Bintaro, has caused population growth in South Tangerang City to increase. The population increased by 0.05% annually in 2017-2019 (Afrin & Yodo, 2020); (BPS South Tangerang City, 2022).

Therefore, the author conducted a study on the Jalan Ciater Raya section, which often experiences traffic flow density from the Ciater Roundabout up to 1.5 km towards the Jakarta-Serpong toll entrance by analyzing the relationship between volume, speed, and traffic density by comparing the Greenshields Method and the Greenberg Method. The purpose of this study is to analyze and find out the best suitable model for the characteristics of Jalan Ciater Raya. Knowing the best model for roads with high traffic volumes, such as Jalan Ciater Raya, can be the basis for a suitable model for roads with the same traffic volume around Jakarta.

LITERATURE REVIEW

Traffic Flow

Traffic flow theory studies the movement of the driver and vehicle between two points with the interaction between them, making them form with each other. Flow is the hourly ratio of the number of vehicles crossing a point on a given lane over a while, measured in units of vehicles per specific unit of time. As a result, the study of traffic flow is an empirical study that relies heavily on the measurement of high-quality actual data (Talib & Taufiq, 2016); (Highway Capacity Manual, 2000); (Li, He, Z., Chen, & Zhou, 2020).

Although motorists in Indonesia have heterogeneous behavior in their traffic conditions, roughly speaking, the tendency of motorist behavior still has some reasonable consistency and can be studied mathematically. To better understand traffic flow, a relationship has been made between the three main characteristics of traffic: volume, density, and speed. This relationship helps road facilities' planning, design, and operation by comparing them with ideal modeling.

Main Variables of Traffic Characteristics

Speed (V) is the parameter of the movement of an object at a certain distance in a unit of time (km/h). In the movement of traffic flow, each vehicle runs at a different speed. In its calculations, the average speed is divided into two, namely Time Mean Speed (TMS), which is defined as the average speed of all vehicles passing through a point of the road during a specific period, and Space Mean Speed (SMS), which is the average speed of all vehicles occupying a section of the road over a particular time.

Density is the number of vehicles occupying the observed road length divided by the practical road length. Density is difficult to measure definitively. However, traffic density is a fundamental macroscopic characteristic that directly indicates the quality of traffic and affects the ease and comfort that can drive a person to pass through the road (Timpal, Sendow, & Audie, 2018); (Tamin, 2008).

Traffic volume is the number of vehicles passing through a point on a section of road in a specific time interval expressed in vehicles' units at a particular time. The volume (current) of traffic is defined by the notation V with the following formulation (Desmi & Yanti, 2019); (Tamin, 2008).

$$Q = D.V$$

Where Q is the volume of traffic (pcu/hour), the other notation V or q; D is the traffic density (pcu/km), the other notation k; and V is the speed of traffic (km/h), the other notation S or u.

Variable Relationships of Volume, Speed, and Density

In macroscopic, the fundamental relationship between variable volume, speed, and density can be expressed by volume as the product of the average speed of space with traffic density (Nurinda, Priyanto, & Malkamah, 2019).

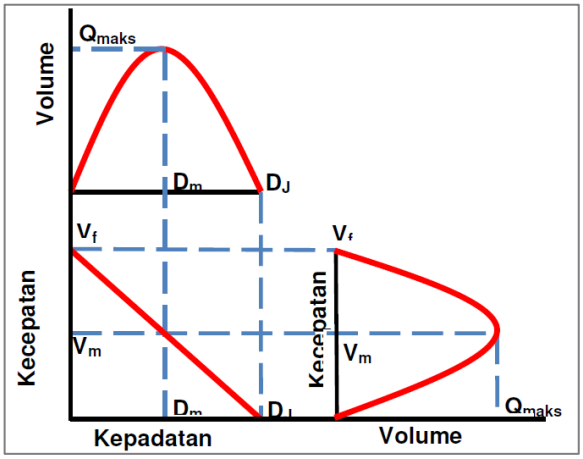


Figure 1. Relations of volume, speed, and density of traffic

In addition to the three parameters above, there are other variables for calculating traffic flow, including the following:

1. VM= maximum capacity or volume (vehicle/hour)
2. SM= speed at maximum traffic volume (km/h) condition
3. DM= density at maximum traffic volume conditions (vehicles/km)

