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# Application of the Greenshield, Greenberg, Underwood, and Bell Models in Evaluating the Capacity of the Lembar Highway Segment (Rural Road) With Comparison to PKJI 2023

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***Keywords***
Greenshield;
Greenberg;
Underwood;
Bell and maximum flow;
capacity

**ABSTRACT**

Road capacity evaluation is essential for maintaining efficient traffic operations, particularly on strategic transportation corridors experiencing continuous traffic growth. The Lembar Highway in West Lombok serves as a major access route connecting regional areas with Lembar Port, resulting in high traffic intensity and varying traffic characteristics influenced by roadside activities. This study aimed to determine the most appropriate macroscopic traffic flow model for evaluating the relationship between traffic speed, density, and volume on the Lembar Highway and to compare the estimated maximum traffic volume with the road capacity calculated using the Indonesian Road Capacity Guidelines (PKJI) 2023. The research employed a quantitative field survey conducted on three road segments. Traffic volume, speed, and geometric road data were collected from 06:00 to 18:00 WITA at 15-minute intervals. Traffic flow characteristics were analyzed using the Greenshield, Greenberg, Underwood, and Bell models, and model performance was evaluated based on correlation and determination coefficients. The findings indicate that the Greenshield model provides the best representation of traffic flow across all three segments, with correlation coefficients of 0.9051, 0.8435, and 0.8607, respectively. The estimated maximum traffic volumes were 2,276.403, 3,111.682, and 2,465.361 passenger car units per hour, all of which remained below the corresponding PKJI 2023 road capacities. These results demonstrate that the existing road sections are still capable of accommodating current traffic demand. Therefore, the Greenshield model is recommended as the most suitable approach for evaluating traffic flow characteristics and supporting road capacity assessment on the Lembar Highway.

## INTRODUCTION

Roads have a very important role for a country in supporting regional development, facilitating access to public services, and encouraging economic growth (Fosu & Twumasi, 2022). In addition, roads are also the main infrastructure for people in carrying out various daily activities, such as working, going to school, trading, and socializing (Berg & Ihlström, 2019). The higher and more diverse the community's activities, the greater the need for transportation facilities. Therefore, adequate transportation facilities are needed to support the smoothness, comfort, and safety of activities.

West Lombok is one of the districts in West Nusa Tenggara Province (NTB) where most of the people work in agriculture, fisheries and tourism (Suthanaya & Suwarningsih, 2023). With the existence of the port of Lembar in Lembar district, West Lombok Regency, it causes very high community activities. The high level of community activity causes problems of significantly increasing transportation so that there is a high increase in the number of vehicles (Srivastava & Kumar, 2023b).

Based on data from the Central Statistics Agency of West Nusa Tenggara Province (2025), the number of motor vehicles has increased every year. In 2023, there were 269,255 vehicles, then increased to 313,819 vehicles in 2024. The increase in the number of vehicles caused several roads to experience a decrease in service levels due to road capacity that was unable to keep up with the increasing traffic volume (Nuhun et al., 2026). This condition has the potential to cause congestion, travel delays, and a decrease in the average speed of vehicles. As a result, traffic efficiency is reduced and triggers various problems, such as increased fuel consumption, air pollution, and decreased comfort and safety for road users (Lu et al., 2021).

Jalan Raya Lembar is the main route that connects Lembar Port with areas in West Lombok district, West Nusa Tenggara. This road acts as an important access for vehicles to get to Lembar Port which is the main crossing port between Lombok and Bali (Bernacki & Lis, 2023). With many activities that occur on the road, it causes a larger volume of traffic, resulting in reduced road performance. Especially the large number of heavy vehicles passing through the road, causing traffic congestion (Srivastava & Kumar, 2023a).

The selection of Jalan Raya Lembar as the location of the research was based on the consideration that the area is one of the areas with fairly high traffic activity, especially as a connecting route between regions and access to the port. These conditions cause variations in traffic flow characteristics that are interesting to study. In addition, on the Lembar Highway section, side obstacles are often found that have the potential to affect the relationship between speed, density, and traffic flow. Activities around the road, such as vehicle entry and exit, pedestrian activities, parking vehicles, and the number of non-motorized vehicles cause disturbances to the smooth flow of traffic (Patkar & Dhamaniya, 2020). This condition has the potential to affect the characteristics of the relationship between speed, density, and traffic volume (Gulivindala & Mehar, 2018). Therefore, this location is considered relevant to be used as a research object in analyzing the characteristics of traffic flow.

