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Effectiveness of Characteristic Model of Traffic Flows in Simpang 4 Road Bireun (Comparison with Greenshield, Greenberg, Underwood) Methods

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Keywords: *greenshield, greenberg, underwood, speed vehicles, traffic flow, density of traffic.*

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I. Introduction

The construction of roads as a form of government commitment in developing infrastructure as a whole is intended as a provider of transportation facilities that facilitate local communities to interact with their surrounding environment, both in the social, economic and cultural fields. As one of the means of land transportation. Roads are intended to be used as an accumulation of various motorized vehicles and non-motorized vehicles. And in this case the number or volume of vehicles crossing the road depends on various parameters including population density, number of vehicles and road conditions.

Simpang 4 highway Bireuen is one of the arterial roads in the city of Bireun which has a fairly high volume of vehicles, especially during the school season, where this highway has thousands of students and a row of shops along the road. This dynamic road condition creates vulnerability in the form of traffic jams through the road. The number of movements in Bireuen can be related to the density of traffic flow on the road. Density can be believed to correlate with the speed of the vehicle and the volume of vehicles that occur on the road.

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By looking at the background, some problems can be raised, namely; what is the shape of the mathematical model of the characteristics of the Bireuen 4 intersection. what is the minimum speed that must be taken by a road user who crosses the highway 4 intersection Bireun, and which model is the most optimal that can describe the real conditions of the characteristics of the road segment.

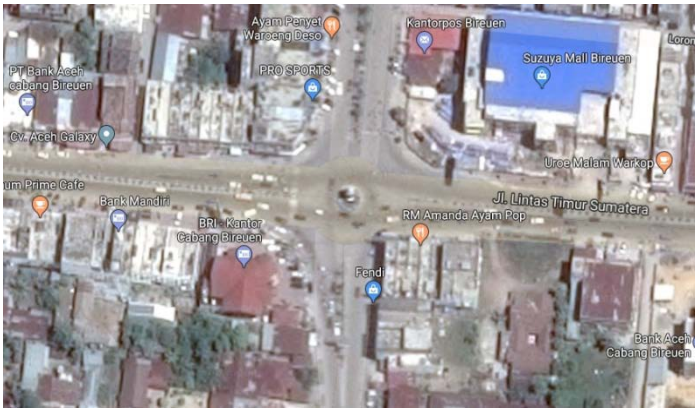
The objectives of this study are to find out the mathematical model between speed - density, volume-speed and volume-density must be carried out by highway intersection 4 Bireuen, know the minimum speed and optimal speed of the vehicle traveling on the road, and Know the Greenshield Model, Greenberg and Underwood models.

This research is intended to find a correlation model between vehicle volume, current and vehicle speed on the road. The road section studied at the Bireuen 4 intersection area, this election is based on preliminary observations where traffic congestion often occurs, the volume of vehicles increases at certain hours. And there has not been a study that has modeled the correlation of current and density on this road segment.

II. Research Methods

This research includes preparation, field data collection, then preparations are made in the form of making the initial and final boundaries on the Bireuen 4 intersection, and a good bounding mark for 100 m can be seen by the observer where the mark is made using color paint the red applied to the places seen by the observer.

The research location was carried out at the Medan-Banda Aceh crossing, Banda Aceh Medan road, Bireuen-Takengon road, Kuala Raja Bireuen road, can be seen on the location map below.



Source: Google Earth

Figure 2.1: Map of location

a) Data Collection

Primary data collection is in the form of traffic volume, light vehicle speed, carried out simultaneously at the research location on Simpang 4 Bireuen road. for 4 days from 7:00 a.m. until 18:00 a.m. Whereas the geometric data collection in the form of the width of the traffic lane (m), the width of the entrance to the main road m), the kereb, the distance of the road (m) were carried out at night so as not to interfere with traffic activities during the study.