4. DJ= density in total traffic jams (vehicles/km)
5. Sff= speed at shallow traffic conditions or density conditions close to 0 (zero) or free current speed (km/h)

The graph of the relationship between current, speed, and density has interrelated boundaries of parameters, as shown above. The following are the conditions:

1. The speed (V or S) approaches the free velocity (Vf) when the density (D) approaches zero or becomes a saturated density (Dj).
2. The current (Q) and density (D) will increase then the speed (V) will drop until it stops (V0) at the optimum density point (Do).
3. The increase in density (D) makes the speed (V) and current (Q) decrease until the density value becomes saturated/maximum (Dj) and the speed value (V0) and current (Q0) become zero.
4. The average free velocity (Vf) occurs when the density (D) equals zero.

Relationship Model of Variables V, S, and D

Greenshield

Since the 1920s, researchers have been working to improve traffic flow measurement by collecting more valuable data to comprehensively understand traffic flow (Greenshields, 1935). The Greenshield model (1935) was the first to provide an observational approach to traffic behavior. This model study was conducted on streets outside the city of Ohio, where traffic conditions are eligible because they are uninterrupted and move freely (steady state condition). Greenshield gets the result that the relationship between velocity and density is assumed to be linear. This model can be described as follows (Tamin, 2008):

$$Us = Uf - ()\frac{Uf}{Dj}$$

From the equation, it is necessary to know that Us is the average speed of space (km/h), D is density (pcu/km), and Dj is the density of clock conditions (pcu/km). The equation is a linear equation y=a+bx, where Uf is considered a constant a and – () is regarded as $\frac{Uf}{Dj}$b, while D and Us are x and y, respectively.

Greenberg

The Greenberg model is the second model that surveys the relationship of velocity and density to traffic flow in tunnels and concludes that a non-linear model is more appropriately used, namely logarithmic functions. The basic formula of Greenberg can be seen below (Tamin, 2008).

$$D = c \cdot e^{b.Us}$$

where c and b are constant values. By using fluid flow by combining the equations of motion and continuity for a single unified dimension of motion and deriving the equations:

$$Us = um \cdot Ln ()\frac{Dj}{D}$$

This Greenberg model requires knowledge of optimum speed parameters and clock conditions density. Similar to the Greenshield model, the density of clock conditions is tough

to observe in the field and estimates of the optimum velocity are more difficult to estimate than the average free velocity (Tamin, 2008).

METHODS

The location of the study was conducted on Jalan Ciater Raya Serpong from the Ciater Roundabout towards BSD. The data used in this study was obtained from field surveys in the form of primary and secondary data.