Road capacity is a measure of the maximum ability of a road to accommodate traffic flow under certain conditions (Directorate General of Highways, PKJI 2023). If the volume of traffic approaches or exceeds capacity, there will be a decrease in the level of service (LoS), which is characterized by an increase in density, a decrease in average speed, and an increase in travel time (Raj & Vedagiri, 2022). Therefore, evaluating the capacity of a road section is an important thing to do to find out the level of road performance and determine the right handling steps in planning and traffic management (Najid & Marlianny, 2022).

Evaluation of road capacity is also an important basis in planning infrastructure development, such as road widening, construction of alternative routes, or the implementation of traffic management policies (Metz, 2021). Capacity analysis is also needed to ensure that existing road infrastructure is able to accommodate future traffic growth efficiently and sustainably (Millah, 2023). The analysis of road capacity can be calculated using PKJI 2023 or by using the Greenshield, Greenberg, Underwood, and Bell models.

In various studies, the analysis of the capacity of the road section can be calculated using PKJI 2023 or by using the Greenshield, Greenberg, Underwood, and Bell models. These four models are widely used in transportation studies because of their ability to identify the characteristics of traffic flow on a road, as well as provide an analytical basis for efficient and precise traffic management (Sholahudin & Nurmayadi, 2021). The models explain the relationship between volume, speed, and density included in the macroscopic traffic analysis (Aly, 2012; Liu, 2020). These three variables also describe the quality of capacity and level of service experienced by the driver of each vehicle (Martin & Brian, 1967). Through this approach, important parameters such as maximum volume, free flow speed, optimal density, and optimal speed can be determined, all of which are useful in the planning and control of transportation systems (Utama, 2016; Desmi et al., 2019).

Based on this, a study was conducted to analyze the relationship between volume, speed, and traffic flow density on the Lembar Highway section using the Greenshield, Greenberg, Underwood, and Bell models so that the most suitable model was obtained and compared the maximum volume based on the selected model with the capacity of the 2023 PKJI method (Rohani et al., 2025).

## METHOD

### Research Location and Time

This research was carried out on three segments on the Lembar Highway section, namely the road segment in front of Bank BNI Gerung Branch (segment 1), the road segment in front of the Jembatan Kembar Health Center (segment 2), and the road segment in front of the West Lombok Security Council (segment 3) on Jalan Raya Lembar located in West Lombok Regency, West Nusa Tenggara Province. This study started from 06.00-18.00 WITA, which was observed and recorded every 15 minutes.

### Data Collection Methods

a. Road geometric data

Geometric measurements of the road are carried out at night so as not to interfere with the flow of traffic. This survey includes lane width, number of lanes, lane width, number of lanes, and road shoulder width.

b. Traffic volume data

Traffic volume data was taken from 06.00-18.00 WITA and recorded at intervals of 15 minutes. The survey data will then be converted to junior high school units/hour by multiplying the vehicle equivalence for each type of vehicle and then summing it up. The following is the emp value (PKJI, 2023): SM = 0.7 , MP = 1 , KS = 1.5 , KB = 1.6, TB = 2.5 in the segment in front of Bank BNI Gerung Branch (segment 1), while the emp value is in the segment in front of the Twin Bridge Health Center (segment 2) and in front of the West Lombok Resort (segment 3), namely SM = 0.5 MP = 1, KS = 1.3, KB = 1.5, TB =2.5

c. Vehicle speed data

The speed of the vehicle used is the local speed (*Spoot Speed),* where this speed data is done by calculating the distance traveled along 50 m, then the distance traveled is divided by the travel time of each vehicle, so that the speed is obtained in units of m/s and after that it is converted into units of km/h and observed every 15 minutes.

## RESULT AND DISCUSSION

### Road Geometric Data

Road geometric data is needed to find out information about the condition of the road to be studied. The following is the geometric data obtained from the results of the survey on Jalan Dr. Sudjono:

**Table 1. Geometric Measurement Results of Sheet Road Sections**

| Segments | Number of columns | Column width (m) | Bandwidth (m) | Shoulder width (m) |
|---|---|---|---|---|
| Segment 1 | 2 | 5 | 10 | 1,6 |
| Segmen 2 | 2 | 3,5 | 7 | 1,45 |
| Segmen 3 | 2 | 3,5 | 7 | 1,725 |

Volume, Velocity and Density Analysis Results

Based on the results of the survey that has been conducted, the results of the calculation of volume in units of kend/hour were obtained and then converted into units of junior high school/hour, speed in units of km/hour and traffic density in units of junior high school/km. The results of the recapitulation are in Tables 2 to 4.

