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The Effect of Road Damage on Road User Satisfaction (Case Study: Southern Ring Road, Tuban Regency)

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ABSTRACT

This study aims to analyze the effect of road damage levels on user satisfaction along the Ring Road / Southern Bypass (Jalan Lingkar Selatan) in Tuban Regency (Kabupaten Tuban). Poor road conditions—such as cracks, potholes, uneven patches, water puddles, and corrugated surfaces—can reduce comfort, safety, and travel speed. A quantitative approach was employed using a questionnaire containing ten statements: five measuring perceptions of road damage (variable X) and five measuring user satisfaction (variable Y). A total of 91 respondents were selected through purposive sampling among regular road users. Data were analyzed using validity testing, reliability testing, and simple linear regression. The validity test showed corrected item–total correlation values ranging from 0.608 to 0.854, all exceeding the r-table value of 0.207, indicating validity. The reliability test produced a Cronbach's alpha of 0.890 for variable X and 0.604 for variable Y, indicating acceptable internal consistency. Regression analysis yielded the equation $\boldsymbol{Y = 29.115 - 0.715X + e}$*, with a correlation coefficient* $\boldsymbol{R = 0.673}$*and a coefficient of determination* $\boldsymbol{R^2 = 0.453}$*; the significance value* $\boldsymbol{p = 0.000}$*(<0.05) indicated a significant negative effect. The study highlights the importance of regular maintenance and prioritized repairs to improve road service quality and user satisfaction. The findings provide empirical evidence for policymaking in road maintenance budgeting, repair prioritization, public safety awareness, and periodic evaluation of maintenance programs.*

KEYWORDS *Linear Regression; Road Damage; Road Maintenance; Road User Satisfaction; Ring Road Tuban.*

INTRODUCTION

Roads are vital transportation infrastructure supporting community mobility and the distribution of goods and services (Adu et al., 2024). Good road quality positively impacts user comfort, time efficiency, and safety (Bikam et al., 2019; Santos et al., 2024). Conversely, damaged road conditions cause negative effects, including higher accident risks, vehicle damage, and road user dissatisfaction (Tandrayen-Ragoobur et al., 2025). Poor road conditions also impose significant economic costs, such as delays in goods distribution, elevated transportation expenses from increased fuel consumption and maintenance, and adverse effects on local businesses reliant on efficient logistics (Selvianti, 2022; Levesque et al., 2023). These economic consequences highlight the critical role of maintaining road infrastructure for regional development (Gertler, 2024).

In Tuban Regency, the Ring Road section plays a key role as a connector reducing city-center traffic density (Nugmanova et al., 2019; Zehawi et al., 2022). The Southern Ring Road serves as a critical arterial route in Tuban Regency's transportation network, functioning as an alternative bypass to alleviate urban congestion and as a vital corridor for regional trade and logistics (Nyongesa, 2019; Li & al., 2024). This road links major industrial zones,

agricultural areas, and commercial districts, making it essential for the local economy and commuter traffic. Its strategic importance for passenger and freight movement means road quality directly affects regional connectivity and economic efficiency (Adu et al., 2024; Adetunji & Aloba, 2021). However, many road users complain about damage to this section, including potholes, cracks, corrugated surfaces, and poor drainage, which impairs driving comfort and influences perceptions of government infrastructure performance (Kharisma et al., 2024).

In public services, road user satisfaction indicates government success in infrastructure management (Kanwal et al., 2020; Kartikasari et al., 2025). Thus, research measuring the effect of road damage on road user satisfaction, particularly on the Tuban Ring Road section, is essential. Study results can provide evaluation and recommendations for stakeholders to enhance road and transportation quality (Ahmadabadi & Heravi, 2019; Joewono et al., 2016).

To maintain focus and alignment with objectives, this research limits scope to the Ring Road or Southern Ring Road section in Tuban Regency. The Southern Ring Road was selected due to higher traffic volume (approximately 1,000 vehicles daily, including many commercial ones), more severe damage evident from observations and complaints, limited detour options amplifying issues, and accelerated deterioration from nearby developments. These factors position it as the most representative case for analyzing road damage and user satisfaction in Tuban Regency.

