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The Effect of Heavy Vehicles on Road Performance R.E. Martadinata Palu Using a Model of the Relationship between Volume, Speed and Traffic Density

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Abstract: The traffic flow on a road segment is analyzed using three characteristics: Speed, Volume, and Traffic Density. Three models are employed to illustrate the mathematical link among volume, speed, and traffic density: Greenshield, Greenberg, and Underwood. This research aims to elucidate the correlation among volume, speed, and traffic density on the R.E. Martadinata Palu road section, evaluate the performance of the road segment, and examine the influence of heavy vehicles on the current conditions. The investigation of the three models, grounded in statistical evaluation and field features, culminated in the preliminary conclusion that the Greenberg relationship model yields the most accurate representation of the current conditions. The Greenberg model yields a coefficient of determination of $r^2 = 0.76$ for scenarios involving heavy vehicles and $r^2 = 0.82$ for scenarios devoid of heavy vehicles, with Vmaks values of 1725 smp/hour and 1534 smp/hour for each condition, respectively, and an estimated model capacity reduction of 11.07% when transitioning from conditions with heavy vehicles to those without. This signifies that the model's capability is affected by the traffic volume. Utilizing the MKJI 1997 methodology, the DS value was determined to be 0.56 with HV and 0.53 without HV, indicating that the RE. Martadinata road segment is much below saturation levels that would result in congestion during peak traffic periods.

Keywords: *Volume, Speed, Density, Greenshield Model, Greenberg Model, Underwood Model, MKJI 1997 Method, Heavy Vehicles.*

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I. INTRODUCTION

Palu City, as the capital of Central Sulawesi Province, just like other cities, experiences significant development every year. The developments that occurred were both population growth, infrastructure and economic growth, which was followed by an increase in the number of logistics needs of the people of Palu City. Data from BPS 2022 shows that ADHK's Gross Regional Domestic Product (GRDP) according to Palu City expenditure in 2021 is 16.39 trillion rupiah and has increased by 5.97% compared to conditions in 2020 which was 15.46 trillion rupiah. All components of consumption expenditure, both household and government, experience increases every year. This implies an increase in logistics mobility flows to Palu City every year in line with the large increase in consumption of the people of Palu City. This will of course be parallel with the increase in the number of heavy vehicle activities which are the main means of logistics distribution on land routes. RE Road. Martadinata as one of the connecting sections entering Palu City and the reverse direction, both from the East Cross route (Palu—Kebon Kopi—Marisa—Gorontalo), the West Cross route (Palu—Pantoloan Harbor—Tolitoli—Buol) and the Central Cross route (Palu—Kebon Kopi—Parigi—Poso) is one of the main sections for heavy vehicle movement. Heavy vehicles that will load and unload goods will mostly pass through this road section before entering the center of Palu City and leaving Palu City either towards the port or overland. This description is one of the considerations in which the central government's authority needs to be studied further.

The theory of traffic flow movements plays an important role in planning, designing and determining various transportation system policies (Utama, 2016). Traffic movement theory explains the quality and quantity of traffic flow so that the most appropriate policy or system selection can be implemented to accommodate existing traffic (road capacity). One approach to understanding traffic behavior in the application of traffic movement theory is to describe it in the form of mathematical and graphical relationships, where theoretically there is a basic relationship

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between volume (flow), speed (speed) and density (density). When applied, these three factors can be used as a basis for implementing traffic management according to existing road conditions.

This research will examine the influence of heavy vehicle activity on road performance using a model of the relationship between Volume, Speed and Traffic Density on the R.E. Road section. Martadianta, Palu City and to describe this mathematical relationship, the author tries to use three approach models including the Greenshield, Greenberg and Underwood models. To examine the description above, in this research the author took the title "The Influence of Heavy Vehicles on the Performance of Road Sections R.E. Martadinata Palu Using a Model of the Relationship between Volume, Speed and Traffic Density".

The objectives of this research are: (1) Describe the relationship between volume, speed and density of traffic flow on the R.E. Martadinata Palu, (2) Provide an assessment of the performance of the R.E. Martadinata road section and (3) Analyze the influence of heavy vehicles on the existing condition of the performance of the R.E. road section. Martadinata Palu.

II. LITERATURE REVIEW

A. *Traffic Flow Characteristics*

The characteristics of traffic flow are determined by the relationships between variables. The pattern of traffic flow is determined by the motions of individual drivers who interact with one another on a road section and the environment in which they are traveling. There is no way to further standardize the behavior of vehicles that are involved in traffic flow. This is due to the fact that the perceptions and capabilities of individual drivers are different. As a result, traffic flow will experience different characteristics as a result of different driver behavior due to local characteristics and driver habits. It is possible that the features of the flow of traffic on a particular road segment will change depending on the time of day. Therefore, the behavior of drivers will have an effect on the behavior of traffic flow. It is necessary to provide a parameter in order to provide a quantitative description of traffic flow in order to gain an understanding of the variety of its characteristics and the range of conditions under which it operates. In order for traffic engineers to analyze, evaluate, and make adjustments to traffic facilities based on the parameters and knowledge of the perpetrators, these parameters need to be able to be specified and assessed by traffic engineers (Oglesby, C.H., & Hicks.R.G. 1998).

➢ *Volume (V)*

Volume is the number of cars seen crossing a certain spot on a road over a set period of time. Traffic volume is typically stated in terms of vehicles per hour (vph) or vehicles per day (vpd).

➢ *Speed (S)*

The second primary measure that elucidates the condition of traffic flow on the roadway is speed. McShane, Roess, and Prassas (2004) define speed as the ratio of vehicle movement across a distance per unit of time. In traffic flow, each vehicle operates at a unique velocity; therefore, a singular speed characteristic is not recognized; rather, a distribution of individual vehicle velocities is observed. The traffic flow's characteristics can be determined by utilizing the average or typical value derived from that distribution (Timpal et al., 2018).

➢ *Density (D)*

The number of vehicles occupying a specific length of road over a specific period is referred to as density, which is expressed as the number of vehicles per unit length or per lane. The density of a two-lane undivided two-way road segment is denoted by the number of vehicles per unit length of the complete two-way length, which is measured in vehicles/km or smp/km.

B. *Traffic Composition*

All traffic flows are converted into Passenger Car Units (SMP) using passenger car equivalents (EMP). Passenger Car Equivalence (EMP) for each type of vehicle depends on the type of road and total traffic flow expressed in vehicles/hour.