The method of data collection in this study is primary and secondary data. Primary data obtained from field surveys in the form of traffic volume, traffic speed, vehicle travel time and geometric measurements of the road, from the data will then be processed to obtain traffic density data. Secondary data as a complement to supporting data in the field includes a road network map of the intersection of 4 Bireuen cities obtained from relevant agencies, such as the Public Works Agency, Transportation Agency, Statistics agencies and sketches of the observation locations on the reviewed roads.

Traffic volume is the number of vehicles that pass a point on a road segment within a certain time interval stated in a unit vehicle at a certain time the average traffic volume is an average vehicle calculated according to a certain unit of time, can daily be said as a volume average daily traffic / LHR or in English is referred to as Average Daily Traffic Volume (ADT). According to Morlok, (1988), the volume of traffic can be calculated using the following formula:

$$q = \frac{n}{t} \qquad (2.1)$$

where q = Volume of traffic passing through a point, n = Number of vehicles passing through that point in the observation time interval, t = Observation time interval.

The traffic flow parameters are divided into 2 categories; (a). The macroscopic parameter: characterizes the overall traffic flow, (b). Microscopic parameters: characterize the individual behavior of vehicles that give each other traffic opportunities to each other.

Macroscopically, the traffic flow is described/characterized by 3 main parameters; (a). Volume or current level (volume or rate of flow). (b). Speed (speed), (c). Density. In addition, headway (h), spacing (s), and occupancy (R) parameters were also used. Regarding the headway and spacing, there are parameters of clearance (c) and gap (g).

Local speed observation is done on a number of vehicles. This is based on the inequality of the speed of each vehicle by the influence of various conditions, both vehicles, drivers, instantaneous density and so on. Therefore, to obtain local speed, simplified statistical procedures are used.

Speed describes the level of movement of a vehicle expressed in the distance of the unit of time or the value of changing distance to time. The unit is kilometers/hour, meters/second. According to Tamin O. Z., (1991) speed is defined as the distance that can be taken by a vehicle of time unity. The unit commonly used is meters / seconds or kilometers / hour. The formula for calculating speed (Morlok, E.K. 1988) :

$$V = \frac{d}{t} \qquad (2.2)$$

Where ; V = Speed (km/h, m/sec), d = Distance (km, m), t = Travel time (hours, seconds).

There are 3 classifications of speed in traffic; (a). Point / moment speed (spot speed), the condition where the vehicle experiences a steady speed at a point, (b). Travel speed (journey speed), the average speed where the value can be determined from the distance traveled divided by the total travel time, (c). Moving speed (running speed), the average speed of a vehicle to cross a certain distance in the condition of the vehicle still running, i.e. the condition after being reduced by the time the obstacle occurs (eg obstacles at the intersection). This moving speed can be determined from the distance traveled divided by total travel time which has been reduced by the time of

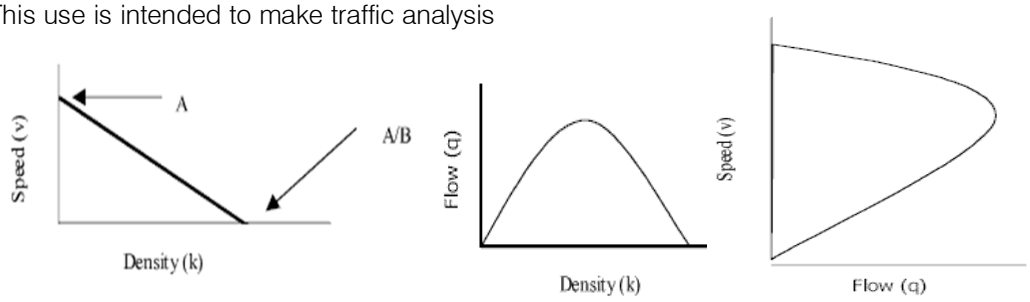
stopping due to obstacles caused by disturbances that occur in traffic.

