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Effect of Road Conditions on Vehicle Operation Costs on Roads in Kolaka Timur District

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ABSTRACT

The purpose of the study was to analyze the condition of street damage (SDI), analyze vehicle operating costs and analyze the effect of street conditions on vehicle operating costs on the Welala – Ra-raa Street section.
The researches method uses an empirical approach and a statistical approach with data collection techniques carried out by direct measurements of street damage and vehicle travel speed. The analysis method for the level of road damage is the SDI method while the vehicle operational cost analysis method (BOK) uses the Lapi ITB method. The result of this study is that the damage to the wellala – ra-raa road is included in the category of heavily damaged with a surface distress index (SDI) of 387.9. vehicle operating costs (BOK) for motorcycles due to street damage is Rp 161.01 /km while the BOK for light vehicles is Rp 545.77 /km. the effect of street damage (SDI) on vehicle operating costs on the welala – ra-raa section is 0.001% for motorcycles while for light vehicles it is 8.9%.

Keywords: *Effects, Street conditions, cost, Vehicles*

I. INTRODUCTION

Roads are land infrastructure which includes all parts of the road, including complementary buildings and equipment intended for traffic that is on the ground and above ground level and regarding roads, the operator is obliged to prioritize road maintenance to meet the service level that has been set. (Law No. 22 of 2009).

Good road conditions will facilitate the mobility of the population in conducting economic relations and other social activities. Meanwhile, if there is road damage, it will not only hinder economic and social activities but can result in accidents. (Rahmanto, 2016).

In Law No. 34/2006, roads are land infrastructure which includes all parts of the road, including complementary buildings and equipment intended for traffic that is on the ground and above ground level and regarding roads, the administration is obliged to prioritize road maintenance to meet the level of service required. has been established.

II. LITERATURE REVIEW

2.1 Definition of Road

Roads are land infrastructure to support people's lives. The road also functions as a liaison in which there are complementary buildings and road equipment for vehicular and human traffic. The existence of roads is very influential for human activities and the development of an area. Rifqi, 2020. In Yudaningrum 2017. Land transportation infrastructure plays an important role for the development of a region. Good road conditions will facilitate the mobility of the population in carrying out economic activities and other social activities.
According to Adisasmita, (2017) the primary road network is a road network with the role of distributing goods and services to develop all regions and at the national level, by connecting all distribution service nodes in the form of activity centers.

2.2 Road Classification

Road classification is the division of roads based on road functions based on the burden of the government, and based on the axle load concerning the dimensions and weight of the vehicle, determining the road classification regarding the volume of traffic using the road, the size of the road capacity, the economy of the road as well as the financing of road construction and maintenance. The following are some types of road classification:

- Classification of roads according to function.
- Classification of roads according to status.

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- Classification of roads by class.

Classification based on provisions, road class and related to classification according to road function in table 1

Table 1. Classification by road class

Function	class	Heaviest axle load (Tons)
Arteries	I	>10
	II	10
collector	IIIA	8
	IIIA	8
Local	IIIB	8
	IIIC	8

(Source: PUPR Ministerial Decree Number 05/PRT/M/2018)

2.3 Types of pavement damage

According to Hardiyatmo (2007) in Afandi (2021). Stating that the damage that occurs in the Surface Distress Index (SDI) method has several damages, namely:

a. Cracks

Cracks are a symptom of damage or rupture of the pavement surface so that it will cause water on the pavement surface to enter the layer below it and this is one of the factors that makes the extent of damage severe.

b. Hole (Potholes)

This damage is in the form of a bowl that can accommodate and absorb water on the road shoulder.

c. Used Wheel Groove (Rutting)

This form of damage occurs in the trajectory of the wheel parallel to the road axle and in the form of a groove. This damage is caused by excessive vehicle loads, causing vehicle ruts.