Table 1: Passenger Car Equivalence Value (PCV)

Type of Vehicle	PCV Factor
Motorcycle (MC)	0,4
Light Vehicle (LV)	1,0
Heavy Vehicles (HV)	1,3

C. *The Relationship Between Volume, Speed, and Density*

➢ *The Characteristics of the Traffic Flow in a Highway Segment are Determined by Three Primary Variables:*

- Volume, which is the number of vehicles past a specific observation point on a stretch of road per unit of time.
- Speed is the maximum distance that a vehicle can travel on a given section of road in a given amount of time.
- Density, which is the quantity of vehicles per unit length of a specific road.

D. *Volume, Speed, and Density Relationship Model*

➢ *Greendshield Method*

Traffic conditions were steady-state, with no interruptions, on a road segment located outside the city of Ohio, where the Greenshield study was conducted. The relationship between average space speed and vehicle density in a traffic flow is linear, as per Greenshield. The unrestricted flow speed (Sf) and jam density (Dj) values are necessary for the completion of the speed-density relationship equation in this model. The value of Sf is more easy to estimate in the field, as it is situated between the intended speed of the road and the speed limit. Furthermore, the value of traffic density is exceedingly challenging to ascertain in the field, with a general range of 185 to 250 vehicles per mile, presuming that the space required for vehicles is between 21 and 28 feet. However, the field conditions, which yield values ranging from 40 to 70

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vehicles per mile, do not align with the optimal density value (Do), which is half of the Dj value. If the density value falls within the range of 27% to 90% of the maximal density value, this model is appropriate (Saxena 1983, in Widana N, I.N 1991).

➤ *Greenberg Method*

Greenberg Research In 1959, a research was performed on a tunnel in Lincoln, New York, where traffic flow was regarded as fluid flow by examining the correlation between speed and density. The study's findings indicated that the correlation between speed and density is a logarithmic function. This model yields a more accurate estimation of jam density (Dj) and establishes a speed-density correlation appropriate for medium to high densities; nevertheless, it generates an inadequate free flow speed (Sf) value for low densities.

➤ *Underwood Method*

According to the Underwood model, which was developed using traffic data on Connecticut's Merrit Parkway, there is an exponential link between density and speed. When the average space speed is equal to the free flow speed at zero density, this model fits well for low traffic quantities but poorly for high traffic volumes.

E. The Capacity of Roads

The ability of a road segment to handle an ideal flow or volume of traffic within a specific time period is known as road capacity. This can be expressed in the number of vehicles that a road segment can handle in an hour (veh/h) or by taking into account the different types of vehicles that travel on a road and using passenger car units as the unit of vehicles in the capacity calculation. As a result, capacity is expressed in passenger car units per hour, or (pcu)/h.

F. Degree of Saturation

Degree of Saturation (DS) is defined as the ratio of volume (Q) to capacity (C) and is an important component in predicting traffic behavior on a road segment. The DS value reflects whether the road segment is still at capacity or not.

G. Level of Service

Level of Service quantifies the performance of a road segment or intersection, determined by factors such as traffic volume, speed, density, and encountered impediments. The quality of service can be assessed according to six distinct degrees of service.

III. METHODOLOGY OF RESEARCH

In this study, the author used a survey research type with a quantitative approach. The survey was conducted over a period of one day, specifically on Wednesday. Where on that day it is considered stable because the activities of the community, whether in offices, schools, universities, or the general public, are already in a stable condition and it is a day when many vehicles pass by, according to information from the UPPKB Kayumalue Transportation Department. The survey will be conducted for 15 hours, from 07:00 to 22:00 WITA.