To find out the value of traffic density obtained from data processing volume and speed of traffic, namely from the results of a comparison between the volume value with the speed of traffic at the same time of observation. The value of traffic density is expressed in smp (the passenger car unit is a traffic flow unit)/km.

The passenger car unit is a traffic flow unit, where flows from various types of vehicles have been converted into light vehicles (including passenger cars) using passenger car equivalence (EMP) (Ririn Gamran, et all 1997). This use is intended to make traffic analysis easy to do with the factors of passenger car units (pcu) of each motorized vehicle according to the Indonesian Road Capacity manual (MKJI 1997), for urban roads are as follows: (a). Vehicle Weight (HV) = 1.30, (b). Light Vehicle (LV) = 1.00, (c). Motorcycle (MC) = 0.40, (d). Non-motorized vehicle = 1.00

b) Relationship Between Speed, Density and Traffic Volume

The relationship between speed, volume and density can be graphicall illustrated as shown in the following figure.



(Source : McShane dan Roes,1990)

Figure 2.2: Relationship between speed, flow and density

From the curve, it can be seen that the basic relationship between volume and speed is that with increasing volume of traffic, the average speed of the room will decrease until the maximum volume is reached (Ririn Gamran, et all 1997). The relationship between speed and density shows that the speed will decrease if the density increases. The relationship between volume and density shows that density will increase if the volume also increases.

i. *Greenshield Model*

Greenshield formulates that the mathematical relationship between speed-density is assumed to be linear (Tamin O.Z, 2000) as stated in equation (2.2). This model is the earliest model recorded in an effort to observe the behavior of traffic flows. Greenshields get the result that the relationship between speed and density takes the form of a linear curve (McShane and Roes, 1990).

The speed at which the maximum volume is obtained by using the equation:

$$V_s = V_m = \frac{V_f}{2} \quad (2.3)$$

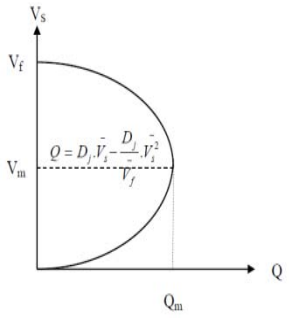


Figure 2.3: Relationship between speed and volume

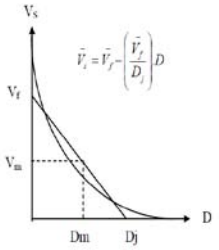


Figure 2.4: Relationship between speed and density

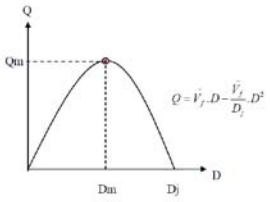


Figure 2.5: Relationship of current and density

ii. *Greenberg Model*

To analyze the relationship between the variables of volume and speed and density according to Greenberg, the following equations are used :

The relationship between Volume and Speed on the Greenberg model uses the following equations :

$$Q = V_s \cdot D_j \cdot \exp\frac{-V_s}{V_m} \quad (2.4)$$

This Volume and Density Relationship applies the following equation :

$$Q = V_m \cdot D \cdot L_n \frac{D_j}{D} \quad (2.5)$$

$$Qmaks = \frac{D_j \cdot V_m}{e} = V_m \cdot D_m \quad (2.6)$$

Speed when maximum volume is obtained :

$$V_s = V_m \quad (2.7)$$

iii. *Underwood models*

To get the relationship between the volume, speed and density variables according to the Underwood exponential model, the relationship between the volume and speed of the Underwood model is used as follows :

$$Q = V_f \cdot D_m \cdot Ln\left(\frac{V_f}{V_s}\right) \quad (2.8)$$

The volume and density relationship applies the following equation :

$$Q = D \cdot V_f \cdot \exp\left(\frac{-D}{D_m}\right) \quad (2.9)$$

The maximum volume (Qmaks) is :