2.4 Surface Distress Index (SDI) Method

According to Manurug, 2018. For a road condition survey to get the SDI value, 4 elements are used for support, namely: % of crack area, average crack width, number of holes/km for segment calculation per 100 meters, the parameter of the number of holes must first be multiplied by 10 before being included in the SDI number of potholes assessment formula. And the average depth of the ruts. The calculation can be seen in table 2 to table 6

Table 2. Road damage assessment

SDI Value	Condition
< 50	Well
50 - 100	Currently
100 - 150	Slightly damaged
>150	heavily damaged

Source: Bina Marga, 2011 in 2016 report

The percentage of crack area can be analyzed using the following equation:

$$\% \text{ Crack area} = \frac{Lr}{Lj} \times 100\%$$

Where:

Lr = area of crack (m^2)
= crack width x crack length

Lj = road area (m^2)
= width of the road x length of the road

Table 3. Assessment of crack area

No	Category	SDI Value[1]
1	< 10%	5
2	10 – 30%	20
3	>30%	40

Source: Bina Marga, 2011 in 2016 report

Table 4. Crack width assessment

No	Category	SDI[2] . value
1	Smooth <1 mm	-
2	Medium 1 – 3 mm	-
3	Width >3 mm	SDI[1] * 2

Source: Bina Marga, 2011 in 2016 report

Table 5. Assessment of the number of holes

No	Category	SDI Value[3]
1	<10 /km	$SDI^2 + 15$
2	10 – 50 /km	$SDI^2 + 75$
3	>50 / km	$SDI^2 + 225$

Source: Bina Marga, 2011 in a 2011 report

Table 6. Used Wheel Rating

No	Category		SDI Value⁴
1	< 1 cm	X = 0.5	SDI³ + 5*X
2	1 – 3 cm	X = 2	SDI³ + 5 * X
3	>3 / km	X = 5	SDI³ + 20

Source: Bina Marga, 2011 in 2016 report

2.5 Vehicle Operating Costs

a. Consumption / fuel consumption

- Goal fuel consumption. 1 = 0.05693 V² - 6.42593 V + 269.18576
- Goal fuel consumption. IIA = 0.21692 V² - 24,11549 V + 954.78624
- Goal fuel consumption. IIIB = 0.21557 V² - 24,17699 V + 94780862

Information:
Fuel consumption (Lt/1000 km)
V = traffic speed/vehicle (km/h)

b. Lubricating oil consumption

- Consumption of goal lubricating oil. 1 = 0.00037 V² - 0.04070 V + 2.20403
- Consumption of goal lubricating oil. IIA = 0.00209 V² - 0.24413 V + 13.2944
- Consumption of goal lubricating oil. IIIB = 0.00186 V² - 0.22035 V + 2.06486

c. Tire Consumption

Group. 1: Y = 0.0008848 V - 0.004533
Group. IIA: Y = 0.0012356 V - 0.0064667
Group. IIIB: Y = 0.00155536 V - 0.0059333
Information:
Y = tire usage per 1000 km
V = running speed (running speed)

d. Maintenance Cost

- Parts

Group I: Y = 0.0000064 V + 0.0005567
Gropu IIA: Y = 0.00000332 V + 0.0020891
Group IIIB: Y = 0.00000191 V + 0.0015400
Information:
Y = spare parts maintenance per 1000 km
V = walking speed

- Mechanic

Group I: Y = 0.00362 V + 0.36267
Group IIA: Y = 0.02311 V + 1.97733
Group IIIB: Y = 0.01511 V + 1.21200
Information:
Y = mechanic hours per 1000 km

e. Depreciation Expense

Group I: $Y = \frac{1}{2{,}50\ V+125}$
Group IIA: $Y = \frac{1}{9{,}0\ V+450}$
Group IIIB: $Y = \frac{1}{6{,}0\ V+300}$
Information:
Y = depreciation per 1000 km, equal to the depreciation value of the vehicle

f. Insurance

Group I: $Y = \frac{38}{500\ V}$
Group IIA: $Y = \frac{6}{2571{,}42857\ V}$
Group IIIB: $= \frac{61}{1714{,}28571\ V}$
Information:
Y = depreciation per 1000 km, equal to the depreciation value of the vehicle

2.6 Regression Analysis

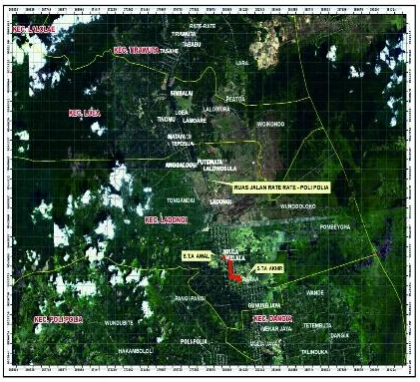
In this study, the analysis of vehicle operational costs uses the PCI (pacific consultants international) model for non-toll roads, namely the sum of variable costs and standing costs, which are influenced by vehicle speed and the type of vehicle used. The equations of the PCI model are as follows:

- Normality test
- Regression coefficient test
- Coefficient of determination

III. RESEARCH METHODS

3.1 Research site

The location of this research was carried out on the welala - ra-raa road, East Kolaka Regency with the length of the road being reviewed as far as 5 km.