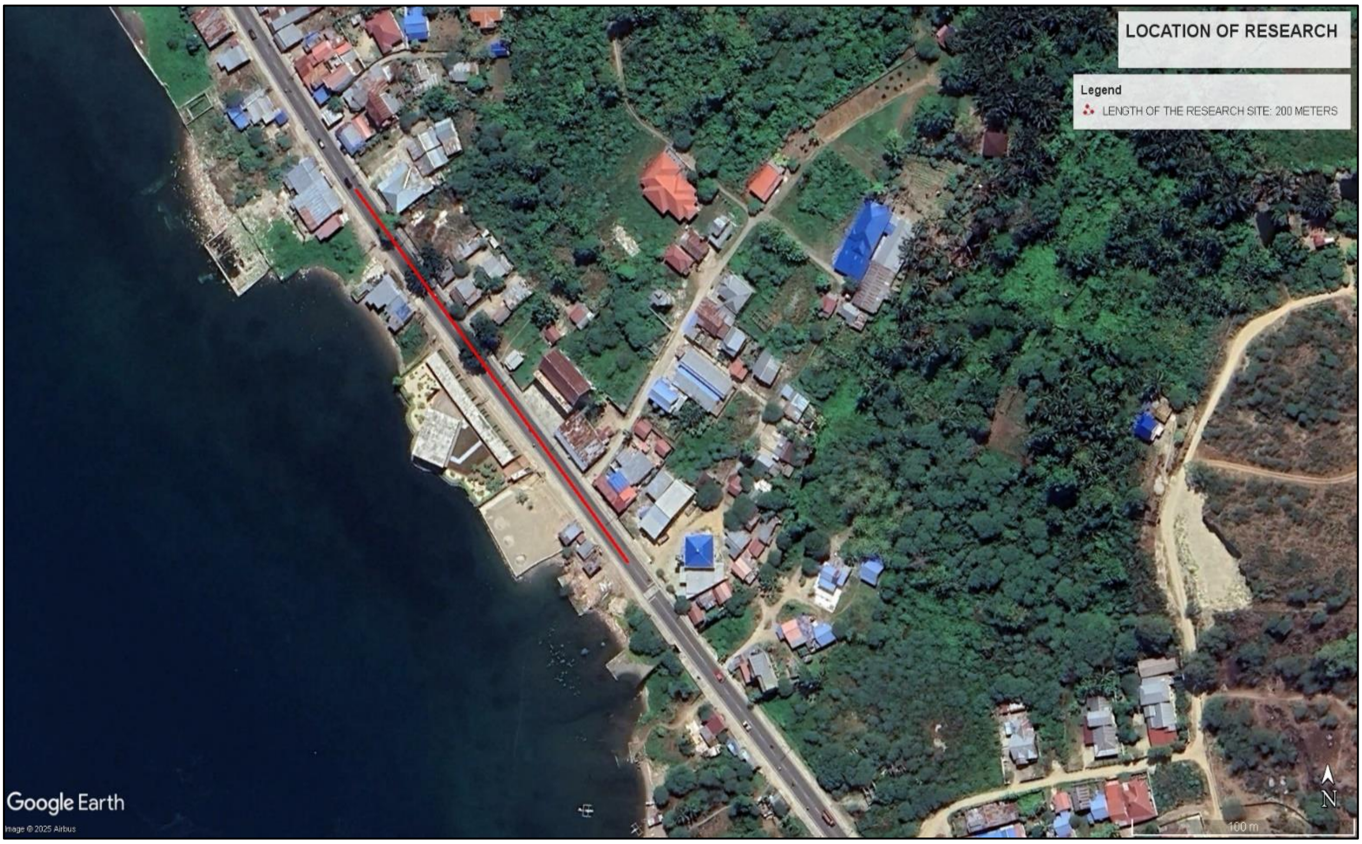

Fig 1: Location of Research

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A. Primary Data

- Traffic volume data covering the number of motorcycles (MC), light vehicles (LV), and heavy vehicles (HV)
- Average Speed Field space is measured using the local speed method, and the type of vehicle speed examined is the average space speed within the research location boundaries.
- Road inventory data that includes the width of the road segment, the number of lanes, and the type of roadside obstacles if any. and others

B. Data Analysis (Analysis of the Relationship between Volume, Speed, and Density)

The Greenshield, Greenberg, and Underwood model techniques are utilized in order to conduct an analysis of the relationship that exists between frequency, volume, and density. The parameters of the model were obtained through the process of regression analysis. In order to ascertain the precision of the regression function, a statistical test was carried out. This test consisted of the correlation analysis of speed and density variables, which involved determining the coefficient of determination (r2), the t-test, and the significance test (F test). It is possible to determine the Road Capacity value by incorporating the values of the model parameters into the equation that represents the maximum volume of each model. By taking into account the actual traffic circumstances at the research location, the outcomes of statistical tests, estimates of congestion density, and capacity, it is possible to construct a model that is a near approximation of the conditions that are now present in the field.

C. Calculating the Performance Value of Road Segments

Calculation of road capacity with the MKJI 1997 Method, thereafter calculating the Degree of Saturation (DS) and determining the Level of Service (LoS) based on the DS value. The subsequent step involves analyzing the comparative road capacity values derived from the Greenberg, Greenshield, and Underwood models in relation to the MKJI 1997 technique, followed by an examination of the influence of heavy vehicles on road capacity.

IV. RESULTS AND DISCUSSION

A. Traffic Data Volume

Traffic volume refers to the quantity of cars that traverse a specific spot or line along a roadway. Volume computation is executed by translating the surveyed number of vehicles per type (MC, LV, and HV) into passenger car equivalent values (emp).

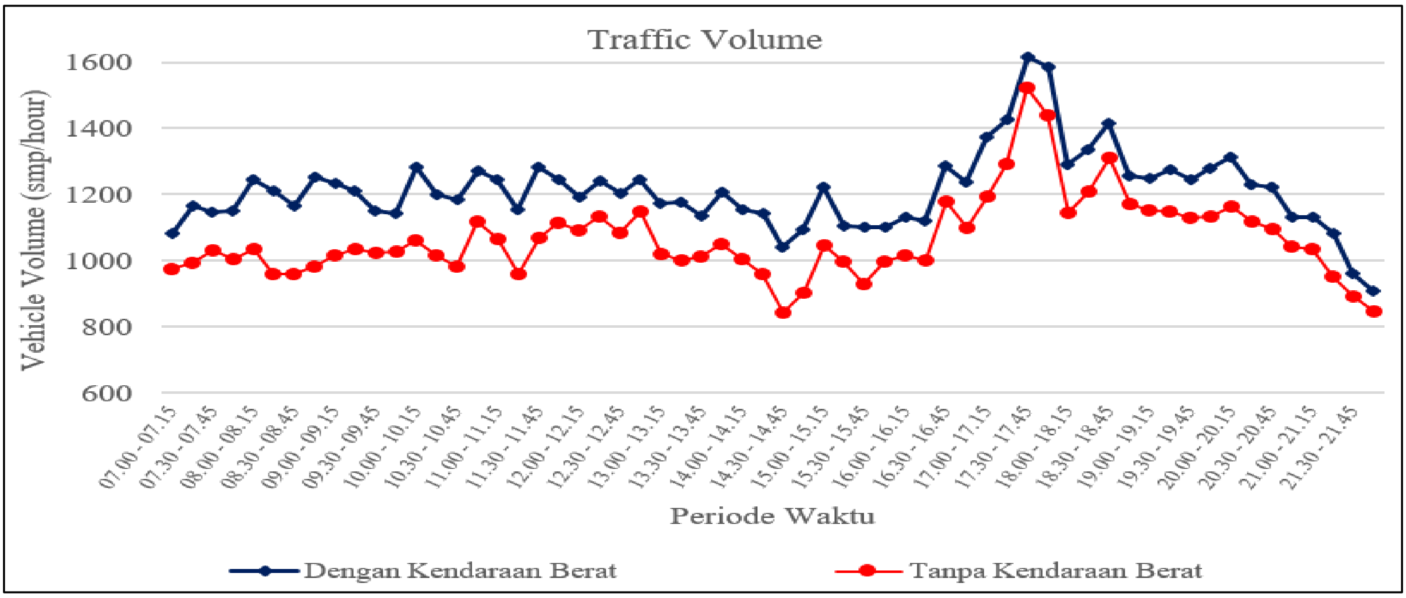

Fig 2: Peak Traffic Volume Graph (Each Condition)

The term "travel time" refers to the typical amount of time that it takes for a vehicle to travel along a predetermined stretch of road. Similar to the way that data on traffic volume is separated, data on journey time is likewise separated according to the kind of vehicle and the direction of movement in each direction.

After the number of vehicles (smp/hour) (n) and the travel time of vehicles (t) within a 15-minute interval are known, the average space speed data for each type of vehicle can be obtained. The calculation of the density variable can be determined by dividing the volume (V) in smp/hour by the average space speed (S) in km/hour.

B. The Relationship Between Volume, Speed, and Density

This study analyzed the link among speed, volume, and density utilizing the Greenshield, Greenberg, and Underwood model methodologies. Let S represent the average space speed, Sf the free flow speed, So the ideal speed, D the density, So the optimum density, and Dj the jam density. The regression coefficients a and b are derived from the regression analysis of the speed-density relationship, wherein the speed-density model is reformulated into a linear equation, y = ax + b.