Other road sections in or beyond Tuban Regency are excluded. Analyzed damage types are limited to common visual issues: potholes, cracking, uneven surfaces, patching, and drainage failures. Respondents comprise active users (two- or four-wheeled) traversing the section, selected via accidental sampling. Variables include road damage level (independent) and user satisfaction level (dependent). Data collection occurred from July to August 2025 to reflect conditions during that period.

The research problem centers on three aspects: road damage conditions on Tuban Regency's Southern Ring Road, user satisfaction levels, and the extent of damage's influence on satisfaction. Accordingly, objectives are to identify damage types, measure satisfaction, and analyze damage effects. Findings offer policy input for local governments on road repair and maintenance, while deepening understanding of how road quality boosts community satisfaction with transportation facilities.

METHOD

This study employed a quantitative approach with a causal-associative research design to measure the relationship between the level of road damage (independent variable) and the level of road user satisfaction (dependent variable). The main goal was to determine whether road damage significantly affected road user satisfaction on the Southern Ring Road (Ring Road) section in Tuban Regency. This research was conducted on the Southern Ring Road section in Tuban Regency during June–July 2025.

The research population comprised all road users passing through the location, including motorcyclists, private car drivers, and public transportation operators. The sample was drawn using accidental sampling, yielding a minimum of 91 respondents calculated via the Slovin formula from an estimated daily population of 1,000 users at a 10% error rate. The research design adopted a cross-sectional approach, with data collected once over a specific period.

The primary instrument was a Likert scale questionnaire assessing respondents' perceptions of road damage conditions and their satisfaction levels. The research procedure proceeded systematically: it began with preparation (instrument development, literature review, and problem formulation), followed by data collection via visual observations and questionnaire distribution. Data processing then ensued, encompassing questionnaire recapitulation, validity and reliability tests, descriptive analysis, simple linear regression, and hypothesis testing.

The data consisted of primary and secondary sources. Primary data included questionnaire responses and field observations on road damage types and severity, supplemented by photo documentation, while secondary data derived from literature, agency reports, and relevant sources. Data collection occurred both online and directly at the site. Analysis involved field surveys to record damage, assessments of impacts on user safety and comfort, calculations of means and standard deviations, normality tests, product-moment correlation, and descriptive analyses of respondent characteristics and variables. This process culminated in compiling results, drawing conclusions, and formulating recommendations.

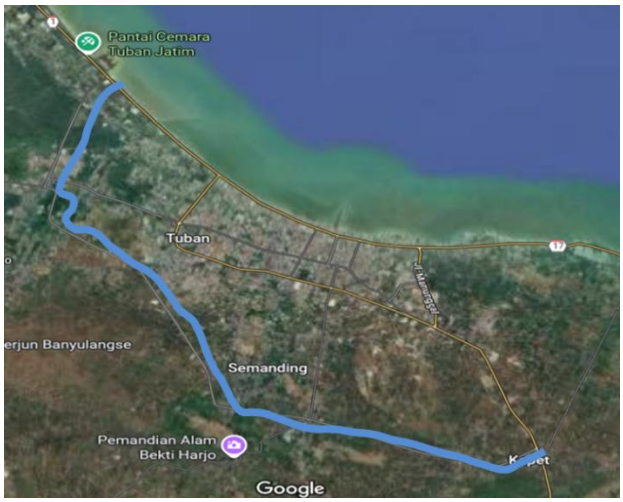

Figure 1. Map of the Research Location
Source : Google Maps

RESULT AND DISCUSSION

Field Survey

From the field survey obtained the condition of the road surface Damage as follows:

1. **Potholes**

Figure 2. Documentation of potholes road surfaces
Source : Field Survey,(2025)

Figure 3. Pothole Road Surface Documentation
Source : Field Survey,(2025)

2. Road Cracks

Figure 4. Documentation of cracks on the road surface
Source : Field Survey,(2025)

3. Bumpy Roads

Figure 5. Documentation of the Surface of the Undulating Road
Source : Field Survey,(2025)

Figure 6. Documentation of the Surface of the Bumpy Road
Source : Field Survey,(2025)

4. Uneven Patches

Figure 7. Uneven Patch Road Surface Documentation
Source : Field Survey,(2025)

Respondent Overview

This study was conducted on 91 respondents who used Jalan Ring Road Tuban. Respondents consisted of users of commercial vehicles, private cars, and motorcycles. Data collection was carried out by online questionnaire method. The distribution of respondents

by vehicle type is presented in Table 1.