Picture 1. Research Sites

3.2 Data Types and Sources

Sources of data in this study include research data, primary data and secondary data, where primary data is obtained directly from the field. Types of data taken are data on types and dimensions of damage and travel speed. while the secondary data is obtained from institutional research on the scope of research and road inventory.

3.3 Research variable

Research variables are data that become a reference in analyzing a problem that occurs, including the following:

Table 7. Research variables

No	Review elements	Indicator
1.	Rated road condition	SDI value
2.	**BOK**	**1. Variable cost** - Fuel cost - Lubricating oil consumption - Tire consumption - Maintenance cost **2. Fixed cost** - depreciation expense - Capital interest - Insurance

Source: Research Design 2021

IV. RESULTS AND DISCUSSION

4.1 Street Damage

Research on the level of damage to the Welala – Ra-raa Road in the East Kolaka Regency. along 5 km, and is divided into 50 segments with a division of 100-meter segments. Data that has been obtained from field surveys such as the type of Pavement Damage with the type of damage to cracks, holes, and ruts.

Table 8. Calculation of SDI Value of Jalan Welala-Rara Sta. 0+100 – Sta 5+000

Segment	Crack Area	Crack Width	Number of Holes	Used Wheels	SDI	Road conditions
0+000 - 0+100	20	40	265	365	365	Heavy Damage
0+100 - 0+200	20	40	115	215	215	Heavy Damage
0+200 - 0+300	40	80	305	405	405	Heavy Damage
0+300 - 0+400	40	80	305	405	405	Heavy Damage
0+400 - 0+500	40	80	305	405	405	Heavy Damage
0+500 - 0+600	40	80	305	405	405	Heavy Damage
0+600 - 0+700	20	40	265	365	365	Heavy Damage
0+700 - 0+800	20	40	265	365	365	Heavy Damage
0+800 - 0+900	20	40	265	365	365	Heavy Damage
0+900 - 1+000	40	80	305	405	405	Heavy Damage
1+000 - 1+100	40	80	305	405	405	Heavy Damage
1+100 - 1+200	40	80	305	405	405	Heavy Damage

1+200 - 1+300	40	80	305	405	405	Heavy Damage
1+300 - 1+400	20	40	265	365	365	Heavy Damage
1+400 - 1+500	40	80	305	405	405	Heavy Damage
1+500 - 1+600	40	80	305	405	405	Heavy Damage
1+600 - 1+700	40	80	305	405	405	Heavy Damage
1+700 - 1+800	40	80	305	405	405	Heavy Damage
1+800 - 1+900	40	80	305	405	405	Heavy Damage
1+900 - 2+000	40	80	305	405	405	Heavy Damage
2+000 - 2+100	40	80	305	405	405	Heavy Damage
2+100 - 2+200	40	80	305	405	405	Heavy Damage
2+200 - 2+300	40	80	305	405	405	Heavy Damage
2+300 - 2+400	40	80	305	405	405	Heavy Damage
2+400 - 2+500	40	80	305	405	405	Heavy Damage
2+500 - 2+600	40	80	305	405	405	Heavy Damage
2+600 - 2+700	40	80	305	405	405	Heavy Damage
2+700 - 2+800	40	80	305	405	405	Heavy Damage
2+800 - 2+900	40	80	305	405	405	Heavy Damage
2+900 - 3+000	40	80	305	405	405	Heavy Damage
3+000 - 3+100	20	40	265	365	365	Heavy Damage
3+100 - 3+200	40	80	305	405	405	Heavy Damage
3+200 - 3+300	40	80	305	405	405	Heavy Damage
3+300 - 3+400	20	40	115	215	215	Heavy Damage
3+400 - 3+500	20	40	265	365	365	Heavy Damage
3+500 - 3+600	20	40	265	365	365	Heavy Damage
3+600 - 3+700	20	40	265	365	365	Heavy Damage
3+700 - 3+800	40	80	305	405	405	Heavy Damage
3+800 - 3+900	40	80	305	405	405	Heavy Damage
4+000 - 4+100	20	40	265	365	365	Heavy Damage
4+100 - 4+200	0	0	225	325	325	Heavy Damage
4+200 - 4+300	40	80	305	405	405	Heavy Damage
4+300 - 4+400	20	40	265	365	365	Heavy Damage
4+400 - 4+500	20	40	265	265	265	Heavy Damage
4+500 - 4+600	40	80	305	305	305	Heavy Damage
4+600 - 4+700	40	80	305	305	305	Heavy Damage
4+700 - 4+800	40	80	305	305	305	Heavy Damage
4+800 - 4+900	40	80	305	305	305	Heavy Damage
4+900 - 5+000	40	80	305	305	305	Heavy Damage
average	374,2	Heavy Damage				

From the results of the pavement condition assessment using the Surface Distress Index (SDI) value, the average SDI value along the Welala - Raraa, Sta. 0+100 up to Sta. 5+000, which is 374.2 with heavily damaged condition.