Table 2: Model of the Relationship between Speed, Volume, and Density

Model	S - D	V - D	V - S
With Heavy Vehicles (HV)			
Greenshield	S = 76,43 - 1,02 D	V = 76,43 D -1,02 D^2	V = 74,70 S -0,98S^2
Greenberg	S= 131,26 - 25,1lnD	V = 131,26D - 25,1 DlnD	V = 186,84. S. exp (-0,04S)
Underwood	S = 83,69 exp (-0,04Do)	V = 83,69. D. exp (-0,04Do)	V = 49,7 S ln(83,694/S)
Without Heavy Vehicles (HV)			
Greenshield	S = 78,1 - 1,19 D	S= 130,74 - 25,69.lnD	S = 85,15 exp (-0,04D)
Greenberg	V = 78,1 D -1,19 D^2	V = 130,74 D - 25,69 DlnD	V = 85,15 D. exp (-0,04D)
Underwood	V = 65,63 S - 0,84.S^2	V = 162,39. S. exp (-0,04.S)	V = 43,93 S ln(85,15/S)

Maximum total volume in both directions (V2directions) for both conditions as shown in the table below:

Table 3: Parameter Values and Model Capacity Estimates

Scenario	Model	a	b	Sf km/hour	So km/haour	Do2-away smp/km	Dj2-away smp/km	V2-away smp/hour
With HV	Greenshield	76,43	-1,02	76,43	38,22	37	75	1427
	Greenberg	131,26	-25,10	0,00	25,10	69	187	1725
	Underwood	4,43	-0,02	83,69	30,77	50	0	1529
Without HV	Greenshield	78,10	-1,19	78,10	39,05	33	66	1281
	Greenberg	130,74	-25,69	0,00	25,69	60	162	1534
	Underwood	4,44	-0,02	85,15	31,35	44	0	1376

The results presented in Table 2 indicate that, under condition I (with heavy vehicles), the Vmaks value in the Greenberg model is 1725 smp/hour, whereas, for condition II (without heavy vehicles), the Vmaks value is 1534 smp/hour.

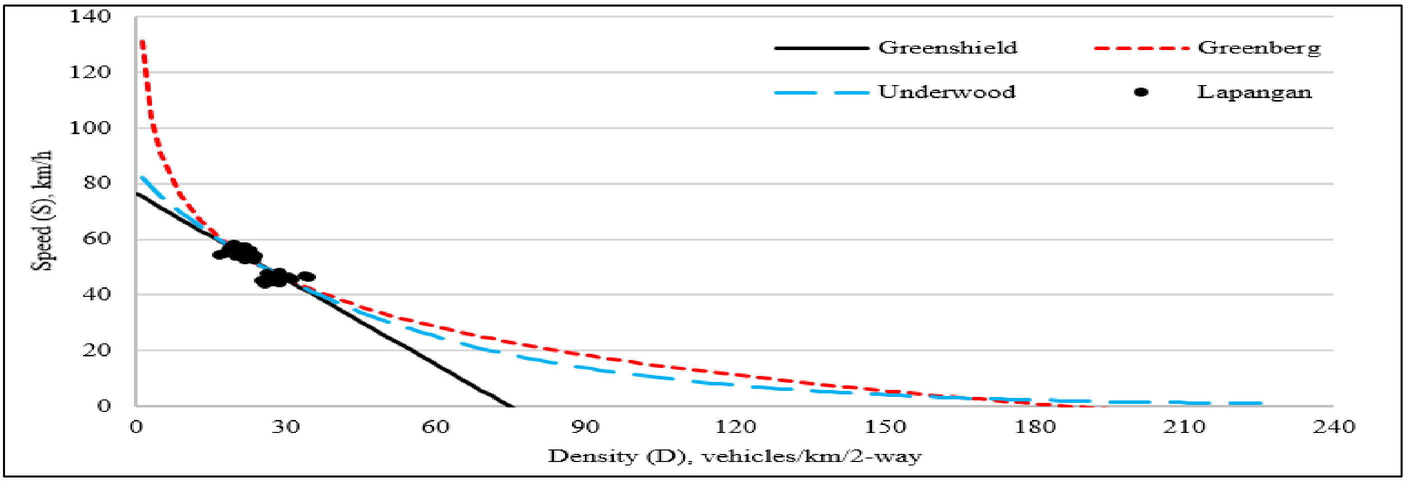

Fig 3: The Relationship between S-D Conditions and Heavy Vehicles (HV)

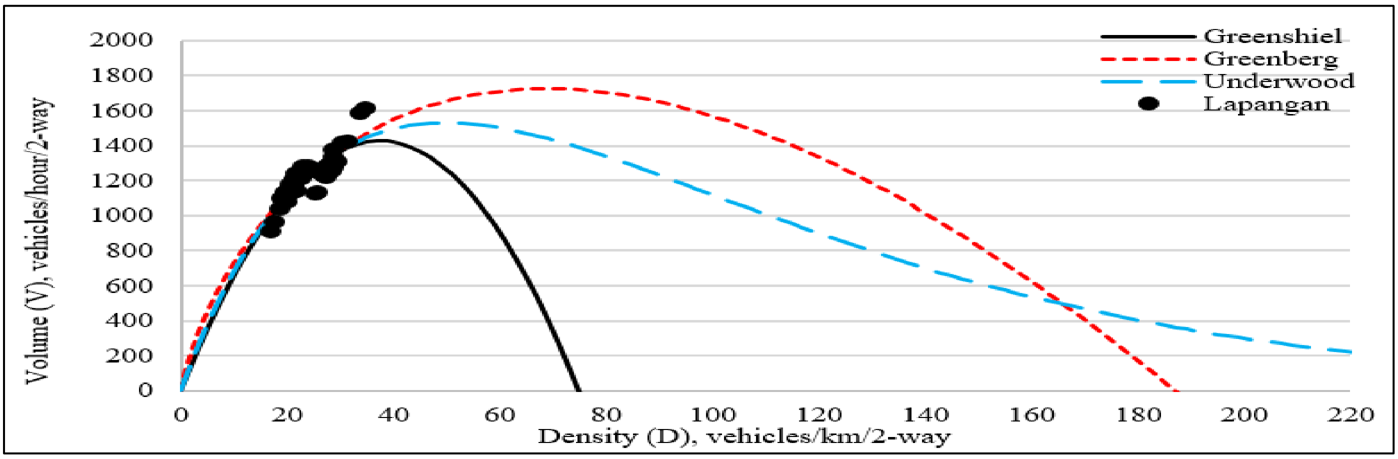

Fig 4: The Relationship between V-D Condition and Heavy Vehicles (HV)