$$Qmaks = \frac{D_m \cdot V_f}{\exp} \quad (2.10)$$

The speed at maximum volume (Qmaks) is obtained by using the equation :

$$V_m = \frac{V_f}{\exp} \quad (2.11)$$

c) Relationship Analysis

According to Riyanto B, (2003), the relationship between the three variables of speed, density and volume is arranged based on the data of traffic flow and speed of vehicles taken every 5 minute period arranged in a list in pairs then the density value can be searched by the basic equation V = D . US. The relationship between speed (US), density (D) and current (V), was analyzed using three methods namely the Greenshield, Greenberg and Underwood methods. Completion of statistics is approached by finding the relationship between speed and density through *regression methods*.

The relationship between speed and density respectively with the Greenshield, Greenberg and Underwood methods is as follows :

a. *Greenshield* : $U_s = U_f - \left(\frac{U_f}{D_j}\right) \cdot D$ (2.12)

b. *Greenberg* : $U_s = U_m \cdot Ln\left(\frac{D_j}{D}\right)$ (2.13)

c. *Underwood* : $U_s = U_f \cdot e\frac{-D}{D_m}$ (2.14)

d) Research Road Map and Comparison Between These Researches with Previous Research

Tabel 2.1: Road map penelitian dan penelitian sebelumnya.

Jurnal	Roux J., 2002	Tamin Z .O., 1992	Mashuri, 2006	Julianto N. E., 2010	Gregory K. L., 2012	Jun J., 2012	Yuniar D., 2013	Iskandar H., 2012
Road Type	Tol	Arteri	Arteri	Arteri	Arteri	Tol	Arteri	Tol
Location	Cape Town	Jakarta	Palu	Semarang	Iloilo	Virginia Utara	Kalimantan	Bandung
Method	Greenberg	Underwood	Greenshield	Underwood	JICA STRADA	-	Greenshield	MKJI ., 1997

Source: Results of Research Recap

Based on the table above which can be taken to be used as references in this study are as follows :

a. Mashuri, (2006) conducted a study on the density of traffic flow on arterial roads in Palu. This study discusses the relationship of the parameters of speed, volume and density using the Greenshield method.
b. Tamin Z. O., (1991) conducted a study of the relationship between speed and volume of traffic on Jalan H.R. Rasuna Said, Jakarta. This study discusses the relationship of the parameters of speed, volume and density using the Underwood method.
c. Julianto N. O., (2010) conducted a study on the relationship between speed and volume of traffic on the Semarang road segment. This study discusses the relationship of the parameters of speed, volume and density using the Underwood method.

The difference between the three studies above with the research that the author will discuss is that the location of the research road that will be carried out is not an arterial road but the chosen road is a toll road which does not have large side barriers and a higher speed capacity difference. Then the velocity and volume data will be used to calculate the vehicle density during the peak hour period using the basis of MKJI calculation, 1997. From the processed data, a graph of the relationship between speed and density will be made and then the optimum speed velocity value will be obtained. meeting.

e) Transportation

In general, the definition of transportation is the transfer of people or goods from one place to another by using a vehicle driven by humans or machines (Nasution, 2004). Transportation can be said as a derivative need, because transportation arises due to the intent or purpose to be achieved through transportation. For example shipping goods, traveling, working and others. The concept of transportation is based on the existence of a journey between origin and destination. Travel is carried out through a certain path that connects origin and destination, using a conveyance or vehicle at a certain speed.

f) Intersections

Intersection is a point on the road network where roads meet and vehicle trajectories intersect. Intersection is the most important factor in determining travel capacity and time on a road network, especially in residential areas. There are several factors that can influence the occurrence of a traffic problem that usually occurs at intersections, including:

a. Volume and capacity, which directly affects obstacles
b. Geometric design, and freedom of view
c. Accidents and road safety, speed and street lights
d. Parking, access and development are safe
e. Pedestrian
f. Distance between intersections

g) Data Analysis Methods

To find out the mathematical relationship between these parameters, several data sets can be obtained from the survey results at the observation location using the A and B values. All analyzes are comparative calculations with the Greenshield, Greenberg and Underwood models. From the results of these calculations can be determined the relationship between speed and density of traffic.