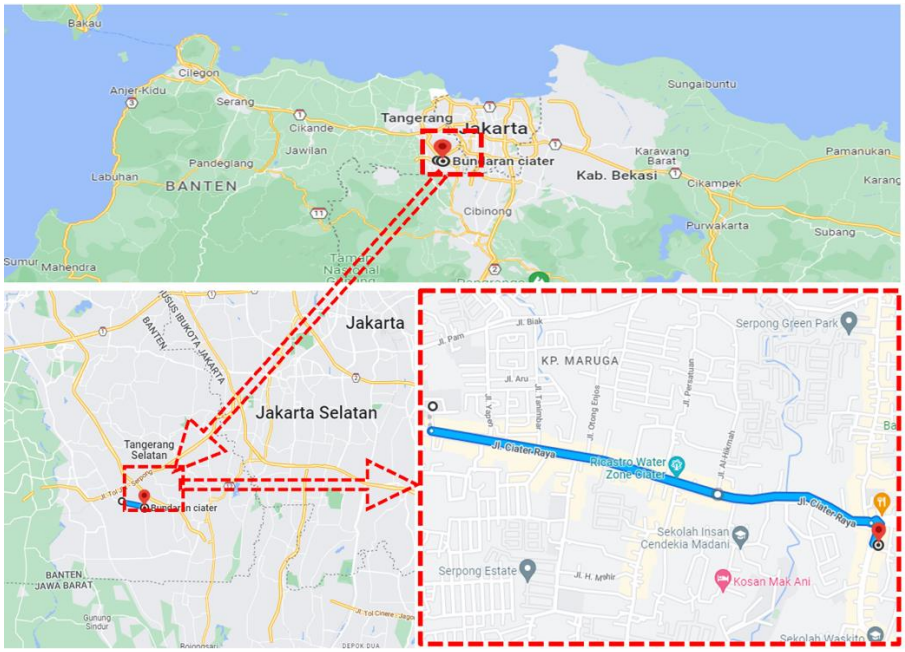


Figure 2. Location of Traffic Characteristics Research

The primary data is the volume of traffic obtained from the analysis of the number of vehicles passing by within 2 hours in the morning and 2 hours in the afternoon. Meanwhile, secondary data is in the form of actual specifications of roads that have been fixed, from the width of the road, the speed of the plan, and the length of the road being reviewed.



Figure 3. Traffic condition of Jalan Ciater Raya Serpong

RESULT AND DISCUSSION

Traffic volume data for one day by taking Monday in the morning at 06.30-08.30 WIB and in the afternoon at 18.00-20.00 WIB. Traffic volume is taken at peak hours, with an interval of 15 minutes. The survey data will then be converted to junior high school units with the following conditions (IHCM 1997):

a. Light vehicles= 1.00
b. Heavy vehicles= 1.20
c. Motorcycle= 0.25

Surveys and measurements are carried out to obtain data on road dimensions and average vehicle speed. Done separately by measuring when the road is busy and *test driving* in *peak hour* conditions using two-wheeled vehicles, which are carried out randomly every 15-minute interval. Another alternative is the Time mean speed with the calculation of the time required for a lightweight vehicle to reach a distance of 20 meters.

On Monday, September 26, 2022, the weather was evident during the morning and evening rush hours, so the observation data is expected to be more valid. The results of observations on the number of vehicles passing on Jalan Ciater Raya Serpong for 2 hours in the morning and 2 hours in the afternoon obtained a peak vehicle volume of 2529.6 pcu/hour, which occurred at 07.00-08.00 in the morning. This volume received the LHR value of Jalan Ciater Raya at 25296 pcu/day. The following is a table of observations of the number of each type of vehicle per 15 minutes.

Table 1. Traffic Observation Result

No	Time	Vehicles			Vehicles Total
		MC	LV	HV	
1	06.30 - 06.45	1255	284	7	1546
2	06.45 - 07.00	1219	226	7	1452
3	07.00 - 07.15	1498	275	10	1783
4	07.15 - 07.30	1515	223	13	1751
5	07.30 - 07.45	1292	252	2	1546
6	07.45 - 08.00	1447	296	13	1756
7	08.00 - 08.15	1225	295	18	1538
8	08.15 - 08.30	1207	274	9	1490
9	18.00 - 18.15	1067	242	3	1312
10	18.15 - 18.30	1037	193	3	1233
11	18.30 - 18.45	1274	234	4	1512
12	18.45 - 19.00	1288	190	4	1482
13	19.00 - 19.15	1163	215	1	1379
14	19.15 - 19.30	1129	252	4	1385
15	19.30 - 19.45	956	251	3	1210
16	19.45 - 20.00	942	233	6	1181

The observation data in table 1 above is converted to junior high units at intervals of 15 minutes (MKJI 1997) on 4-lane 2-way road types divided with the traffic flow of more than 1050 vehicles per hour. The Motorcycle, Light Vehicle, and Heavy Vehicle categories are multiplied by 0.50, 1.00, and 1.20, respectively. The result of converting the number of vehicles to the EMP equivalent is as follows.

Table 2. Result of Converting Observation Data to Equivalent Units (pcu)

No	Time	Vehicles			Q (pcu/15 min)
		MC	LV	HV	
1	06.30 - 06.45	313,75	284	8,4	606,15
2	06.45 - 07.00	304,75	226	8,4	539,15
3	07.00 - 07.15	374,50	275	12	661,5
4	07.15 - 07.30	378,75	223	15,6	617,35
5	07.30 - 07.45	323,00	252	2,4	577,4
6	07.45 - 08.00	361,75	296	15,6	673,35
7	08.00 - 08.15	306,25	295	21,6	622,85
8	08.15 - 08.30	301,75	274	10,8	586,55
9	18.00 - 18.15	266,75	242	3,6	512,35
10	18.15 - 18.30	259,25	193	3,6	455,85
11	18.30 - 18.45	318,50	234	4,8	557,3
12	18.45 - 19.00	322,00	190	4,8	516,8
13	19.00 - 19.15	290,75	215	1,2	506,95
14	19.15 - 19.30	282,25	252	4,8	539,05
15	19.30 - 19.45	239,00	251	3,6	493,6
16	19.45 - 20.00	235,50	233	7,2	475,7