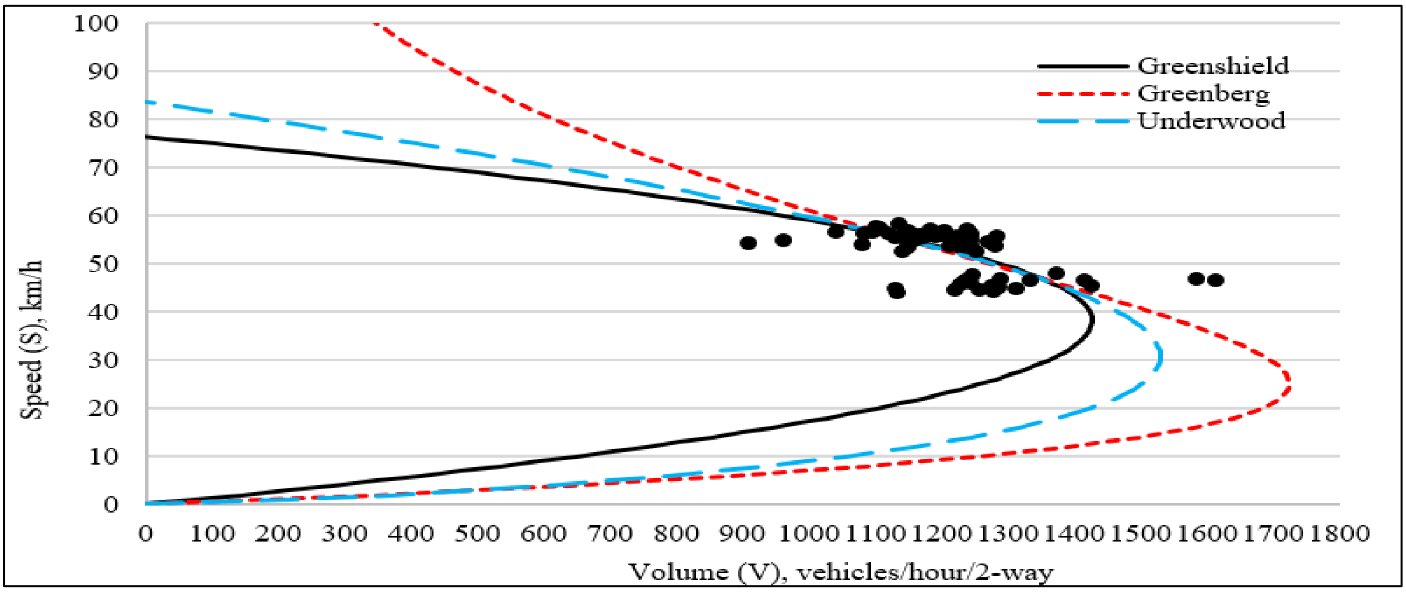

Fig 5: The Relationship between S-V Conditions and Heavy Vehicles (HV)

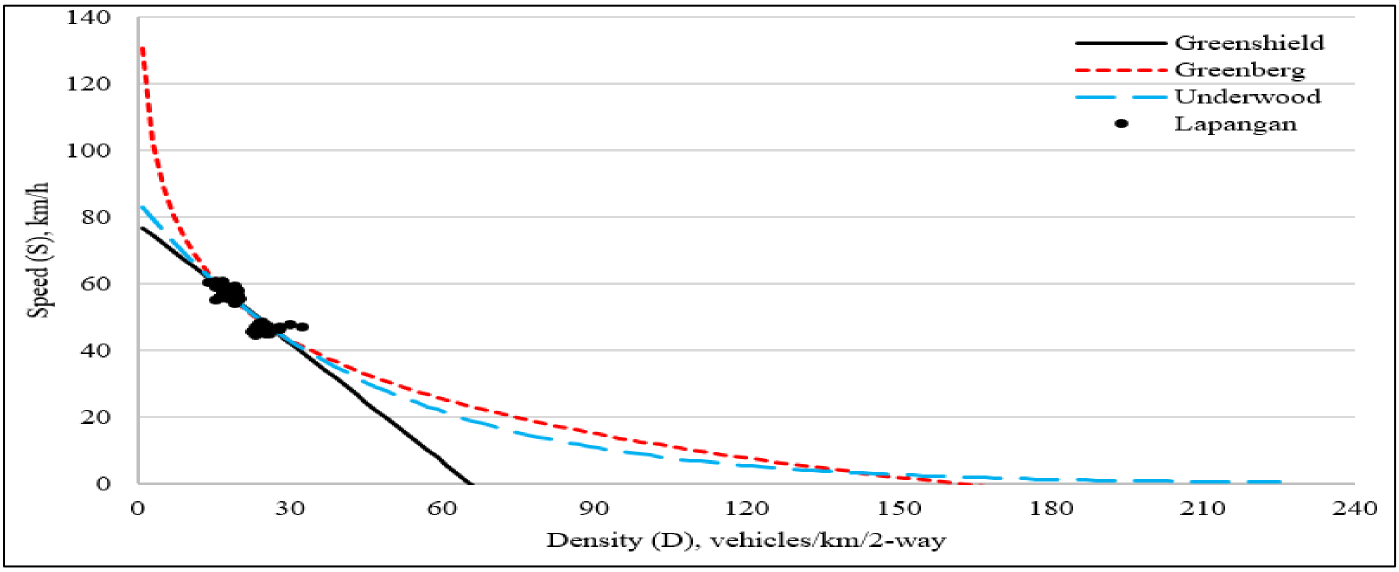

Fig 6 S-D Relationship Scenario without Heavy Vehicles (HV)

