SSRG International Journal of Civil Engineering
ISSN: 2348-8352 / https://doi.org/10.14445/23488352/IJCE-V10I5P104

Volume 10 Issue 5, 30-36, May 2023

Original Article

Road Pavement Damage Caused by Traffic Segment : Road of Governor Soebardjo

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Received: 07 March 2023 Revised: 24 April 2023 Accepted: 10 May 2023 Published: 31 May 2023

Abstract *- Traffic volume and vehicle load are one of the causes of road damage. The research was conducted on the Road of Governor Soebardjo. The research objective was to determine the effect of traffic volume and standard loads on road damage. The method used is the method of regression analysis and correlation. This method obtains the relationship between traffic volume and standard load (equivalent single axle load/ESA) on road damage with r and P values. The study results show a relationship between traffic volume and standard weight on road damage. The analysis yields the equation y = 6E-07x2 + 0.0038x + 0.3849 with a robust correlation with the r value of 0.9178. Heavy vehicles significantly damage the road compared to light vehicles; it can be seen from the P value, which is less than 0.05. Analysis of the standard load (ESA), road damage has a very strong correlation with an r-value of 0.9073 with the equation y = 2.4274.e6E-05X.*

Keywords *- Road damage, Regression, Traffic, Vehicle volume, Standard load.*

1. Introduction

The increased load affects the transportation needs, which will increase the transportation needs. So it is necessary to support transportation infrastructure in a proper condition. Governor Soebardjo Street is one of the alternative connecting roads between the city of Banjarmasin and the city of Banjarbaru. Jalan Governor Soebardjo is also close to the Trisakti Port, causing many heavily loaded vehicles to pass through the road. The impact of this activity results in the possibility of the load received by the road exceeding the design load (overloading) [1]. Cause damage to the road being traversed so that it needs repairs so that the accident rate is reduced and makes it easier for road users to travel. Damage repair can be repaired according to the damage that has occurred, and the correct repair is to repair, close and then carry out routine maintenance [5]. The research aims to obtain a relationship between traffic volume, standard load (ESA), and the value of road damage to road damage on the Road of Governor Soebardjo.

The research was conducted on the Road of Governor Soebardjo, which is located in the city of Banjarmasin. In research, the road is divided into eight segments according to road damage.

2. Literature Review

The road we have met until now results from discoveries and developments in human civilization. Roads can be distinguished as flexible, rigid, and composite/ composite pavements [21].

Based on the Indonesian Highway Capacity Manual (IHCM) [9], vehicles that cross the road consist of:

- Light Vehicles (LV) consist of passenger cars, pickups, microbuses, pickups, and small trucks).
- Heavy Vehicles (HV) consist of buses, two-axle trucks, three-axle trucks and combination trucks.
- Motorcycles (MC consists of motorcycles and 3-wheeled vehicles.
- Non-motorized vehicles (UM) such as bicycles, rickshaws, horse carriages and strollers.

Road damage consists of several types, such as alligator cracks, corrugation, depression, edge cracking, joint reflection cracking, lane, longitudinal and transverse cracking, patching, potholes, rutting, shoving, bleeding, block cracking, and slippage cracking [20].

This road damage can be assessed based on the Procedures for Developing a City Road Maintenance Program, Indonesia [8], as shown in Table 1. Based on this road damage assessment, road maintenance can be carried out such as routine maintenance, periodic maintenance, rehabilitation, and reconstruction [13]

Table 1. Value of road conditions based on the type of damage procedures for developing a city road maintenance program in indonesia

Cracking	
Type	**Number**
Alligator	5
Random	4
Transverse	3
Longitudinal	1
None	0
Wide	**Number**
>2 mm	3
1 - 2 mm	2
<1 mm	1
None	0
Damage Area	**Number**
>30%	3
10 - 30%	2
<10%	1
None	0
Rutting	
Depth	**Number**
>20 mm	7
11 - 20 mm	5
6 – 10 mm	3
0 – 5 mm	1
None	0
Patching and Potholes	
Area	**Number**
>30%	3
20 – 30%	2
10 – 20%	1
<10%	0
Roughness	
Type	**Number**
Disintegration	4
Grain release	3
Rough	2
Fatty	1
Close Texture	0
Depression	
Depth	**Number**
>5/100 m	4
2 – 5/10 m	2
0 – 2/100 m	1
None	0

Regression method analysis usually uses the value of r and $Pvalue$. , According to Mona et al. [14] test the significance if the value ($Pvalue$) < 0.05 means that the independent variable affects the dependent variable, but if the value ($Pvalue$) > 0.05 then the independent variable does not affect the dependent variable. According to Radam et al. [18], the interpretation of the r value for the strength of the correlation is seen in Table 2.