III. Results and Discussion

a) Results

The survey for this study has been conducted for four days, namely on February 19 2018, Monday, Tuesday, Thursday, and Sunday at Simpang IV Bireun, Bireun Regency. The results obtained from the data obtained directly from observations in the field are as follows :

i. *Traffic Volume*

Based on the results of data processing, the traffic volume is obtained by the total volume on every day of junior high school / hour observation, while the full results are displayed in the table below.

Table 3.1: Recapitulation of average traffic volume

No.	hari/Tgl	Average Volume (smp/15 minutes)	Average Volume (smp/hour)
1	Monday	1065,53	4664,37
2	Tuesday	918,32	3699,24
3	Wednesday	699,1	2807,08
4	Thursday	1481,99	6117,62

Sumber : Hasil Pengujian

Based on the results of the study for four days the biggest traffic flow is the direction of the Banda Aceh-Medan road because this road is the main road to the center of Bireun city especially during peak hours. Based on fluctuations graph, the traffic volume from the direction of the Banda Aceh-Medan road that passes through this intersection is quite dense until it reaches 29237.60 (smp / hour), because in the morning it is the first tip of everyone's routine in starting the day.

Based on daily data processing, the peak hour volume is on Tuesday, which is 2292.20 (smp/hour) morning at 12.00-13.00. and afternoon with the number 2128.10 (smp/hour) at 17.00-18.00.

Volume fluctuation The traffic generated from the survey is used to determine peak hours, namely peak morning hours (07.00-08.00), peak afternoon hours (12.00-13.00), and evening peak hours (17.00-18.30).

ii. *Traffic Speed*

From the results of data processing, the average local velocity obtained in the direction of Bireun Medan-Banda Aceh is Monday 29.00 km/h, Tuesday July-Takengon road 28.91 km/h, Thursday Banda Aceh-Medan road 29.93 km/h, the week of Kuala Raja road is 30.57 km/h.

iii. *Traffic Density*

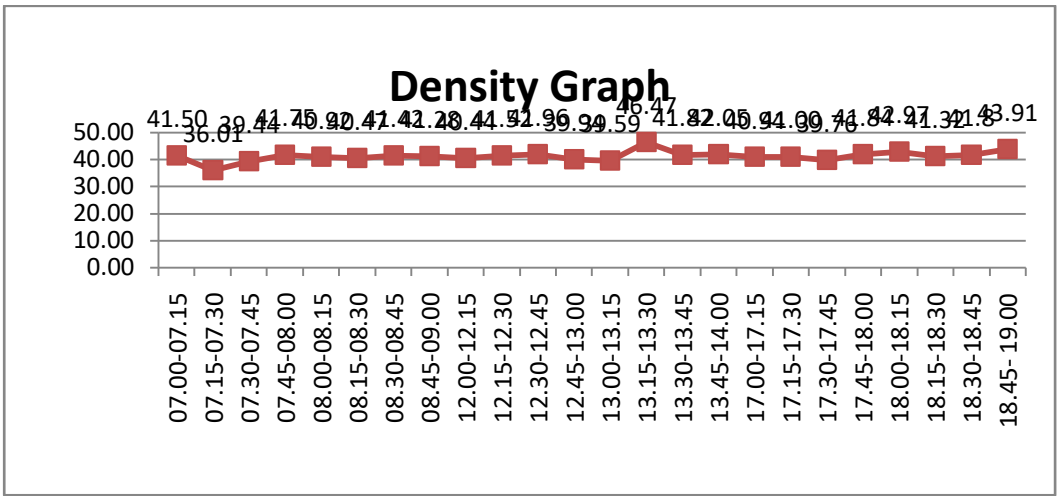
To find out the value of traffic density obtained from data processing volume and speed of traffic, namely from the results of a comparison between the volume value with the speed of traffic at the same time of observation. The value of traffic density is expressed in units smp/km.