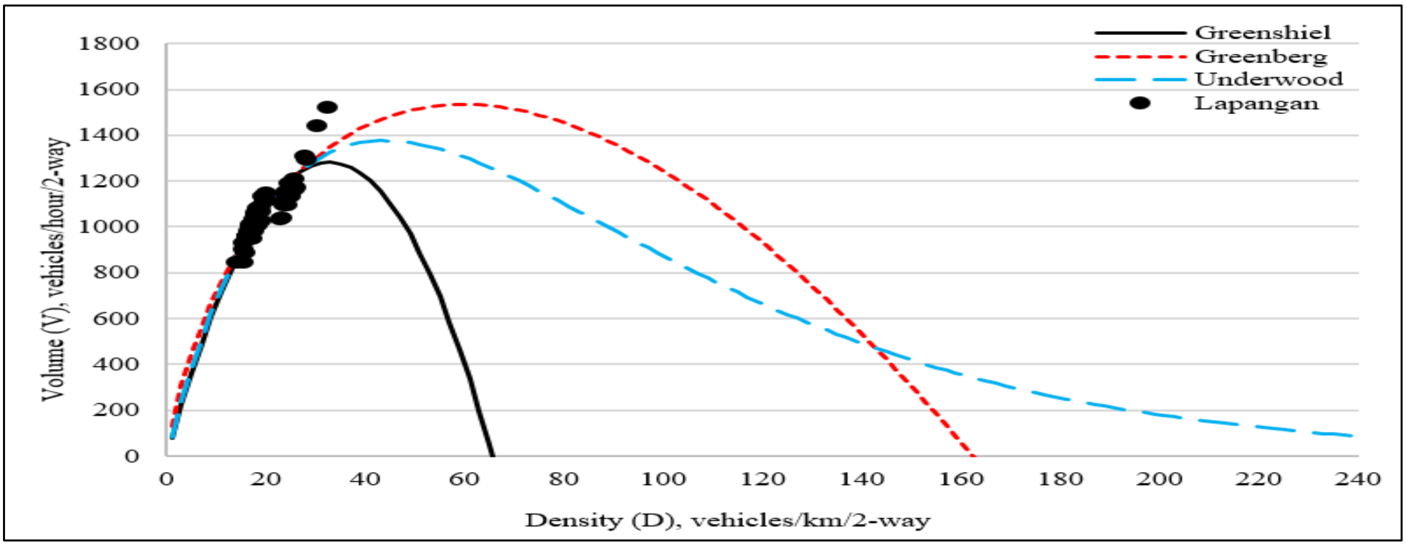

Fig 7: V-D Relationship in a Scenario without Heavy Vehicles (HV)

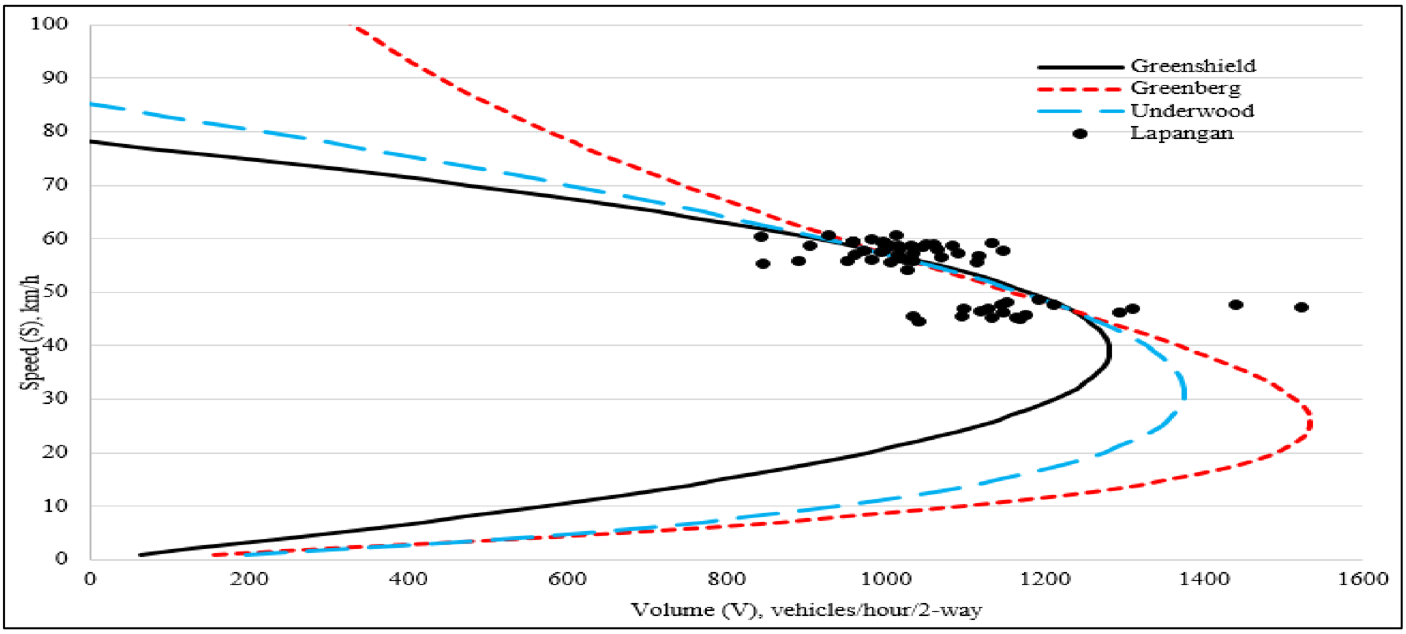

Fig 8: S - V relationship Scenario without Heavy Vehicles (HV)

According to the findings of the data analysis and the graph depicting the link between speed, volume, and density, it can be described as follows:

- The coefficient of determination (r^2) value for the three models in each scenario is $\geq$ 0.7. The results of the statistical analysis at a 95% confidence level indicate a correlation between speed and traffic density.
- The r^2 value of the scenario without heavy vehicles is higher than the current condition with heavy vehicles. Meanwhile, the coefficient of determination (r^2) values of the models in descending order are the r^2 values of the Greenberg, Greenshield, and Underwood models.
- The curve of the relationship between speed (S) and density (D) in the three models shows that speed will decrease as density increases. Free flow speed will occur when density is equal to zero, and when speed is equal to zero, congestion will occur. The value of the free flow speed (Sf) model in the scenario without heavy vehicles shows an improvement in conditions compared to the scenario with heavy vehicles. The same is true for the model's optimum speed value; the scenario without heavy vehicles is greater than that with heavy vehicles.
- In Figure 4.5, the relationship between speed (S) and density (D) in the scenario without heavy vehicles shows that the slope of the regression line is relatively steeper compared to the condition with heavy vehicles. This indicates that under conditions without heavy vehicles, the increase in density results in a relatively greater change in speed compared to segments with heavy vehicles.
- The curve of the relationship between volume and speed based on the three models of Greenshield, Greenberg, and Underwood represents that an increase in traffic volume causes the average space speed to decrease until critical density (maximum volume) is reached. After the critical density is reached, the average space speed and volume will decrease. From the graph, the condition with heavy vehicles shows the critical density value (maximum volume) indicating a higher result compared to without heavy vehicles in each model.
- The curve of the relationship between volume (V) and density (D) based on the three models represents that the maximum volume occurs when the road lane capacity is already fulfilled. After reaching the maximum point, the volume will decrease even though the density increases until congestion occurs. In the analysis results shown in the graph, the density value for the scenario with heavy vehicles is higher compared to the scenario without heavy vehicles from the three relationship models.