Table 2. (r) Value based on correlation coefficient

R^2 Value	The absolute value of the correlation coefficient (|r|)	Interpretation
< 0.04	0.00 – 0.199	Slight correlation; almost negligible relationship
0.04	0.20 – 0.399	Low correlation; the relationship is sure but small
0.16	0.40 – 0.699	Moderate correlation; substantial relationship
0.49	0.70 – 0.899	Strong correlation; marked relationship
0.81	0.90 – 1.000	Robust correlation; very reliable relationship

3. Method

In research, data collection uses the Directorate General of Highways of Indonesian method [7]. The steps taken are as follows:

1. Identification of Problems
2. Retrieving traffic volume data and road damage data. Traffic volume data is taken for 12 hours on one of the segments. Then the data becomes a benchmark for other segments whose data is taken for 2 hours.
3. Determine the value of road damage. The following table determines the value of road damage.
4. Calculating the total value of road damage to get the road condition value. The following table determines the value of road conditions.
5. Determine the priority order score. The following formula can calculate the score:
6. Determine the relationship between traffic volume, standard load (ESA) and the value of road damage to road damage using the regression method.

4. Results and Discussion

4.1. Traffic Volume

The traffic volume on the eight segments observed is shown in Table 3.

Table 3. Traffic volume

Transportation type	Seg. 1	Seg. 2	Seg. 3	Seg. 4	Seg. 5	Seg. 6	Seg. 7	Seg. 8
Van	809	1343	1566	858	905	1120	1010	1006
Public transportation	46	0	0	0	21	5	0	0
Small Bus	10	0	0	0	16	0	0	16
Big Bus	7	11	2	7	11	7	6	4
Pickup	1093	1619	818	1068	739	782	583	661
Truck 2 as four-wheel	593	377	292	217	200	316	425	76
Truck 2 as six-wheel	1040	923	1092	641	1191	2382	1478	1247
Truck 3 as	172	373	390	52	362	536	417	396
Truck 4 as	75	38	57	8	23	268	115	35
Trailer	126	193	488	133	104	329	225	72
Motorcycle	3632	3986	3558	2899	4797	4537	5459	5571
Motorcycle 3 wheel	0	5	0	20	0	0	0	0
Bicycle/ rickshaw, cart	20	0	0	20	40	40	60	220
Total	7623	8866	8263	5923	8409	10323	9777	9302

From the volume data above, convert it into pcu/hour by multiplying the passenger car equivalent (pce). The value of pce used is pce based on the Indonesian Highway Capacity Manual (IHCM) 1997 [9].

The traffic load is obtained from the traffic volume converted to a standard load (Equivalent Single Axle Load, ESA) using the Vehicle Damage Factor (VDF). The VDF value is based on the Road Pavement Design Manual (RPDM), 2017 [10] as shown in Table 4.

Table 4. VDF value of commercial vehicle (RPDM, 2017)

Vehicle Type	Island							
	Java				Borneo			
	Actual Load		Normal		Actual Load		Normal	
	VDF 4	VDF 5	VDF 4	VDF 5	VDF 4	VDF 5	VDF 4	VDF 5
6A	0.55	0.5	0.55	0.5	0.55	0.5	0.55	0.5
6B	5.3	9.2	4	5.1	4.8	8.5	3.4	4.7
7A1	8.2	14.4	4.7	6.4	9.9	18.3	4.1	5.3
7C1	11.0	19.8	7.4	9.7	11.7	20.4	7.0	10.2

Table 5. ESA value of each type of vehicle

Segment	6A	6B	7A	7C	ESA
1	593	1040	172	201	16385
2	377	923	373	230	19548
3	292	1092	390	545	27680
4	0	641	52	141	9286
5	200	1191	362	127	19439
6	316	2382	536	598	42402
7	425	1478	417	340	27346
8	76	1247	396	106	20054

The ESA values for various types of vehicles can be seen in Table 5.

4.2. Road Damage

The value of road damage for each segment is shown in Table 6.

Table 6. Value of road damage

Segment	Skor Road Damage
1	8
2	11
3	9
4	2
5	11
6	22
7	9
8	8

To analyze road damage in several segments, it is best if the conditions of all segments are the same, especially the road structure. Eight segments were observed in the study by analyzing the traffic volume of light vehicles (LV), heavy vehicles and average daily traffic (ADT). As in Table 7.