1. Greenshield models

The data resulting from the conversion of the number of vehicles is the volume (Q) of vehicles per 15 minutes. The result is multiplied by the speed (V, the result of the observation), and then the traffic density (D) is obtained. In the Greenshield model, the

volume is notated as yi while the density is xi. The following are the calculation results of xi, yi, xi^2, yi^2, and xi multiplied by yi, presented in table 3.

Table 3. Analysis Parameter of Traffic Characteristic Greenshield models

No	Time	Q (pcu/hour) xi * yi	V (km/h) yi	D (pcu/km) xi	yi^2	xi^2
1	06.30 - 06.45	2424,60	26	93,25	676	8696,28
2	06.45 - 07.00	2156,60	33	65,35	1089	4270,82
3	07.00 - 07.15	2646,00	28	94,50	784	8930,25
4	07.15 - 07.30	2469,40	29	85,15	841	7250,82
5	07.30 - 07.45	2309,60	35	65,99	1225	4354,49
6	07.45 - 08.00	2693,40	43	62,64	1849	3923,42
7	08.00 - 08.15	2491,40	44	56,62	1936	3206,13
8	08.15 - 08.30	2346,20	48	48,88	2304	2389,17
9	18.00 - 18.15	2049,40	39	52,55	1521	2761,37
10	18.15 - 18.30	1823,40	42	43,41	1764	1884,80
11	18.30 - 18.45	2229,20	40	55,73	1600	3105,83
12	18.45 - 19.00	2067,20	46	44,94	2116	2019,53
13	19.00 - 19.15	2027,80	44	46,09	1936	2123,95
14	19.15 - 19.30	2156,20	43	50,14	1849	2514,44
15	19.30 - 19.45	1974,40	46	42,92	2116	1842,28
16	19.45 - 20.00	1902,80	50	38,06	2500	1448,26
Total		**35767,60**	**636,00**	**946,23**	**26106**	**60721,84**

Coefficients B and A are calculated as follows:

$$B = = \frac{N\ .\ \sum_{i=1}^{N}(xi.yi) - \sum_{i=1}^{N} xi\ .\ \sum_{i=1}^{N} yi}{N\ .\ \sum_{i=1}^{N}(xi)^2 - (\sum_{i=1}^{N} xi^2)} \frac{16\ .(35767{,}6) - (946{,}23\ .\ 636)}{16\ .(946{,}23)^2 - (60721{,}84)}$$

B = - 0.387

A = ȳ1 – B . ẋ1

A = Vf = 62,657 km/h

Dj = A/(-B) = 62,657 / 0.387 = 161,764 smp/km

For the coefficient of determination, $r^2 = \frac{N\ .\sum_{i=1}^{N}(xi.yi) - \sum_{i=1}^{N} xi\ .\sum_{i=1}^{N} yi}{\sqrt{N.\sum_{i=1}^{N} xi^2 - (\sum_{i=1}^{N} xi)^2\ .\ N.\sum_{i=1}^{N} yi^2 - (\sum_{i=1}^{N} yi)^2}}$

r^2 = 0.866

The maximum speed (Vm) at maximum volume (Qm) is 31.328 km/h.

2. Model Greenberg

For Greenberg models, speed is also annotated with yi. However, for notation xi is the value of LN(Density). Then the value of the volume (Q) is the result of multiplication between velocity (yi) and LN(D) (xi). The Greenberg model's volume calculation can be seen in table 4 below.