C. Model Selection

Selection of the optimal model involves multiple criteria, including those derived from statistical analysis, those informed by traffic characteristics observed in the field, and those that are deemed reasonable. The model can be evaluated using statistical criteria, specifically the coefficient of determination (r2), as well as traffic criteria, which include free flow speed (Sf), congestion density (Dj), and capacity (Vmaks). Model selection is performed to acquire model parameters that align with the traffic characteristics observed in the field.

➢ *On the Basis of the Aforementioned Criteria, the Following are the Actions that can be Done in Order to Select a Model:*

- The coefficient of determination (r^2) values of the three models in each scenario, from highest to lowest, are the Greenberg model, the Greenshield model, and the Underwood model.
- Significance test that the relationship between traffic flow variables (speed-density-volume) in the Greenshield, Greenberg, and Underwood models is significant at a 95% confidence level where the

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calculated t and F statistical test values are greater than the t and F table values.

- The value of free stream velocity (Sf), The value of speed taken from the three models is the highest, because the higher the free flow speed value, the closer it is to the actual condition. In Figure 4.5, it can be seen that the values of free flow speed from highest to lowest are Greenberg, Underwood, and Greenshield, respectively.
- Traffic Density Value (Dj); The best Dj value is the one that most closely approximates field conditions. The field condition value of Dj is estimated to range between 185-250 vehicles per mile or 120 – 160 vehicles per km (May, A.D. 1990). The best model analysis results for traffic density (Dj) are the Greenberg, Underwood, and Greenshield models, respectively.
- The empirical basic capacity value commonly for the 2/2 UD road type is around 2,900 pcus/hour (MKJI 1990). The estimated model capacity results are close to the empirical capacities of Greenberg, Underwood, and Greenshield, respectively.
- The Greenberg model is the closest model to the relationship between Traffic Flow Speed (S) – Traffic Density (D) – Traffic Volume (V) at the study location, based on the five criteria.

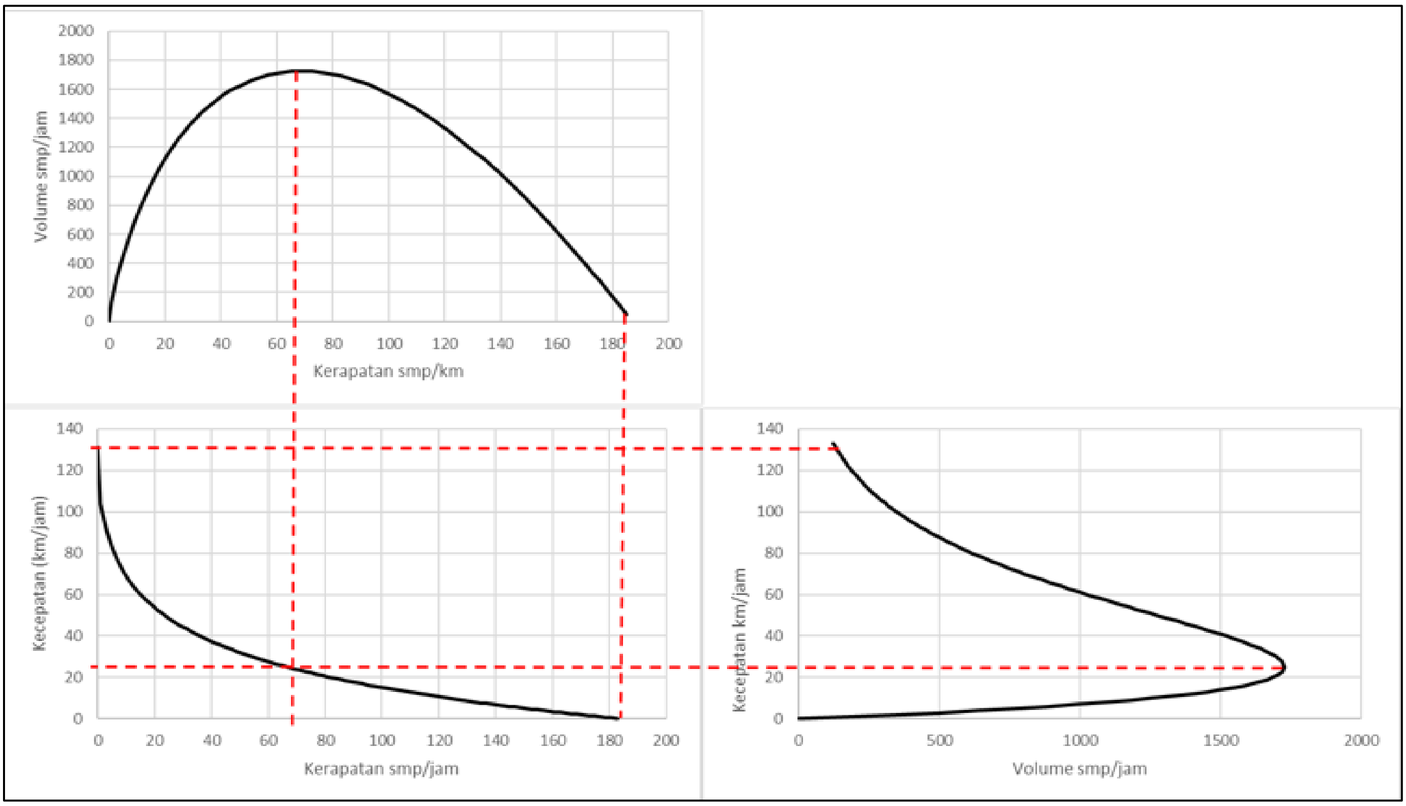

Fig 9: Graph of the Relationship Between Volume, Velocity, and Density of the Greenberg Model

D. Capacity Calculation based on the MKJI 1997 Method

The Relationship Between Speed, Volume, and Density.