**Table 2. Recapitulation of Volume, Velocity and Density Values for Segment 1**

| Segmen 1 | | | |
|---|---|---|---|
| Time Interval | Volume (Q) | Speed (Vs) | Density (D) |
| | junior high school/hour | km/jam | Smp/km |
| 06.00-07.00 | 569,7 | 38,760 | 14,698 |
| 07.00-08.00 | 1573,6 | 31,296 | 50,281 |
| 08.00-09.00 | 972,6 | 38,117 | 25,516 |
| 09.00-10.00 | 1073,4 | 35,815 | 29,971 |
| 10.00-11.00 | 1210,5 | 37,594 | 32,199 |
| 11.00-12.00 | 1204,7 | 37,364 | 32,243 |
| 12.00-13.00 | 1162,4 | 37,156 | 31,285 |
| 13.00-14.00 | 1125,6 | 37,882 | 29,714 |
| 14.00-15.00 | 1356,8 | 36,422 | 37,252 |
| 15.00-16.00 | 1177,6 | 36,542 | 32,226 |
| 16.00-17.00 | 1580,6 | 34,985 | 45,180 |

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| 17.00-18.00 | 1606,6 | 32,205 | 49,886 |
|---|---|---|---|

**Table 3. Volume, Velocity and Density Values Recapitulation for Segment 2**

| | Segmen 2 | | |
|---|---|---|---|
| Time Interval | Volume (Q) | Speed (Vs) | Density (D) |
| | junior high school/hour | km/jam | Smp/km |
| 06.00-07.00 | 836,1 | 43,398 | 19,266 |
| 07.00-08.00 | 1545,2 | 42,430 | 36,417 |
| 08.00-09.00 | 1199,8 | 42,308 | 28,359 |
| 09.00-10.00 | 1169,1 | 42,428 | 27,555 |
| 10.00-11.00 | 1287,7 | 41,629 | 30,933 |
| 11.00-12.00 | 1123,1 | 42,562 | 26,387 |
| 12.00-13.00 | 986,6 | 42,245 | 23,354 |
| 13.00-14.00 | 1174,7 | 43,467 | 27,025 |
| 14.00-15.00 | 1220,8 | 42,431 | 28,771 |
| 15.00-16.00 | 1489,4 | 41,263 | 36,095 |
| 16.00-17.00 | 1764,8 | 38,995 | 45,257 |
| 17.00-18.00 | 1424,6 | 40,210 | 35,429 |

**Table 4. Volume, Velocity and Density Values Recapitulation for Segment 3**

| | Segmen 3 | | |
|---|---|---|---|
| Time Interval | Volume (Q) | Speed (Vs) | Density (D) |
| | junior high school/hour | km/jam | Smp/km |
| 06.00-07.00 | 696,9 | 43,780 | 15,918 |
| 07.00-08.00 | 1424,2 | 40,030 | 35,578 |
| 08.00-09.00 | 1258,4 | 40,036 | 31,432 |
| 09.00-10.00 | 1189,6 | 41,861 | 28,418 |
| 10.00-11.00 | 1423,9 | 41,764 | 34,094 |
| 11.00-12.00 | 1437,2 | 40,703 | 35,309 |
| 12.00-13.00 | 1437,3 | 40,631 | 35,374 |
| 13.00-14.00 | 1089,7 | 40,954 | 26,608 |
| 14.00-15.00 | 1204,4 | 41,160 | 29,261 |
| 15.00-16.00 | 1225,4 | 40,487 | 30,266 |
| 16.00-17.00 | 1367,0 | 39,793 | 34,352 |
| 17.00-18.00 | 1595,9 | 35,795 | 44,584 |

**Model Analysis of the Relationship Between Volume, Speed and Traffic Density**

After analysis of the three parameters, the relationship between speed and density (Vs-D), volume and density (Q-D), and volume with speed (Q-Vs) was obtained. The results of the analysis of the relationship between the three parameters using the Greenshield, Greenberg, Underwood and Bell models can be seen in tables 5 to 7. Meanwhile, the value of the correlation coefficient (r) and the determination coefficient (r2) can be seen in table 8.