4.2 vehicle operating cost

The vehicle operational cost (BOK) analysis is calculated based on the value of traffic speed. Vehicle operational costs to be analyzed include fuel costs, lubricating oil costs, tire costs, maintenance costs including spare parts and mechanics, depreciation costs and insurance costs. The following is a recapitulation of vehicle operating costs on the Welala – Ra-raa Road section.

Table 9. Recapitulation of Vehicle Operating Cost Value

No	BOK motorbike			car book		
	left	right	Average	left	right	Average
1	2,147	2.11	2.12857	10,076	10,692	10,384
2	2.075	1.7241	1.89951	9.9337	10,298	10,116
3	2,173	1.6688	1.92087	9.6627	9.9337	9.7982
4	2,122	1.7976	1.95989	9.9337	9.8642	9.8989
5	2,241	1.8106	2.02595	10,076	10,223	10,15
6	2,098	1.8373	1.96771	10,375	9.7287	10,052
7	2,186	1,851	2.01856	10,375	11.114	10,744
8	2.2	1.9227	2.06113	10,611	10,298	10,455
9	2,227	1.8238	2.02551	10,298	10.004	10,151
10	2,285	1.7848	2.03488	10.004	10,298	10,151
11	2.11	1.8373	1.97367	9.9337	10,298	10,116
12	2,285	1.7722	2.0286	9,233	9.9337	9.5833
13	2,147	1.7358	1.94146	9.4103	10,774	10,092
14	2,135	1.8106	1.97257	9.6627	9.7287	9.6957
15	2.27	1.7477	2.00896	9.7959	10,298	10,047
16	2,135	1.7126	1.92357	9.1763	9.8642	9.5202
17	2,315	1.6688	1.99201	8.9607	10,298	9.6295
18	2,147	1.8373	1.9922	10,298	10,452	10,375
19	2,173	1.7722	1.97257	9.4717	10,223	9.8474
20	2,086	1.6794	1.88292	8.9607	10,149	9.5548
21	2,227	1.7358	1.98149	9,291	10,611	9.9509
22	2.11	1.6794	1.89474	8.6279	10,375	9.5013
23	2,173	1.6005	1.88672	8.9607	10,223	9.5919
24	2,086	1.6482	1.86732	9.1206	10,531	9.8258
25	2.021	1.6584	1.83957	9.5979	10,076	9,837
26	1,972	1.6584	1.81517	9.8642	10,452	10,158
27	2,135	1.7976	1.96607	9.7287	10,692	10.21
28	2.053	1.6794	1.86602	9,291	10,223	9,757
29	2,086	1.6382	1.86233	10,149	10,857	10,503
30	2,086	1.6482	1.86732	10,076	10,298	10,187
31	2.064	1.6005	1.83208	10,149	9.7959	9.9724
32	2,001	1.6794	1.84	9.5979	10,452	10,025
33	1,981	1.7013	1.8413	10,076	9.35	9,713
34	2.053	1.7358	1.8942	10,375	10,375	10,375
35	2.021	1.7477	1.88422	10,692	9.8642	10,278
36	2.075	1.7126	1.89376	10,223	10,149	10,186
37	2,098	1.6584	1.87826	10,223	10,692	10,457
38	2,122	1.7722	1.9472	10.004	9.8642	9.9343
39	2,098	1.7477	1.92292	10,611	9.7959	10,203
40	2,173	1.7241	1.94851	9.9337	10,452	10,193
41	2.2	1.6482	1.92392	10,611	9.8642	10,237
42	2,147	1.7241	1.9356	10,223	10,223	10,223
43	2.2	1.8649	2.03224	10,149	9.7959	9.9724
44	2,122	1.7126	1.91739	9.9337	10,298	10,116
45	2,256	1.7358	1.99571	9.7959	10,298	10,047
46	2,173	1.7976	1.98526	10,298	10,375	10,336
47	2,173	1.6482	1.91057	10,298	10,531	10,415
48	2,122	1.6482	1.8852	9.9337	9.9337	9.9337
49	2,213	1.7013	1.95731	10,076	10,692	10,384
50	2,186	1.6096	1.89789	10,076	9.7287	9.9024
Amount			96.9014	Amount		502.79
Average			1,938	Average		10.056

From the above recapitulation, it is obtained that the average value for the operational cost of motorcycles is 1,938 while for light vehicles it is 10,056.