b) Discussion

Based on the results of data analysis as described above, then by improving the results of data processing and matters relating to the object of this research, get the discussion as follows. From the results of the graph the relationship between volume and traffic density can be obtained the maximum speed conditions (D) 3297.83 smp/km. This condition is a more real condition closer to the Greenberg model, because only one density condition that occurs and seen from the equations shows that the maximum speed conditions are affected by the density of traffic. From the graph the relationship of speed and density can be explained that if the density increases from zero then the speed of traffic continues to increase, so that more than the density at optimum conditions, a condition will be achieved where the increase in traffic density will not increase the flow of traffic. traffic flow.

The mathematical relationship between speed and traffic density using the Greenshield and underwood model shows the speed of weak traffic density, where it can be explained that if the traffic density continues to increase so that it exceeds the optimum density then the speed of traffic decreases. The results obtained from data processing and analysis show that the relationship that occurs between the speed and density of traffic is looking down. This result is in accordance with what was assumed by the Greenberg method before, namely the mathematical relationship between the speed and density of traffic is to drop down, except that there is a slightly different behavior.

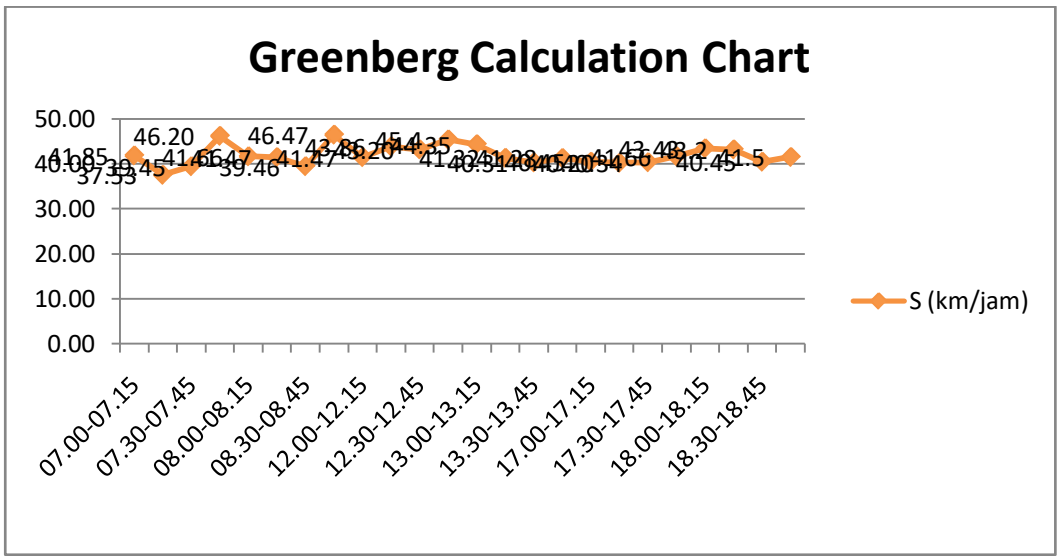
In this study, a comparative analysis of existing traffic characteristics models, namely Greenshield, Greenberg and Underwood, was used, the effectiveness and efficiency of the presentation of the data displayed by each of these methods and from the three methods compared to which the solution was more optimal in vehicle movement. from the relationship between density, speed, and more optimal values found in the Greenberg model.