**Table 5. Recapitulation of Q-Vs-D Relationship Model Calculation Results (Segment 1)**

| Model *Greenshield* | |
|---|---|
| Hubungan | Equations |
| US-D | $\mathrm{Vs} = 43{,}183 \; - 0{,}025 \times \mathrm{D}$ |
| Q-D | $\mathrm{Q} = \; 43{,}183 \times \mathrm{D} - 0{,}025 \times \mathrm{D}^2$ |
| Q-Vs | $\mathrm{Q} = \; -210{,}862 \times \mathrm{Vs}4{,}883 \times \mathrm{Vs}^{2}$ |
| **Model *Greenberg*** | |
| Hubungan | Equations |
| US-D | $\mathrm{Vs} = 6{,}380 \; \times \ln(\frac{2063{,}807}{\mathrm{D}})$ |
| Q-D | $\mathrm{Q} = 8{,}417 \; \times \mathrm{D} \times \ln(\frac{373{,}313}{\mathrm{D}})$ |
| Q-Vs | $\mathrm{Q} = 2063{,}807 \; \times \mathrm{V_s} \times \; e^{-\frac{\mathrm{Vs}}{6{,}380}}$ |
| **Model *Underwood*** | |
| Hubungan | Equations |
| US-D | $\mathrm{Vs} = 44{,}083 \; \times \; e^{-\frac{\mathrm{D}}{171{,}357}}$ |
| Q-D | $\mathrm{Q} \quad \mathrm{Q} \quad = 44{,}083 \; \times \mathrm{D} \times e^{-\frac{\mathrm{D}}{171{,}357}}$ |
| Q-Vs | $\mathrm{Q} \quad \mathrm{Q} \; = 171{,}357 \; \times \mathrm{Vs} \times \ln(\frac{44{,}083}{\mathrm{Vs}})$ |
| **Model *Bell*** | |
| Hubungan | Equations |
| US-D | $\mathrm{Vs} = 52{,}076 \times \; e^{-0.5\,(\frac{\mathrm{D}}{3{,}974})^2}$ |
| Q-D | $\mathrm{Q} = 52{,}067 \; \times \mathrm{D} \times e^{-0.5\,(\frac{\mathrm{D}}{3{,}974})^2}$ |
| Q-Vs | $\mathrm{Q} = 5{,}62 \times \mathrm{Vs} \times \ln(\frac{52{,}076}{\mathrm{Vs}})^{0.5}$ |

**Table 6. Recapitulation of the Calculation Results of the Q-Vs-D Relationship Model (Segment 2)**

| Model *Greenshield* | |
|---|---|
| Hubungan | Equations |
| US-D | $\mathrm{Vs} = 46{,}617 \; - 0{,}155 \times \mathrm{D}$ |
| Q-D | $\mathrm{Q} = \; 46{,}617 \times \mathrm{D} - 0{,}155 \times \mathrm{D}^2$ |
| Q-Vs | $\mathrm{Q} = \; -300{,}391 \times \mathrm{Vs}6{,}436 \times \mathrm{Vs}^{2}$ |
| **Model *Greenberg*** | |
| Hubungan | Equations |
| US-D | $\mathrm{Vs} = 7{,}153 \times \ln(\frac{1448{,}339}{\mathrm{D}})$ |
| Q-D | $\mathrm{Q} = 7{,}153 \; \times \mathrm{D} \times \ln(\frac{1448{,}339}{\mathrm{D}})$ |
| Q-Vs | $\mathrm{Q} = 1448{,}339 \; \times \mathrm{V_s} \times \; e^{-\frac{\mathrm{Vs}}{7{,}153}}$ |
| **Model *Underwood*** | |
| Hubungan | Equations |
| US-D | $\mathrm{Vs} = 47{,}020 \; \times \; e^{-\frac{\mathrm{D}}{265{,}323}}$ |
| Q-D | $\mathrm{Q} = 47{,}020 \; \times \mathrm{D} \times e^{-\frac{\mathrm{D}}{265{,}323}}$ |
| Q-Vs | $\mathrm{Q} = 265{,}323 \; \times \mathrm{Vs} \times \ln(\frac{47{,}020}{\mathrm{Vs}})$ |
| **Model *Bell*** | |
| Hubungan | Equations |

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| | |
|---|---|
| US-D | $Vs = 52{,}556 \times e^{-0.5\,(\frac{D}{4{,}926})^2}$ |
| Q-D | $Q = 52{,}556 \times D \times e^{-0.5\,(\frac{D}{4{,}926})^2}$ |
| Q-Vs | $Q = 6{,}996 \times Vs \times \ln(\frac{52{,}556}{Vs})^{0.5}$ |