Table 1. Distribution of Respondents by Vehicle Type

Vehicle Type	Number of Respondents	Percentage (%)
Commercial Vehicles	45	49,5%
Motorbike	28	30,8%
Private Cars	18	19,8%
Total	**91**	**100%**

Source : Research Results,(2025)

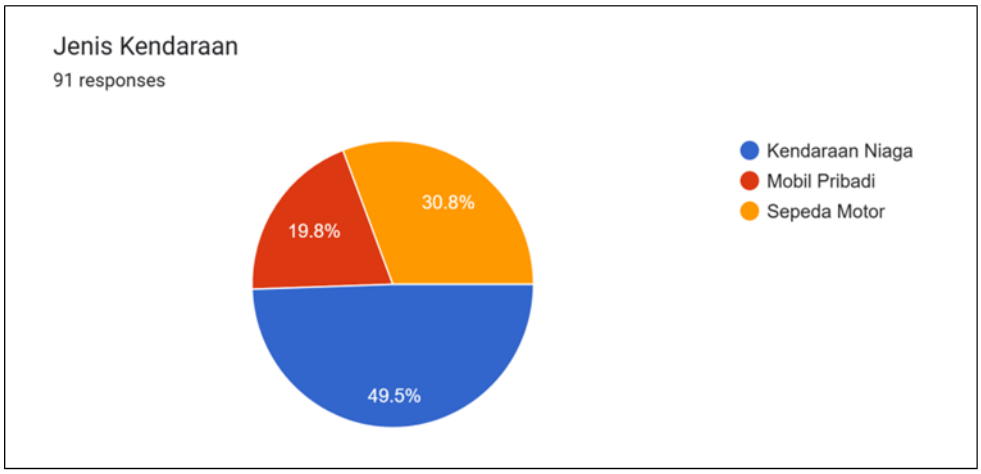

Figure 8. Google Form Questionnaire Results (2025)

These results show that the majority of respondents are commercial vehicle users who routinely pass through the southern ring road, Tuban Regency as a logistics distribution route or other business activities.

Validity and Reliability Tests

1) Validity Test

The validity test aims to find out the extent to which the items in the questionnaire are able to measure the construct in question. In this study, the validity test was carried out using the Pearson Product Moment correlation technique, which measures the relationship between the score of each statement item and the total score. The calculation was carried out using the help of SPSS software.

Decision-making criteria:

a. If r counts > r of the table at a significance level of 5% (α = 0.05), then the item is valid.
b. If r calculates ≤ r table, then the item is invalid.

With a total of 91 respondents, the r-value of the table at α= 0.05 and df = 89 is around 0.207.

Table 2. Nilai r Product Moment

N	Taraf Signif 5%	Taraf Signif 10%	N	Taraf Signif 5%	Taraf Signif 10%	N	Taraf Signif 5%	Taraf Signif 10%
3	0.997	0.999	27	0.381	0.487	55	0.266	0.345
4	0.950	0.990	28	0.374	0.478	60	0.254	0.330
5	0.878	0.959	29	0.367	0.470	65	0.244	0.317
6	0.811	0.917	30	0.361	0.463	70	0.235	0.306

N	Taraf Signif		N	Taraf Signif		N	Taraf Signif	
	5%	10%		5%	10%		5%	10%
7	0.754	0.874	31	0.355	0.456	75	0.227	0.296
8	0.707	0.834	32	0.349	0.449	80	0.220	0.286
9	0.666	0.798	33	0.344	0.442	85	0.213	0.278
10	0.632	0.765	34	0.339	0.436	90	0.207	0.270
11	0.602	0.735	35	0.334	0.430	95	0.202	0.263
12	0.576	0.708	36	0.329	0.424	100	0.195	0.256
13	0.553	0.684	37	0.325	0.418	125	0.176	0.230
14	0.532	0.661	38	0.320	0.413	150	0.159	0.210
15	0.514	0.641	39	0.316	0.408	175	0.148	0.194
16	0.497	0.623	40	0.312	0.403	200	0.138	0.181
17	0.482	0.606	41	0.308	0.398	300	0.113	0.148
18	0.468	0.590	42	0.304	0.393	400	0.098	0.128
19	0.456	0.575	43	0.301	0.389	500	0.088	0.115
20	0.444	0.561	44	0.297	0.384	600	0.080	0.105
21	0.433	0.549	45	0.294	0.380	700	0.074	0.097
22	0.423	0.537	46	0.291	0.376	800	0.070	0.091
23	0.413	0.526	47	0.288	0.372	900	0.065	0.086
24	0.404	0.515	48	0.284	0.368	1000	0.062	0.081
25	0.396	0.505	49	0.281	0.364			
26	0.388	0.496	50	0.279	0.361			