Table 4. Analysis Parameter of Traffic Characteristic Greenberg models

No	Vs (Yi)	D	LN(D) (Xi)	yi^2	xi^2	Q (xi*yi)
1	26	93,254	4,535	676	20,569	117,92
2	33	65,352	4,180	1089	17,471	137,93
3	28	94,500	4,549	784	20,690	127,36
4	29	85,152	4,444	841	19,753	128,89
5	35	65,989	4,189	1225	17,552	146,63
6	43	62,637	4,137	1849	17,118	177,91
7	44	56,623	4,036	1936	16,293	177,60
8	48	48,879	3,889	2304	15,127	186,69
9	39	52,549	3,962	1521	15,695	154,51
10	42	43,414	3,771	1764	14,219	158,37
11	40	55,730	4,021	1600	16,165	160,82
12	46	44,939	3,805	2116	14,480	175,04
13	44	46,086	3,831	1936	14,673	168,54
14	43	50,144	3,915	1849	15,326	168,34
15	46	42,922	3,759	2116	14,133	172,93
16	50	38,056	3,639	2500	13,243	181,95
Total	**636**	**946,225**	**64,663**	**26106**	**262,506**	**2541,444**

Coefficients B and A are calculated as follows:

$$B = = \frac{N\ .\ \sum_{i=1}^{N}(xi.yi) - \sum_{i=1}^{N} xi\ .\ \sum_{i=1}^{N} yi}{N\ .\ \sum_{i=1}^{N}(xi)^2 - (\sum_{i=1}^{N} xi^2)} \frac{16\ .(2541{,}44) - (64{,}663\ .\ 636)}{16\ .(64{,}663)^2 - (262{,}506)}$$

B = - 24,609

A = ȳ1 – B . ẋ1

A = Vf = 139,206 km/h

Dj = Exp(A/(-B)) = 139,206 / 24,609 = 286.20 smp/km

For the coefficient of determination, $r^2 = \frac{N.\sum_{i=1}^{N}(xi.yi) - \sum_{i=1}^{N} xi.\sum_{i=1}^{N} yi}{\sqrt{N.\sum_{i=1}^{N} xi^2 - (\sum_{i=1}^{N} xi)^2 . N.\sum_{i=1}^{N} yi^2 - (\sum_{i=1}^{N} yi)^2}}$

$r^2 = 0.862$

The maximum speed (Vm) at maximum volume (Qm) is 24.609 km/h.

3. Variable Recapitulation of Volume, Speed, and Density Relationships

The calculation analysis of the maximum value of the variable traffic characteristics of Jalan Ciater Raya Serpong can be seen in Table 5.

Table 5. Recapitulation of Traffic Characteristic Maximum Values of Jalan Ciater Raya

Variables	Units	Models	
		Greenshield	**Greenberg**
Qm	pcu/hour	2533,891	2591,02
Vf	km/hour	62,657	139,206
Vm	km/hour	31,328	24,609
Dj	Junior High School/KM	161,764	286,200
r^2	-	0,866	0,862

From the calculations using the formula of both models obtained coefficient A, coefficient B, free speed (Vf), maximum speed (Vm), saturated density (Dj), maximum volume (Qm), and determination value (r^2). The calculation of the relationship of volume, velocity, and density of the Greenshield and Greenberg models is obtained using the following equation.

a. **Greenshield models**

Vs = 62,657 – (62,657 / 161,764) x D

Q' = 161,764 x Vs – (161,764 / 62,657) x Vs^2

Q'' = 62,657 x D – (62,657 / 161,764) x D^2

b. **Model Greenberg**

Vs = 24.609 x LN(286.2 / D)

Q' = Vs x 286.2 x EXP(–Vs / 24,609)

Q'' = 24.609 x D x Ln (286.2 / D)

The relationship between velocity and density of Greenshield and Greenberg models uses the Vs equation above. First, density is substituted equality Vs both models, with a fixed value of D corresponding to the quotient between the volume and the observation speed. Then the relationship of speed with the density of the two models is illustrated in figure 4 as follows.