**Table 7. Recapitulation of the Calculation Results of the Q-Vs-D Relationship Model (Segment 3)**

| Model *Greenshield* | |
|---|---|
| Hubungan | Equations |
| US-D | $Vs = 48{,}007 - 0{,}234 \times D$ |
| Q-D | $Q = 48{,}007 \times D - 0{,}234 \times D^2$ |
| Q-Vs | $Q = -205{,}418 \times Vs4{,}279 \times Vs^2$ |
| **Model *Greenberg*** | |
| Hubungan | Equations |
| US-D | $Vs = 8{,}417 \times \ln(\frac{373{,}313}{D})$ |
| Q-D | $Q = 8{,}417 \times D \times \ln(\frac{373{,}313}{D})$ |
| Q-Vs | $Q = 377{,}313 \times V_s \times e^{-\frac{V_s}{8{,}417}}$ |
| **Model *Underwood*** | |
| Hubungan | Equations |
| US-D | $Vs = 48{,}920 \times e^{-\frac{D}{166{,}899}}$ |
| Q-D | $Q = 48{,}920 \times D \times e^{-\frac{D}{166{,}899}}$ |
| Q-Vs | $Q = 166{,}899 \times Vs \times \ln(\frac{48{,}920}{Vs})$ |
| **Model *Bell*** | |
| Hubungan | Equations |
| US-D | $Vs = 56{,}761 \times e^{-0.5\,(\frac{D}{4{,}080})^2}$ |
| Q-D | $Q = 56{,}761 \times D \times e^{-0.5\,(\frac{D}{4{,}080})^2}$ |
| Q-Vs | $Q = 5{,}779 \times Vs \times \ln(\frac{56{,}761}{Vs})^{0.5}$ |

**Table 8. Values of correlation coefficient (r) and determination coefficient (r2)**

| Model *Greenshield* | | | | | | |
|---|---|---|---|---|---|---|
| Hubungan | Segmen 1 | | Segmen 2 | | Segmen 3 | |
| | R | R2 | R | R2 | R | R2 |
| US-D | 0,9051 | 0,8156 | 0,8435 | 0,7116 | 0,8607 | 0,7409 |
| Q-D | 1 | 1 | 1 | 1 | 1 | 1 |
| Q-Vs | 0,934 | 0,8715 | 0,8232 | 0,7026 | 0,8955 | 0,802 |
| **Model *Greenberg*** | | | | | | |
| Hubungan | Segmen 1 | | Segmen 2 | | Segmen 3 | |
| | R | R2 | R | R2 | R | R2 |
| US-D | 0,782 | 0,6119 | 0,7946 | 0,6315 | 0,9153 | 0,8378 |
| Q-D | 0,9871 | 0,9744 | 0,9956 | 0,9913 | 0,9976 | 0,9953 |
| Q-Vs | 0,8953 | 0,8017 | 0,8051 | 0,6452 | 0,7727 | 0,5972 |
| **Model *Underwood*** | | | | | | |
| Hubungan | Segmen 1 | | Segmen 2 | | Segmen 3 | |
| | R | R2 | R | R2 | R | R2 |
| US-D | 0,826 | 0,6824 | 0,7908 | 0,6254 | 0,8484 | 0,7191 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Q-D | 0,9727 | 0,9462 | 0,9877 | 0,9756 | 0,9719 | 0,9447 |
| Q-Vs | 0,943 | 0,8965 | 0,8289 | 0,6871 | 0,8913 | 0,7945 |
| **Model *Bell*** | | | | | | |
| Hubungan | Segmen 1 | | Segmen 2 | | Segmen 3 | |
| | R | R2 | R | R2 | R | R2 |
| US-D | 0,7979 | 0,6367 | 0,8261 | 0,6826 | 0,8223 | 0,6763 |
| Q-D | 0, 9868 | 0,9738 | 0,9717 | 0,9443 | 0,9924 | 0,9849 |
| Q-Vs | 0,7578 | 0,5744 | 0,7284 | 0,5306 | 0,8691 | 0,7554 |

**Model Depiction of Segments 1, 2, and 3**

The relationship model between the three parameters for the four models reviewed can be seen in figures 1 to 4.