Table 7. Variable recapitulation

No.	Damage Score	LV (pcu/hour)	HV (pcu/hour)	ADT (pcu/hour)
1	8	2551	1420	4397
2	11	3340	1536	5336
3	9	2142	2029	4780
4	2	1933	835	3018
5	11	1881	1691	4079
6	22	2224	3523	6803
7	9	2017	2241	4930
8	8	1759	1753	4037

The relationship between independent and dependent variables, namely between the damage score and the type of vehicle LV, HV and ADT, in Figure 1, Figure 2 and Figure 3 below.

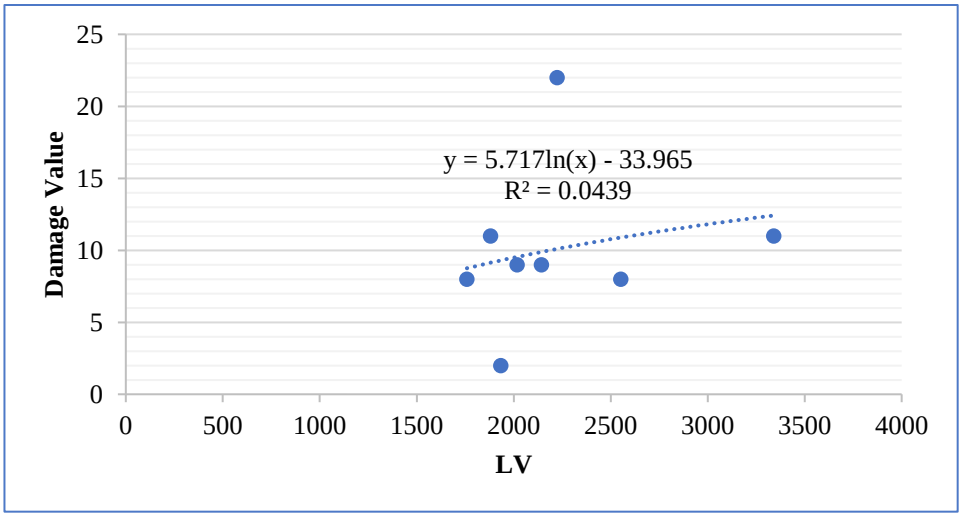

Fig. 1 LV and damage

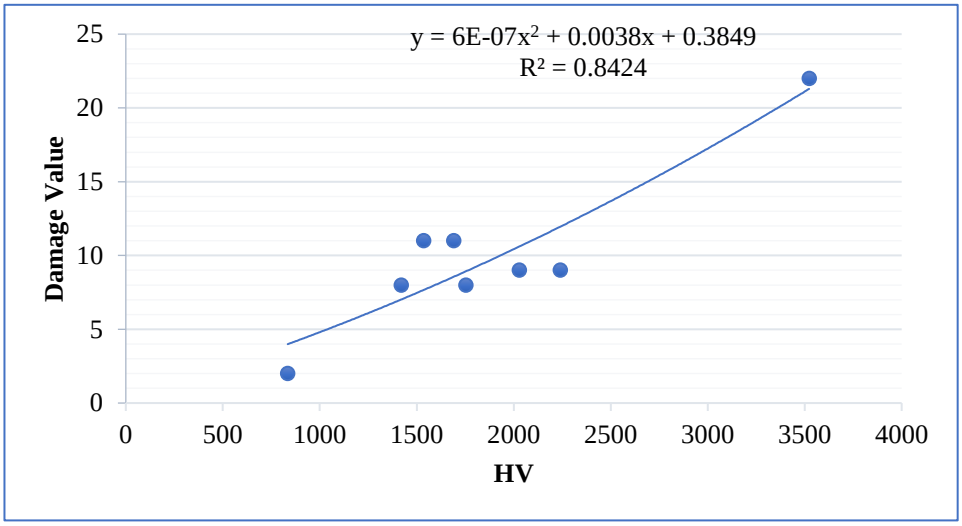

Fig. 2 HV and damage

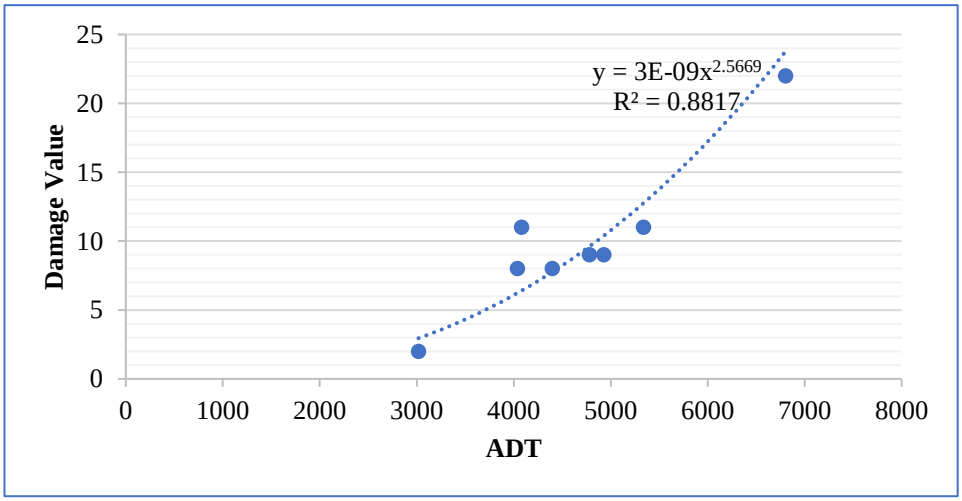

Fig. 3 ADT and damage

In Figure 1, it can be seen that the R2 value is 0.0439, so the r value is 0.2095. This explains that if the correlation between road damage and light vehicles (LV), it means that road damage is not caused by light vehicles. Figure 2 describes the relationship between road damage and heavy vehicles, which has a robust correlation, with a correlation value (r) of 0.9178. It is clear if the road damage is caused by heavy vehicles (HV). Furthermore, Figure 3 depicts the relationship between the overall average daily traffic (ADT) and damage, showing a robust correlation with an r-value of 0.939.

When viewed based on the P-value, to find out which is more damaging to the road between the volume of light vehicles and heavy vehicles, it can be seen that the P-value of heavy vehicles is <0.05, this explains that the volume of heavy vehicles does affect road damage, as can be seen in Table 8.