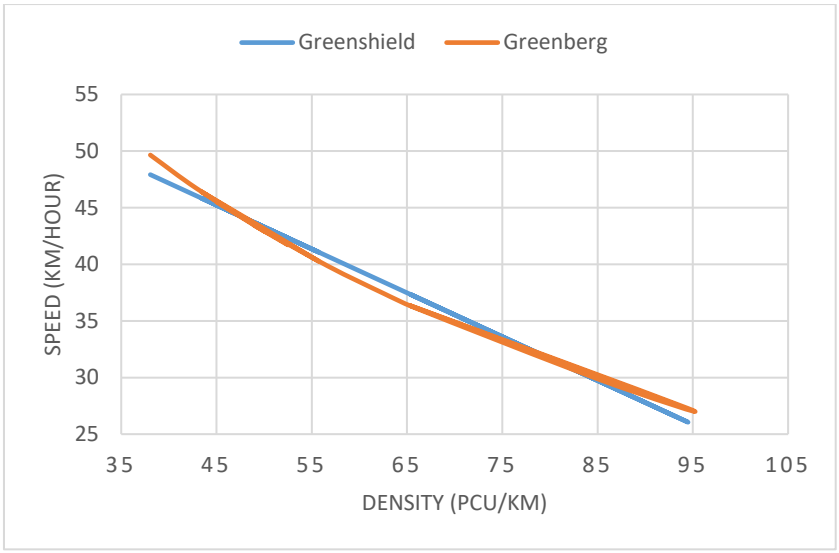


Figure 4. Graph of V and D Relationships

The relationship between the speed and volume of the Greenshield and Greenberg models uses the Vs equation above. Next, the density is substituted for the Q' equation of both models, with the value of Vs remaining as per the observation results. Then the relationship of velocity with the volume of the two models is illustrated in figure 5 as follows.

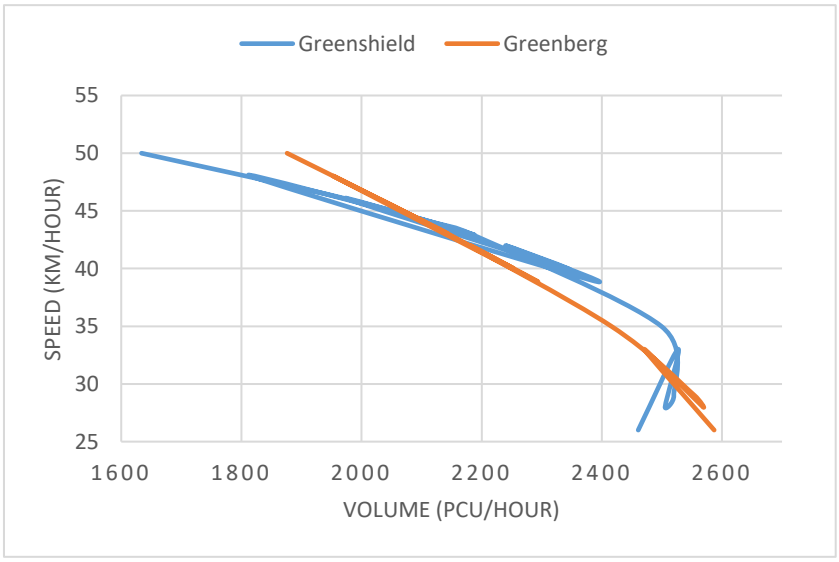


Figure 5. Graph of the Relationship V and Q

The relationship between the density and volume of the Greenshield and Greenberg models uses the Vs equation above. In addition, density is substituted for the Q" equation of both models, with a fixed value of D corresponding to the quotient between the volume and the observation speed. So the relationship of density with the volume of the two models is illustrated in Figure 6.