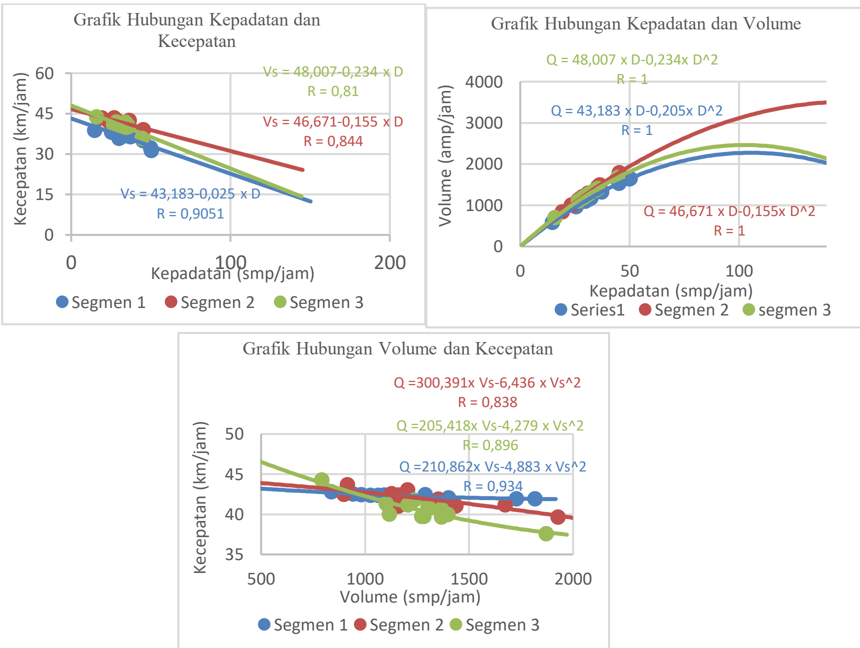


**Figure 2. Graph of the Relationship Between Vs – D, Q – D, Q – Vs, With Greenslield's Model, Segments 1, 2, and 3**

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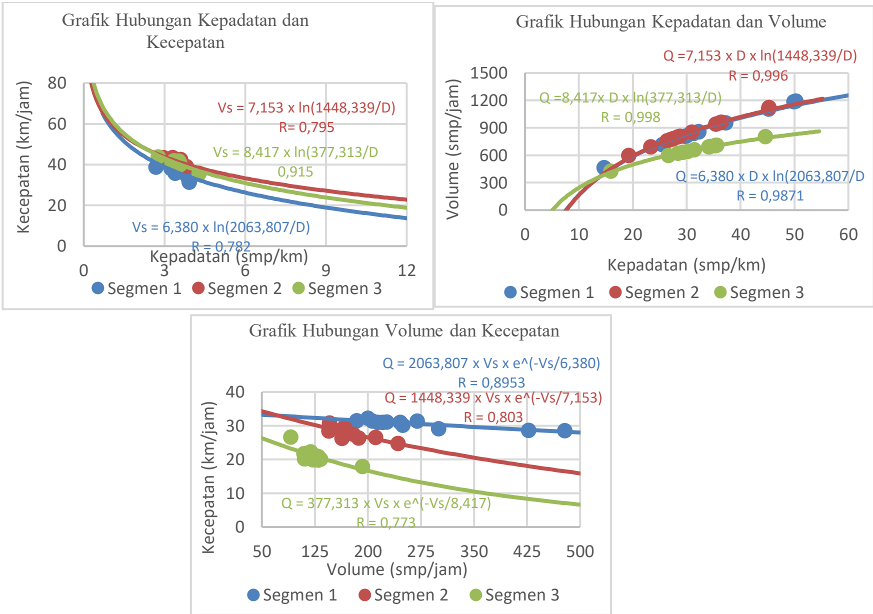