a. Variable X Validity Test Results

Based on the results of the calculation using SPSS on the 5 Variable X statement items used in this study, the result of r calculation was > 0.207 Thus, the questionnaire instrument can be said to be Valid.

Table 3. Variable X Validity Test Results

		X1	X2	X3	X4	X5	X_TOTAL
X1	Pearson Correlation	1	0.503**	0.810**	0.485**	0.583**	0.812**
	Sig. (2-tailed)		.000	.000	.000	.000	.000
	N	91	91	91	91	91	91
X2	Pearson Correlation	0.503**	1	0.534**	0.774**	0.630**	0.825**
	Sig. (2-tailed)	.000		.000	.000	.000	.000
	N	91	91	91	91	91	91
X3	Pearson Correlation	0.810**	0.534**	1	0.549**	0.551**	0.828**
	Sig. (2-tailed)	.000	.000		.000	.000	.000
	N	91	91	91	91	91	91
X4	Pearson Correlation	0.485**	0.774**	0.549**	1	0.753**	0.854**
	Sig. (2-tailed)	.000	.000	.000		.000	.000
	N	91	91	91	91	91	91
X5	Pearson Correlation	0.583**	0.630**	0.551**	0.753**	1	0.845**
	Sig. (2-tailed)	.000	.000	.000	.000		.000

	N	91	91	91	91	91	91
X_TOTAL	Pearson Correlation	0.812**	0.825**	0.828**	0.854**	0.845**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	
	N	91	91	91	91	91	91

** Korelasi signifikan pada level 0.01 (2-tailed)

Source : SPSS25 analysis results, (2025)

b. Results of the Variable Y Validity Test

Based on the results of the calculation using SPSS on 5 Variable X statement items used in this study, the result of r calculation was > 0.207 Thus, the questionnaire instrument can be said to be Valid.

Table 4. Variable Y Validity Test Results

		Y1	**Y2**	**Y3**	**Y4**	**Y5**	**Y_TOTAL**
Y1	Pearson Correlation	1	0.735**	0.085	0.144	0.555**	0.694**
	Sig. (2-tailed)		.000	.000	.000	.000	.000
	N	91	91	91	91	91	91
Y2	Pearson Correlation	0.735**	1	0.064	0.155	0.498**	0.664**
	Sig. (2-tailed)	.000		.000	.000	.000	.000
	N	91	91	91	91	91	91
Y3	Pearson Correlation	0.085	0.064	1	0.443**	0.062	0.608**
	Sig. (2-tailed)	.000	.000		.000	.000	.000
	N	91	91	91	91	91	91
Y4	Pearson Correlation	0.144	0.155	0.443**	1	0.014	0.612**
	Sig. (2-tailed)	.000	.000	.000		.000	.000
	N	91	91	91	91	91	91
Y5	Pearson Correlation	0.555**	0.498**	0.062	0.014	1	0.626**
	Sig. (2-tailed)	.000	.000	.000	.000		.000
	N	91	91	91	91	91	91
Y_TOTAL	Pearson Correlation	0.694**	0.664**	0.608**	0.612**	0.626**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	
	N	91	91	91	91	91	91

** Significant correlation on level 0.01 (2-tailed)

Source : SPSS25 analysis results, (2025)

2) Reliability Test

Reliability tests are used to determine the internal consistency of the research instrument. One commonly used method is to calculate Cronbach's Alpha coefficient. Cronbach's Alpha score indicates the level of consistency between items in a questionnaire.

a. Results of the Variable X Reliability Validity Test

Table 5. Variable X Reliability Test Results

Reliability statistics	
Cronbach's Alpha	N of items
.890	5

Source : SPSS25 analysis results, (2025)

Based on the results of the calculation using SPSS on 5 items of variable X statement about road damage used in this study, a Cronbach's Alpha value of 0.890 was obtained.