4.3. Relationship Road Damage and Load (ESA)

Value of road damage and load on the observed road segments, as shown in Table 9.

The analysis results show that loads have a powerful influence on road damage, with a correlation value (r) of 0.9037. From Figure 4, as shown below, a correlation value (r) of 0.9073 is produced. This explains the strong relationship between the influence of a load of passing vehicles on road damage.

Table 8. Multiple regression analysis

	Coefficients	Standard Error	t Stat	P-value
Intercept	-8,543495	4,204905	-2,03179	0,09789
LV	0,0027192	0,00158227	1,71855	0,14634
HV	0,0066422	0,00102636	6,47154	0,00131
Multiple R	0,914354			
R Square	0,836042			
Adjusted R Square	0,808716			
Standard Error	4,204905			
Observations	7			

Table 9. Damage value and load

No.	Damage Value	ESA
1	8	16385
2	11	19548
3	9	27680
4	2	9286
5	11	19439
6	22	42402
7	9	27346
8	8	20054

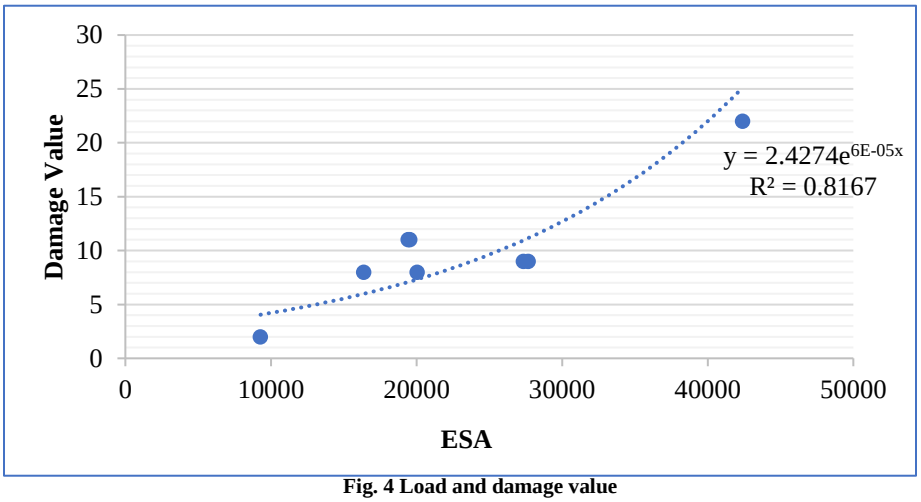

Fig. 4 Load and damage value

5. Conclusion

From the analysis results, it can be concluded that road damage is affected by the volume of heavy vehicles. The analysis yields the equation y = 6E-07x2 + 0.0038x + 0.3849 with a robust correlation with the r value of 0.9178. Heavy vehicles significantly damage the road compared to light vehicles, it can be seen from the Pvalue of less than 0.05.

Analysis of the standard load (ESA), road damage has a very strong correlation with an r-value of 0.9073 with the equation y = 2.4274.e6E-05X.

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