The basic formula for assessing urban road capacity according to the Indonesian Road Capacity Manual (MKJI) 1997, based on environmental variables and geometric road conditions at the research location, is the following:

- C = Co x FCw x FCsp x FCsf x FCcs
- C = 2900 x 1,14 x 1 x 0,97 x 0,90
- C = 2886 smp/hour

Table 4: Percentage of Capacity Differences for Each Model using the MKJI 1997 Method

Scenario	**Model**	**Kapasitas Model**	**Capacity MKJI 1997**	**Accuracy Against MKJI 1997**
		smp/hour	**smp/hour**	**%**
With HV	Greenshield	1427	2886	50,55
	Greenberg	1725	2886	40,23
	Underwood	1529	2886	47,02
Without HV	Greenshield	1281	2886	55,60
	Greenberg	1534	2886	46,83
	Underwood	1377	2886	52,29

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According to the table above, the Greenberg Model exhibits the least percentage difference in capacity value (C) when compared to the Indonesian Road Capacity Manual Method (MKJI) 1997. The percentage value for conditions with heavy vehicles is 40.23%, while the percentage value for conditions without heavy vehicles is 46.83%.

E. Degree of Saturation Based on the MKJI 1997 Method

The DS value reflects whether the road segment is still at capacity or not. The Degree of Saturation can be estimated by combining traffic volume and road capacity reported in smp/hour.

Table 5: Saturation Degree Values (DS)

Condition	**Review Time**	**Total V2-way**	**Capacity (C)**		**Degree of Saturation (DS)**	
			Model	**MKJI 1997**		
		smp/hour	**smp/hour**	**smp/hour**	**Model**	**MKJI 1997**
With HV	07.00 - 12.00	1283	1725	2886	0.74	0.44
	12.00 - 18.00	1614	1725	2886	0.94	0.56
	18.00 - 22.00	1416	1725	2886	0.82	0.49
Without HV	07.00 - 12.00	1117	1534	2886	0.73	0.39
	12.00 - 18.00	1523	1534	2886	0.99	0.53
	18.00 - 22.00	1310	1534	2886	0.85	0.45

The decrease in model capacity value between conditions with heavy vehicles (HV) with a capacity value of 1725 smp/hour and conditions without heavy vehicles (HV) with a capacity value of 1534 smp/hour is 11.07%. This shows that the model's capacity value is greatly influenced by the volume of traffic, where an increase in the volume of traffic on a road segment will also lead to a higher Vmaks or road capacity.

For the degree of saturation, however, Condition I (with heavy vehicles) at 0.94 and Condition II (without heavy vehicles) at Ds = 0.99 yielded the highest degrees of saturation. Given the real conditions in the field, where there are no long lineups during peak traffic, the outcomes derived by this model are judged unrealistic.

In contrast to the road capacity value determined by the Indonesian Road Capacity Manual (MKJI) 1997 method, which remains constant, there is no change in value. This is due to the fact that the MKJI 1997 method is used to calculate road capacity values, which are derived from a variety of variables, including:

- Basic capacity (Co) (smph/h)
- Road width adjustment factor (FCw)
- Directional separation adjustment factor (only for undivided roads) (FCSP)
- Adjustment factor for side friction and road shoulder/kerb (FCSF)
- City Size Adjustment Factor (FCCS)

Meanwhile, the peak volume in Condition I (with heavy vehicles) occurs in the segment from 12:00 PM to 6:00 PM, with a degree of saturation (DS) value of 0.56. In Condition II (without heavy vehicles), the peak volume is 0.53. This implies that the saturation degree values for both segments have not surpassed the mandatory value of 0.75 in MKJI 1997. Consequently, the road segment is still far from the saturation condition, which is characterized by the absence of lengthy queues during peak traffic.

Taking into consideration the information presented above, it is possible to draw the conclusion that the performance of the road segment on the R.E. Martadinata will be impacted by the number of heavy vehicles that use the road section.

V. CONCLUSIONS & RECOMMENDATIONS

A. Conclusions

- The three models exhibit a virtually identical trend in the relationship between volume, speed, and density. Nevertheless, the Greenberg Model was chosen as the optimal model based on the regression results, which were compared to the three models based on statistical analysis criteria, field traffic characteristics, and reasonableness criteria. The r2 value for the condition with heavy vehicles was 0.76, while the condition without heavy vehicles had a r2 value of 0.82. The table below displays the estimated capacity (Vmaks), the free flow speed (Sf), and the equation of the speed-density (S-D) relationship from the selected Greenberg model.

Table 6: Relationship Model (S-D), So Value, and Vmaks of the Selected Model

Condition	**S - D**	**V - D**	**V – S**	**Sf**	**Vmax**
With HV	S= 131,26 - 25,1lnD	V = 131,26D - 25,1 DlnD	V = 186,84. S. exp (-0,04S)	25,10	1725
Without HV	$V = 78{,}1\ D - 1{,}19\ D^2$	V = 130,74 D - 25,69 DlnD	V = 85,15 D. exp (-0,04D)	25,69	1534

- Performance assessment of the R.E Martadinata road segment based on the MKJI 1997 model and method.

✓ For condition I (with heavy vehicles) and condition II (without heavy vehicles), there is a difference in the estimated road capacity based on the Greenberg Model compared to the estimation according to the MKJI 1997 Method. For condition I, the difference is 40.23%, where the maximum volume from the Greenberg model is 1725 smp/hour, and for condition II, the difference is 46.83%,

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where the maximum volume from the model is 1534 smp/hour. Meanwhile, the capacity value from the Indonesian Road Capacity Manual Method (MKJI) 1997 is 2886 smp/hour.

- ✓ There was a decrease in the model's capacity value between the condition with heavy vehicles (HV) with a capacity value of 1725 smp/hour and the condition without heavy vehicles (HV) with a capacity value of 1534 smp/hour, which is 11.07%. This shows that the model's capacity value is greatly influenced by the volume of traffic, where the higher the traffic volume on a road segment, the higher the Vmaks value or road capacity will be.
- ✓ Meanwhile, for the model's degree of saturation, the highest degree of saturation value was obtained for Condition I (with heavy vehicles) at 0.94 and Condition II (without heavy vehicles) at Ds = 0.99. The results obtained by this model are considered unrealistic compared to real conditions in the field where there are no long queues during peak traffic.
- ✓ And for the degree of saturation based on the MKJI 1997 Method for Condition I (with heavy vehicles), the peak volume occurs in the segment from 12:00 PM to 6:00 PM with a degree of saturation (DS) value of 0.56, and for the peak volume in Condition II (without heavy vehicles), a degree of saturation value of 0.53 is obtained. This indicates that both saturation degree values are in good condition for facilitating traffic flow.

- Based on the obtained data, it can be concluded that on the R.E. Martadinata road segment, the condition of the volume of heavy vehicles will affect the performance level of that road segment.

B. *Recommendations*

- Several things that need to be considered during the collection of traffic survey data (traffic volume data and vehicle travel time data).
- Further studies are needed on the impact of stopped vehicles or roadside obstacles on traffic performance on other road segments.

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