Thus, the questionnaire instrument can be said to have high reliability (category: Reliable).

b. Results of the Variable Y Reliability Validity Test

Table 6. Variable Y Reliability Test Results

Reliability statistics	
Cronbach's Alpha	N of items
.604	5

Source : SPSS25 analysis results, (2025)

Based on the results of the calculation using SPSS on 5 items of variable Y statements about road user satisfaction used in this study, a Cronbach's Alpha value of 0.604 was obtained. Thus, the questionnaire instrument can be said to have high reliability (category: Reliable).

Descriptive Analysis of Variable Data

a) Road Damage Perception Level (X)

Table 7. Road Damage Perception Level (X)

	N	Minimum	Maximum	Mean	Std. Deviation
X1	91	4	5	4.60	0.492
X2	91	4	5	4.42	0.496
X3	91	4	5	4.53	0.502
X4	91	4	5	4.37	0.486
X5	91	3	5	4.36	0.506
Valid N (listwise)	91				

Source : SPSS25 analysis results, (2025)

Based on the results of the descriptive statistics above, it can be described that the distribution of data obtained by the researcher from the Road Damage Variable is:

1. Potholes (X1)

From the data, it can be described that the minimum value is 4 while the maximum value is 5, the average value is 4.60 and the standard deviation is 0.492.

2. Road Cracks (X2)

From the data, it can be described that the minimum value is 4 while the maximum value is 5, the average value is 4.92 and the standard deviation is 0.496.

3. Bumpy Road (X3)

From this data, it can be described that the minimum value is 4 while the maximum value is 5, the average value is 4.53 and the standard deviation is 0.502.

4. Uneven Patches (x4)

From the data, it can be described that the minimum value is 4 while the maximum value is 5, the average value is 4.37 and the standard deviation is 0.486.

5. Puddle

From this data, it can be described that the minimum value is 3 while the maximum value is 5, the average value is 4.36 and the standard deviation is 0.505.

b) User Satisfaction Level (Y)

Table 8. User Satisfaction Level (Y)

	N	Minimum	Maximum	Mean	Std. Deviation
Y1	91	1	4	1.64	0.548
Y2	91	1	2	1.55	0.500
Y3	91	2	5	4.23	0.857
Y4	91	3	5	3.99	0.796
Y5	91	1	3	1.78	0.757
Valid N (listwise)	91				

Source : SPSS25 analysis results, (2025)

Based on the results of the descriptive statistics above, it can be described that the distribution of data obtained by the researcher from the Road User Satisfaction Variable is :

1. Comfort (Y1)

From the data, it can be described that the minimum value is 1 while the maximum value is 4, the average value is 1.64 and the standard deviation is 0.548.

2. Security (Y2)

From the data, it can be described that the minimum value is 1 while the maximum value is 2, the average value is 1.55 and the standard deviation is 0.500.

3. Travel Time (Y3)

From the data, it can be described that the minimum value is 2 while the maximum value is 5, the average value is 3.07 and the standard deviation is 0.857.

4. Operating Costs(Y4)

From the data, it can be described that the minimum value is 3 while the maximum value is 5, the average value is 3.99 and the standard deviation is 0.796.

5. Visual assessment of road conditions (Y5)

From this data, it can be described that the minimum value is 1 while the maximum value is 3, the average value is 3.07 and the standard deviation is 0.757.

Inductive Analysis

1) Classic Assumption Test

The classical assumption test was used to test the feasibility of the regression model in this study. The classical assumption test consists of a normality test, a linearity multico test, a heteroscedasticity test and an autocorality test. Before testing a hypothesis with multiple linear regression, a classical assumption test is first carried out. The purpose of the classical assumption test is to obtain regression line equations that can actually be used to predict dependent variables.