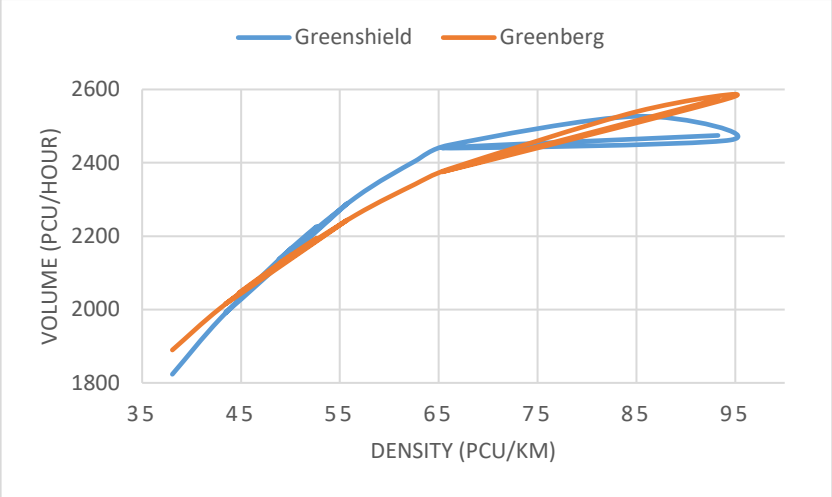


Figure 6. Graph of Q and D Relationships

CONCLUSION

From the results of the analysis obtained, it can be concluded that the traffic characteristics variables modeling Greenshield and Greenberg have a significant difference in the variables Vf = 62.66 km / h (Greenshield) and Vf = 139.21 km / h (Greenberg). Other variables that are quite different are Dj = 161.76 pcu/km (Greenshield) and Dj = 286.20 pcu/km (Greenberg). However, the two models for Qm and Vm are similar: Qm = 2533.89 smp/h and Vm = 31.33 km/h (Greenshield) and Qm = 2591.02 smp/h and Vm = 24.61 km/h (Greenberg). Meanwhile, based on the determination value (r^2), the Greenshield and Greenberg methods are close in value; namely, $r^2 = 0.866$ with the Greenshield model and $r^2 = 0.862$ with the Greenberg model.

REFERENCE

Afrin, T., & Yodo, N. (2020). A survey of road traffic congestion measures towards a sustainable and resilient transportation system. *Sustainability, 12(11)*, 4660.

BPS South Tangerang City. (2022, September 29). Retrieved from tangselkota.bps.go.id: https://tangselkota.bps.go.id/indicator/12/85/1/jumlah-penduduk.html

Calvert, S. C., & Snelder, M. (2018). A methodology for road traffic resilience analysis and review of related concepts. *Transportmetrica A: transport science, 14(1-2)*, 130-154.

Christine, C., Rifai, A. I., & Handayani, S. (2022). Level of Service Evaluation of Pedestrian Facility in Tourism Area: Case Study Jalan Braga, Bandung. *Citizen: Indonesian Multidisciplinary Scientific Journal*, *2*(5), 748-756.

Christine, C., Rifai, A. I., & Handayani, S. (2022). Level of Service Evaluation of Pedestrian Facility in Tourism Area: Case Study Jalan Braga, Bandung. *Citizen: Indonesian Multidisciplinary Scientific Journal*, *2*(5), 748-756.

Philanthropist, W. B., Rifai, A. I., Ramadan, A. H., & Isradi, M. (2021). Analysis of Pedestrian Facility Services on Shopping Mall Areain Satellite City During Pandemic COVID-19. *ADRI International Journal of Sciences, Engineering and Technology*, *6*(2), 99-107.

Desmi, A., & Yanti, R. (2019). Effectiveness of Characteristic Model of Traffic Flows in Simpang 4 Road Bireun (Comparison with Greenshield, Greenberg, Underwood) Methods. *Global Journal of Research In Engineering*.

Firmansyah, F., Rifai, A. I., & Taufik, M. (2022). The Performance of Roundabouts with Traffic Signals: A Case Kadipaten Intersection, Indonesia A Case Kadipaten Intersection, Indonesia. *Citizen: Indonesian Multidisciplinary Scientific Journal*, *2*(5), 823-832.

Ganin, A. A., Kitsak, M., Marchese, D., Keisler, J. M., Seager, T., & Linkov, I. (2017). Resilience and efficiency in transportation networks. *Science advances*, 12.

Han, L. D., Wang, S., & Chen, Y. (2022). Analysis of Traffic Signs Information Volume Affecting Driver's Visual Characteristics and Driving Safety. *International journal of environmental research and public health*, 16.

Highway Capacity Manual. (2000). Washington D. C.: Transportation Research Board, National Research Council.

Kosovets, M. A., Lozhkin, V. N., & Lozhkina, O. V. (2021). Engineering Method for Calculating Changes in the Structure and Intensity of Traffic Flow. *IOP Conference Series: Earth and Environmental Science*, 052043.

Li, L. J., He, Z., Chen, X. M., & Zhou, X. (2020). Trajectory data-based traffic flow studies: A revisit. *Transportation Research Part C: Emerging Technologies*, *114*, 225-240.