**Figure 3. Graph of the Relationship Between Vs – D, Q – D, Q – Vs, With Greenberg's Model, Segments 1, 2, and 3**

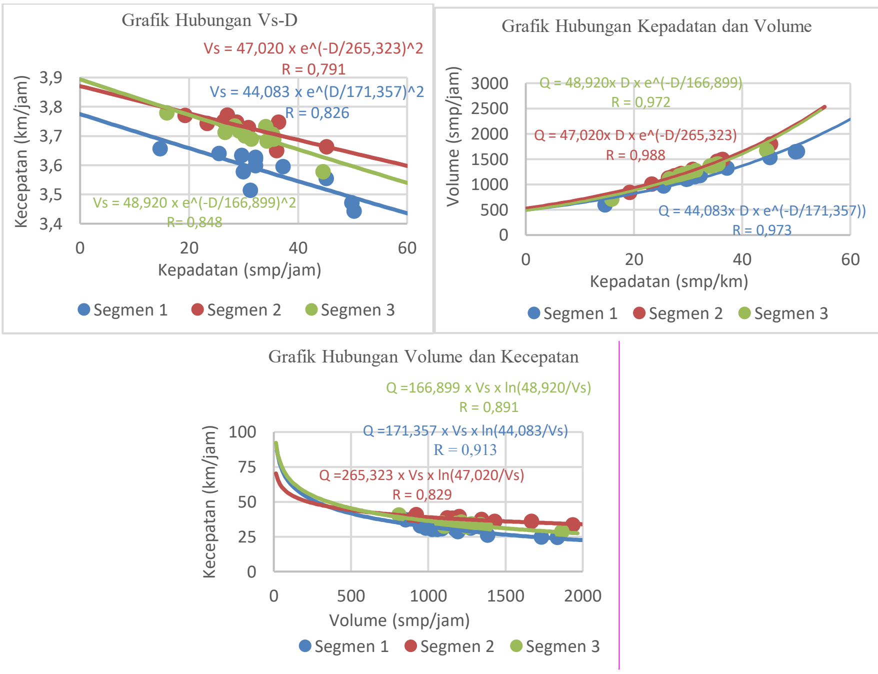


**Figure 4. Graph of the Relationship Between Vs – D, Q – D, Q – Vs, With Underwood's Model, Segments 1, 2, and 3**

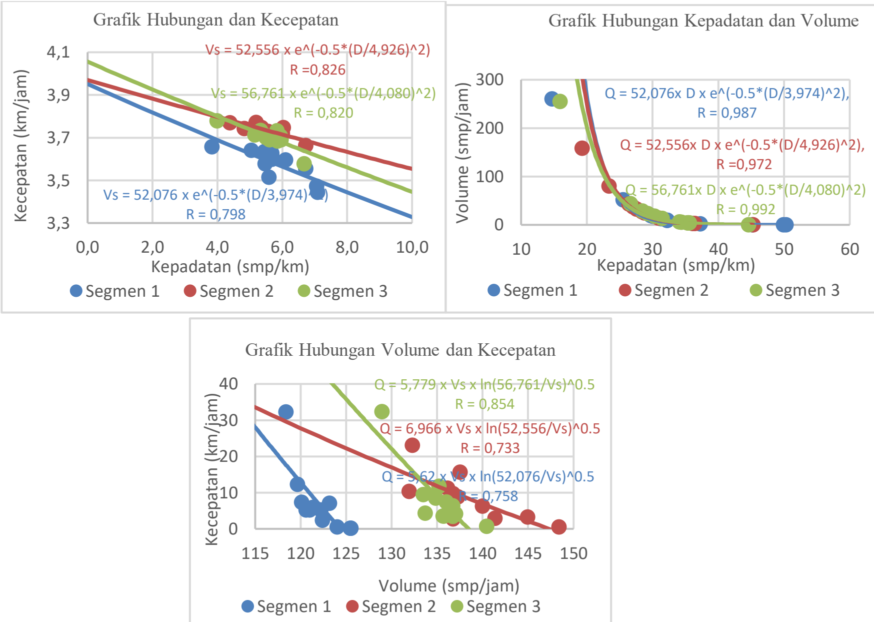


**Figure 5. Graph of the Relationship Between Vs – D, Q – D, Q – Vs, With the Bell Model, Segments 1, 2, and 3**

In addition to the model of the relationship between volume, speed and traffic density as shown in the table above, the characteristics of traffic flow can also be obtained including the maximum volume (Qm), maximum speed (Vm), free flow speed (Vsff), maximum density (Dm) and congestion density (Dj) from the four models reviewed, namely the Greenshield, Greenberg, Underwood and Bell models. The following is a recapitulation of the characteristics in each model.

**Table 7. Traffic characteristics on each Segment 1 model**

| Parameter | Segmen 1 | | | |
|---|---|---|---|---|
| | Greenshield | Greenberg | Underwood | Bell |
| Volume Maksimum/Qm (smp/jam) | 2276,403 | 13167,598 | 2778,954 | 125,529 |
| Kecepatan Maksimum/Vm (km/jam) | 21,591 | 6,380 | 16,217 | 31,586 |
| Kecepatan Arus Bebas/Vsff (km/jam) | 43,183 | ∞ | 44,083 | 52,076 |
| Kepadatan Maksimum/Dm (smp/km) | 105,431 | 2063,807 | 171,357 | 3,974 |
| Kerapatan Pada Saat Macet/Dj (smp/km) | 210,862 | 5610,006 | ∞ | ∞ |

**Table 8. Traffic characteristics on each Segment 2 model**

| Parameter | Segmen 2 | | | |
|---|---|---|---|---|
| | Greenshield | Greenberg | Underwood | Bell |
| Volume Maksimum/Qm (smp/jam) | 3111,682 | 10360,446 | 4589,445 | 157,023 |
| Kecepatan Maksimum/Vm (km/jam) | 23,335 | 7,153 | 17,298 | 31,877 |
| Kecepatan Arus Bebas/Vsff (km/jam) | 46,671 | ∞ | 47,020 | 52,556 |
| Kepadatan Maksimum/Dm (smp/km) | 133,346 | 1448,339 | 265,323 | 4,926 |
| Kerapatan Pada Saat Macet/Dj (smp/km) | 266,691 | 3936,990 | ∞ | ∞ |

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**Table 9. Traffic characteristics on each model Segment 3**

| Parameter | Segmen 3 | | | |
|---|---|---|---|---|
| | Greenshield | Greenberg | Underwood | Bell |
| Volume Maksimum/Qm (smp/jam) | 2465,361 | 3176,673 | 3003,598 | 140,474 |
| Kecepatan Maksimum/Vm (km/jam) | 24,003 | 8,417 | 17,997 | 34,427 |
| Kecepatan Arus Bebas/Vsff (km/jam) | 48,007 | ∞ | 48,920 | 56,761 |
| Kepadatan Maksimum/Dm (smp/km) | 102,709 | 377,428 | 166,899 | 4,080 |
| Kerapatan Pada Saat Macet/Dj (smp/km) | 205,418 | 1025,955 | ∞ | ∞ |