2) Normality Test

To check whether or not data coming from a normally distributed population can be seen

from the curve in Figure 9 Histogram

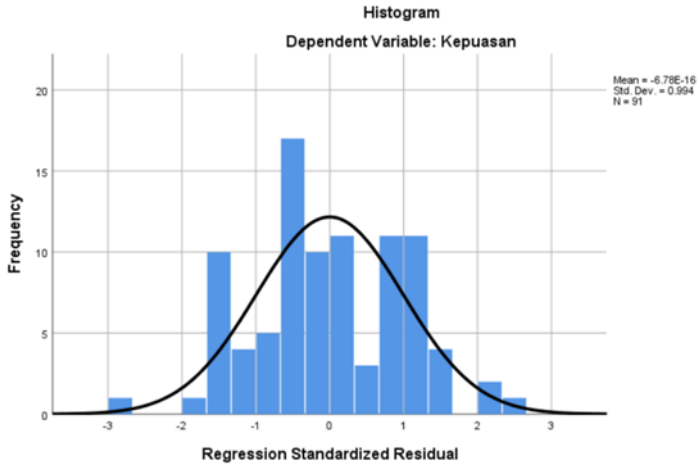

Figure 9. Histogram
Source : SPSS25 analysis results, (2025)

Based on the histogram output above, it can be seen that the curve has a slope that tends to be balanced, both on the left and right sides, and the curve is shaped like a bell which is almost perfect, the distribution of the existing data is evenly distributed over all areas of the normal curve. It can be concluded that the data is distributed normally. Likewise with the following Normal P-P Plot output:

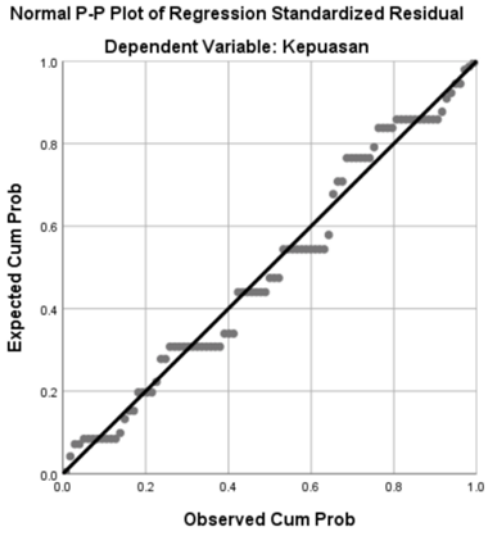

Figure 10. Normal Graph of P-Plot
Source : SPSS25 analysis results, (2025)

From the normal P-Plots curve above, it is known that the data points are unidirectional following a diagonal line, so the distribution of data is distributed normally.

3) Coefficient of Determination

Table 9. Coefficient of Determination

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.673[a]	.453	.447	1.633

a. Predictors: (Constant), Damage

Source : SPSS25 analysis results, (2025)

The R Square value is 0.453 which means that road damage affects road user satisfaction by 45.3% while the remaining 54.7% is influenced by other factors.

Inferential Analysis

To determine the effect of road damage on road user satisfaction, a simple linear regression analysis was carried out using SPSS.

1) Model Linear Regression

Table 10. Results of Linear Regression Analysis

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 - (Constant)	29.115	1.864		15.621	.000
Damage	-.715	.083	-.673	**-8.582**	**.000**

a. Dependent Variable: Satisfaction

Source : SPSS25 analysis results, (2025)

Based on the output in SPSS above, the regression model can be formulated as follows:

Y = 29.115 (a) - 0.715 (X) + e

The regression equation model means:

- **Constanta (a)** = 3.113 That is, if the damage is constant or
  Still, the satisfaction of road users is 29,115.
- **Coefficient of regression direction / β(X)** = - 0.715 (negative value) This means that if the damage increases by 1 (unit) then the satisfaction
  Road users will experience a decrease of -0.715

Hypothesis Test

1. T Test

Table 11. T Test

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 - (Constant)	29.115	1.864		15.621	.000
Damage	-.715	.083	-.673	**-8.582**	**.000**

a. Dependent Variable: Satisfaction

Source : SPSS25 analysis results, (2025)

Based on the Coefficients table, the results of the t-test were obtained as follows:

a) Constant

The constant value of 29.115 with a significance of 0.000 < 0.05 indicates that if there is no road damage (damage variable value = 0), then the satisfaction value of road users is at 29.115.

b) Road Damage Variables

The value of the regression coefficient for the impairment variable was -0.715 with a t-calculated value = -8.582 and a significance of 0.000 < 0.05. This shows that the variable of road damage has a negative and significant effect on the satisfaction of road users.