Martinez, J. L., Carlos, T. C., Soler, D., Lemus-Zúñiga, L.-G., Cano, J.-C., Manzoni, J.-C., & Gayraud, T. (2019). A Centralized Route-Management Solution for Autonomous Vehicles in Urban Areas. *Electronics*, 722.

Nurinda, G., Priyanto, S., & Malkamah, S. (2019). The Relationship between Speed Volume and Traffic Density on Padjajaran Road Section, Sleman. *Techniciania Vol. XXIV No.1*.

Pelangie, K. R., Rifai, A. I., & Yudhistira, P. (2022). Services Analysis of Pedestrian Facility in Office and Business Area: Case Study Jalan Wahid Hasyim, Jakarta. *Citizen: Indonesian Multidisciplinary Scientific Journal*, *2*(5), 804-814.

Prakoso, B., & Rifai, A. I. (2018). Analysis of Toll Road Service Performance in the Process of Capacity Building (Case Study of Jakarta–Cikampek Toll Road).

Primary, A., Rifai, A. I., & Thole, J. (2022). The Analysis of Pedestrian Service in Railway Station Area: A Case Tanah Abang Station, Jakarta A Case Tanah Abang Station, Jakarta. *Citizen: Indonesian Multidisciplinary Scientific Journal*, *2*(5), 794-803.

Rahayu, A. J., Rifai, A. I., & End, A. F. (2022). The Phenomena of On-Street Parking at Duchy Traditional Market, West Java. *Citizen: Indonesian Multidisciplinary Scientific Journal*, *2*(5).

Rifai, A. I. (2021). Analysis of Road Performance and the impact of Development in Pasar Minggu. *International Journal of Civil Engineering*, *6*(1).

Rifai, A. I., & Aulia, E. S. (2019). Analysis of Factors Causing Traffic Accidents on Sultan Agung Street, Bekasi. *Neutrons*, *18*(2), 1-9.

Rifai, A. I., Harefa, R. A., Isradi, M., & Mufhidin, A. (2021, September). How did the Impact of the 2nd Wave of COVID-19 on Parking Characteristics at Non-Referral Hospitals? Case Study: Permata Cibubur Hospital, Indonesia. In *Journal of World Conference (JWC) (*Vol. 3, No. 5, pp. 481-490).

Sidiq, A. M., Rifai, A. I., Isradi, M., & Philanthropist, W. B. (2022). Identification of Traffic Accident Problem Levels on Motorcycle Rider Behavior Using Traffic Conflict Technique (Tct) Method Case Study: Cileungsi Road. *ADRI International Journal of Civil Engineering*, *7*(1), 172-179.

Singh, S., Barhmaiah, B., Kodavanji, A., & Santhakumar, M. (2020). Analysis of two-wheeler characteristics at signalized intersection under mixed traffic conditions: A case study of Tiruchirappalli city. *Resilience and Sustainable Transportation Systems*, 35-43.

Sumantri, V. N., Rifai, A. I., & Ferial, F. (2022). Impact of inter-urban street lighting on users perception of road safety behavior: A Case of Jalan Majalengka-Rajagaluh. *Citizen: Indonesian Multidisciplinary Scientific Journal*, *2*(5), 703-711.

Tamin, O. (2008). *Planning, Modeling, & Transportation Engineering.* Bandung: ITB.

Talib, & Taufiq, N. M. (2016). Analysis Of The Relationship Between Volume, Speed, And Density Of Traffic Flow On Prof. Dr. H.B. Jassin's Road Section By Comparing The Greenshield Method And The Greenberg Method. *RADIAL – juRnal perADaban saIns, rekayAsa and technoLogi Sekolah Tinggi Teknik (STITEK) Bina Taruna Gorontalo Vol. 6 No.1*, 59-68.

Timpal, G. S., Sendow, T. K., & Audie, R. (2018). Capacity Analysis Based on Greenshield, Greenberg, and Underwood Modeling, Road Performance Analysis on Sam Ratulangi Manado Road Section. *Static Civil Journal*, 599-610.

Yunita, K. S., & Rifai, A. I. (2019). Performance Analysis of Road Sections and Uncited Interchanges (Case Study of The Three-Arm Interchange of Jatikramat Highway–Jalan dr. Ratna Jatiasih Kota Bekasi).