4.3 The Effect of Road Damage on the Value of Vehicle Operating Costs

1. Perform data normality test on data pairs.

The test is carried out by paying attention to the distribution of data on a linear line where, the basis for the decision is that the data points follow a linear line then the data is normally distributed and if the points do not follow a linear line, then the data is not normally distributed or using a histogram curve approach with the basis of the decision. is that the curve is symmetrical bell-shaped.

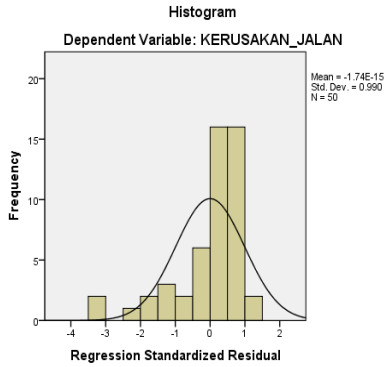


Figure 2. Data Normality Test Based on Motorcycle Plot Test Approach

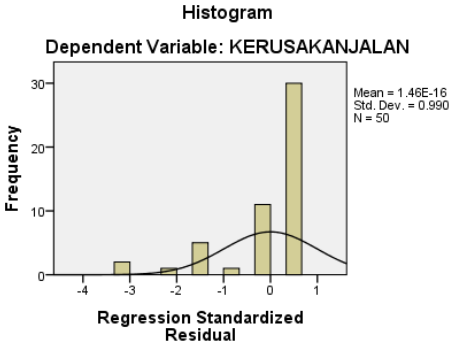


Figure 3. Normality test data based on light vehicle plot test

2. Determine the value of the coefficient of determination from the results of regression testing.

- The value of the determinant coefficient for motorcycles is .0.001. This means that the effect of the level of road damage on the operational costs of motorcycles is 0.001%.
- The correlation value for motorcycles is 0.027, this means that the level of road damage has a close relationship with the low operating costs of motorcycles because the correlation coefficient produced is in the interval 0 to 0.199.
- The regression coefficient value is 0.050 with a significance value of 0.853, this means that the level of road damage does not affect the operational costs of motorcycles because the resulting significance value is greater than 0.05.

Model Summary b				
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	**.027 a**	**.001**	**-.020**	**49.64077**
a. Predictors: (Constant), BOK_VEHICLE_MOTOR				
b. Dependent Variable: ROAD DAMAGE				

3. Determine the value of the coefficient of determination from the results of regression testing

- The value of the determinant coefficient for light vehicles is 0.089. This means that the effect of the level of road damage on the operational costs of motorcycles is 8.9%.
- The correlation value for light vehicles is 0.342, this means that the level of road damage has a close relationship with low light vehicle operational costs because the correlation coefficient value produced is in the interval 0.2 to 0.399.
- The regression coefficient value is -0.59.001 with a significance value of 0.015, this means that the level of road damage affects the operational costs of light vehicles because the resulting significance value is smaller than 0.05.

Model Summary b					
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**	
1	**.342 a**	**.089**	**.070**	**49.64077**	
a. Predictors: (Constant), ROAD DAMAGE					
b. Dependent Variable: LIGHT VEHICLE BOK					

V. CONCLUSIONS AND SUGGESTIONS

5.1 Conclusion

The result of this research is that the damage to the welala - ra-raa road is included in the category of heavily damaged with a Surface Distress Index (SDI) of 387.9. Vehicle operational costs (BOK) for motorcycles due to road damage are 161.01/km while the BOK for light vehicles is 545.77/km. The effect of road damage (SDI) on Vehicle Operational Costs on the Welala – Ra-raa Road section is 0.001% for motorcycles while light vehicles are 8.9%.

5.2 Suggestion

Some suggestions that may be put forward for consideration include:

1. It is necessary to carry out repairs to the damage to the street structure on the street welala - rara.
2. It is necessary to conduct further research on vehicle operational costs, especially on the street welala - rara.

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