This means that every one unit increase in the level of road damage will reduce

the satisfaction rate of road users by 0.715 points.

2. Test F

Table 12. Test F

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	196.443	1	196.443	73.651	.000[b]
	Residual	237.381	89	2.667		
	Total	433.824	90			

a. Dependent Variable: Satisfaction
b. Predictors: (Constant), Damage

Source : SPSS25 analysis results, (2025)

Based on the results of the ANOVA (Analysis of Variance) test shown in the table above, a Fcal value of 73.651 was obtained with a significance value (Sig.) of 0.000. This significance value is smaller than the established significance level (α = 0.05), and the calculated F-value (73.651) is greater than Ftabel (3.95).

Thus, it can be concluded that the regression model used is significant, meaning that the independent variable, namely road damage, simultaneously has a significant effect on the dependent variable, namely the satisfaction of road users.

Discussion

Research Findings

This study revealed that there was a significant negative influence between road damage and road user satisfaction on the Tuban Ring Road section. The results of the regression analysis showed a coefficient value of –0.715 with a significance level of 0.013. This means that the higher the level of road damage felt by users, the lower their satisfaction in using the road.

In terms of vehicle type, commercial vehicle users showed the lowest level of satisfaction, allegedly because the impact of road damage on heavy vehicles was greater, both in terms of comfort, time efficiency, and operational costs.

Interpretation of the findings

The results of the study showed that road damage directly affects the quality of the driving experience. Holes, cracks, and uneven surfaces cause shocks, slow down vehicle speeds, and increase the risk of accidents. This logically lowers the level of satisfaction of road users.

The fact that commercial vehicles are the most affected group reinforces the suspicion that road maintenance should pay attention to the volume and load of traffic served, not just based on the aesthetics of the road surface.

Integration of Findings into Established Theories

These findings are in line with the theory of public services (Zeithaml et al., 1990) which states that user satisfaction is influenced by the perception of the quality of services received, including infrastructure. In the context of roads, the physical quality of roads is part of public services that must be maintained.

In addition, these results support the findings of Wahyudi (2020) and Rahmawati (2021) who concluded that road damage increases operational costs, slows down travel time, and

decreases user safety. However, the study enriched the literature by linking user perceptions to vehicle type segmentation, which had rarely been described in detail in previous studies.

Theoretically, these findings can strengthen the principle in Customer Satisfaction Theory, where there is a gap between the expectations and reality experienced by consumers. When the road conditions do not meet user expectations, satisfaction decreases.

Research Implications and Limitations

1) Practical Implications:

The results of this study can be used as a reference in road maintenance planning by the Tuban Regency Public Works Office. Increased user satisfaction can be achieved through:

   a. Immediate repairs to the most damaged parts of the road, especially those passed by commercial vehicles.
   b. Implementation of a digital public reporting system for damage reporting.
   c. Periodic maintenance scheduling that takes into account daily traffic levels and the type of vehicles passing through.

2) The limitations of this study lie in the:

   a. This study only uses a questionnaire approach so it is subjective and does not include technical data such as IRI (International Roughness Index) values.
   b. The number of respondents was limited to 91 people who may not yet represent all road users with different time and weather variations.
   c. Not considering the influence of other external factors such as street lighting, traffic signs, and environmental safety.

3) Advanced Research Directions:

Future research is expected to combine a quantitative approach of perception with a technical survey of road conditions, as well as expand the respondent population with a variation of survey times and vehicle classification in more detail.

CONCLUSION

Research on 91 respondents using the Southern Ring Road section in Tuban Regency revealed moderate to severe road damage, including cracks, potholes, uneven patches, wavy surfaces, and puddles, which compromised user comfort and safety. Questionnaire results indicated widespread dissatisfaction, particularly from bumpy surfaces and potholes hindering smooth driving, while regression analysis confirmed a significant negative effect of road damage on satisfaction (F_count = 73.651, Sig. = 0.000; t_count = -8.582, Sig. = 0.000; coefficient = -0.715), showing that greater damage reduced satisfaction levels. Recommendations include routine repairs by local governments targeting severe spots, heightened user caution and reporting, and for future research, incorporating variables like traffic volume, drainage quality, and safety metrics through advanced methods such as structural equation modeling or longitudinal studies to better elucidate road condition impacts on user satisfaction.

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