Based on statistical analysis of the four models, it was shown that the Greenshield model had the highest correlation coefficient (r) values in segment 1 (high side resistance) and segment 2 (moderate side resistance), thus indicating a very strong level of relationship. Thus, it can be concluded that the Greenshield model is the most appropriate model to be used in both segments. Meanwhile, in segment 3 (low side resistance), Greenberg's model produced the largest correlation coefficient value compared to the other three models. However, the density value during traffic jams (Dj) obtained is very large, which is 1025,955 smp/km, so it is considered not in accordance with the conditions in the field. Therefore, the model that is considered most suitable for segment 3 is the Greenshield model with a correlation coefficient value (r) of 0.861, although the value is lower than the Greenberg model. Thus, it can be concluded that the most suitable model for segments 1, 2, and 3 is the Greenshield model.

Based on the model that best suits the road segment, namely the Greenshield model, the characteristics of the traffic flow are as follows:

**Table 10. Characteristics of the traffic flow model in Segments 1, 2 and 3**

| **Parameter** | **Model *Greenshiled*** | | |
|---|---|---|---|
| | **Segmen 1** | **Segmen 2** | **Segmen 3** |
| Maximum Volume/Qm (smp/h) | 2276,403 | 3111,684 | 2465,361 |
| Maximum Speed/Vm (km/h) | 21,591 | 23,335 | 24,003 |
| Free Current Speed/Vsff (km/h) | 43,183 | 46,671 | 48,007 |
| Maximum Density/Dm (smp/km) | 105,431 | 133,346 | 102,709 |
| Density During Traffic Jam/Dj (smp/km) | 210,862 | 266,691 | 205,418 |

**Capacity**

Capacity (C) in segment 1 with high side resistance

C = C0 x FCLJ x FCPA x FCHS

= 4000 x 1.21 x 0.97 x 0.917

= 4305.13 smp/h

Segment 2 capacity with medium side resistance

= 4000 x 1.00 x 0.97 x 0.94

= 3647.20 smp/h

Segment 3 capacity with low side resistance

C = 4000 x 1.00 x 0.97 x 0.985

= 3821.80 smp/h

The maximum volume (Qm) based on the most suitable model, namely the Greenshield model in segment 1, is 2276.403 smp/hour, while the capacity reaches 4305.13 smp/hour. This condition shows that the maximum volume is still below capacity, so that the road section in the segment is still able to accommodate the flow of passing traffic. The same thing also happened in segment 2, where the maximum volume (Qm) was 3111.682 smp/hour. When compared to the capacity in segment 2 which is 3647.20 smp/hour, it can be seen that the maximum volume remains lower than the capacity, so that the road section can still accommodate the existing traffic flow. In segment 3 where the most suitable model is Greenshield, the maximum volume (Qm) is obtained of 2465.361 smp/hour, while the capacity is 3647.20 smp/hour. This shows that the capacity of the road section is still sufficient to accommodate the flow of traffic passing through the segment.

## CONCLUSION

Based on the results of the analysis and discussion using four approach models on the three segments of the Gerung Lembar Highway, it can be concluded that the most suitable model for segment 1, segment 2, and segment 3 is the Greenshield model compared to the other three models, with correlation coefficient (R) values of 0.9051, 0.8435, and 0.8607, respectively. Based on the selected model, the traffic flow characteristics in segment 1 show a maximum volume (Qm) of 2276.403 smp/hour, maximum speed (Vm) of 21.591 km/hour, free-flow speed (Vsff) of 43.183 km/hour, maximum density (Dm) of 105.431 smp/km, and jam density (Dj) of 210.862 smp/km.

In segment 2, the maximum volume (Qm) is 3111.682 smp/hour, maximum speed (Vm) is 23.335 km/hour, free-flow speed (Vsff) is 46.671 km/hour, maximum density (Dm) is 133.346 smp/km, and jam density (Dj) is 266.691 smp/km. Meanwhile, in segment 3, the maximum volume (Qm) is 2465.361 smp/hour, speed at peak flow (Vm) is 24.003 km/hour, free-flow speed (Vsff) is 48.007 km/hour, maximum density (Dm) is 102.709 smp/km, and jam density (Dj) is 205.418 smp/km. Furthermore, the road capacity based on PKJI 2023 is 4305.13 smp/hour in segment 1, 3647.20 smp/hour in segment 2, and 3821.80 smp/hour in segment 3. When compared with the maximum volume obtained from the selected model, the maximum volume values in all segments remain below the road capacity, indicating that the road sections are still able to accommodate the existing traffic flow.

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