Source: Test Results

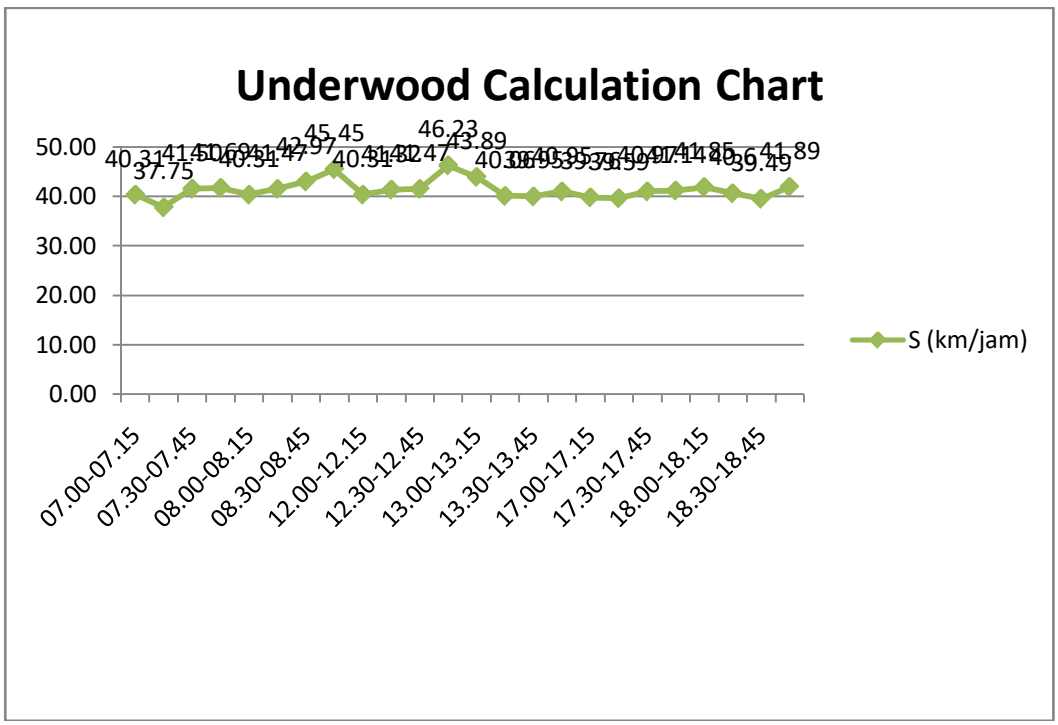
S (km/h)

Graph 3.1: Greenshield calculation



Source: Test Results

Chart 3.2: Calculation of Greenberg



Source: Test Results

Chart 3.3: Calculation of Underwood

The graph of the Greenshield model in this study (Graph 3.1 shows that the optimum density is low. While the underwood graph results show that the density is lower than the Greenshield model graph. For the density velocity, Greenberg has a higher optimum value, while the volume density relationship, both showed results that were almost close to the relationship of volume velocity, so the Greenshield and Underwood approach was still better.

IV. Conclusions and Suggestions

a) Conclusions

Based on the results of the research and discussion conducted at Simpang 4 Bireun in Bireuen Regency, some conclusions can be taken as follows; the lowest traffic speed and the highest traffic density obtained on Monday, namely DM = 40,6231 smp/km and SM = 0,19 km/hour, the form of mathematical

relationship between speed and density using the Greenshield, Greenberg, Underwood model shows speed with weak traffic density, and the effectiveness of the traffic flow characteristic model is the most optimum model found in the Greenberg model because it has a higher value.

b) Suggestions

Further research is needed to get more real values from the three models, namely, Greenshield, Greenberg, and Underwood, comparison of calculations using the Indonesian Capacity Manual (MKJI 1997) Greenshield, Greenberg and Underwood linear modeling needs to be examined again with heavy traffic conditions and high side barriers. The volume of traffic that continues to grow each year becomes the biggest problem for the intersection, especially Simpang 4 Bireuen. To produce a research study from the comparative calculation of the Greenshield, Greenberg and Underwood models in a more accurate relationship of traffic flow characteristics.

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