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Influence Factors of Road Maintenance for the Safety of Road Users on the Jakarta - Tangerang Toll Segment

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ABSTRACT

In an effort to fulfill the Minimum Service Standards (MSS) for toll roads according to the toll road law, all toll road business entities (TRBE) must fulfill them. This includes the Jakarta – Tangerang toll road section. Therefore, routine maintenance and maintenance of roads and facilities is always carried out. So that in toll lanes various maintenance activities are always found, in situations of very congested traffic conditions. And because maintenance activities use road lanes, this has an impact on the safety of toll road users. Data retrieval through questionnaires Phase I and Phase II with data sample collection tools using google form, observation, document collection, all data results will be analyzed using Microsoft excel and multiple linear regression using IBM SPSS version 21. From data analysis, potential factors are obtained. causing an influence on road safety during maintenance is the management of maintenance work, among which the influence is the management of work materials, management of the work environment, management of work equipment, management of work methods, and labor management. While the most dominant factor influencing individually is the management of the work environment.

Keywords: factor analysis, effect of maintenance, road user safety

INTRODUCTION

The Jakarta - Tangerang toll road is also considered by the public as a way to reduce congestion and congestion on arterial roads, thereby increasing driving speed and reducing travel time.

Figure 1 Geographical location of the Jakarta - Tangerang toll road, Indonesia.

Due to its very important benefits, this toll road has experienced an increase in the amount of traffic from its initial operation in 1984 to the present (Widyaningsih, 2017). So that it exceeds the ability of the planned average daily traffic limit.

Where this toll road has geographic data (Departemen Pekerjaan Umum, 2009) it is a flat road with the number of lanes 8/2 D Average Daily Traffic Standard (ADT) of 120,000 vehicles/day, but in the realization of the capacity and function of the Jakarta – Tangerang toll road it has the number of ADT far exceeds the standard capacity as shown in the graphic image of the

comparison of the number of Standard ADT with the realization of the ADT below.

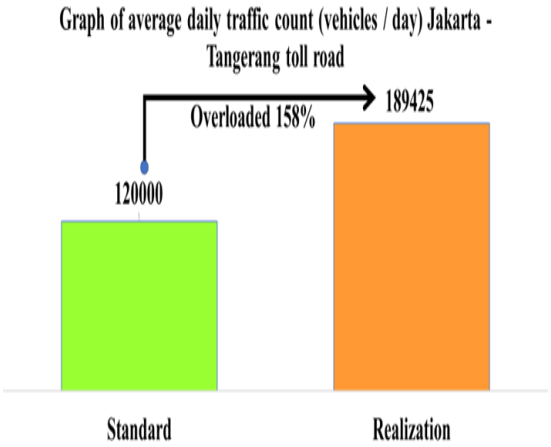

Figure 2 Graph of Comparison of ADT Standards with Realized ADT

Based on the condition of the average daily traffic density (ADT), it can cause damage to road pavements and road facilities. So that the Jakarta - Tangerang Toll Road Business Entity (TRBE) must have a higher intensity of routine maintenance activities that must be carried out by managers, to provide services by carrying out maintenance activities so that the toll road remains in a safe road condition in accordance with the Minimum Service Standards (MSS) for toll roads. (Menteri Pekerjaan Umum dan Perumahan Rakyat Republik Indonesia, 2015).

Transportation disturbances that can affect the decline in service levels, one of which is road repair and maintenance (Ramadhani et al., 2021). Road repair and maintenance is carried out due to several factors, caused by internal factors and external factors. Internal factors can occur due to road conditions and facilities, unable to withstand the load and volume of passing vehicles, resulting in potholes, poor road drainage, to the condition of the road pavement structure that has passed the service period of the road itself.

As has been done by the Toll Road Business Entity, which carries out road repairs and maintenance on the Jakarta – Tangerang toll road, which is caused by internal factors, namely the volume of vehicle traffic that exceeds road capacity and as a fulfillment of toll road MSS, maintenance is carried out. As a result of road maintenance activities and facilities always using the road lane, the implementation can affect the level of safety of road users.

Based on the above background, a research was conducted to analyze the safety factors of toll road users which were influenced by the existence of road maintenance work. As the purpose of this research to 1) define and analyze road maintenance problems for road user safety. 2) Researching and analyzing the factors that influence maintenance activities on the Jakarta-Tangerang toll road. 3) Researching and analyzing the individual factors that have the most influence on maintenance activities on the Jakarta-Tangerang toll road section.

This study used a survey method through phase I and phase II questionnaires. (Sugiyono, 2017)

LITERATURE REVIEW

Traffic

According to Law No. 22 of 2009 (Presiden Republik Indonesia, 2009) Road Traffic and Transportation is a unified system consisting of Traffic, Road Transport, Traffic and Road Transport Networks, Traffic and Road Transport Infrastructure, Vehicles, Drivers, Road Users, and their Management.

And Traffic is the movement of vehicles and people in the Road Traffic Room.

Toll road

According to the Government Regulation of the Republic of Indonesia number 15 of 2005 concerning Toll Roads, that toll roads are national public roads but users are required to pay tolls (Presiden Republik Indonesia, 2005).

Road User Safety

In realizing road safety, traffic safety and security must be carried out as regulated in Law No. 22 of 2009, concerning Road Traffic and Transportation, that traffic

safety and road transportation are a situation in which all people, goods and/or or the vehicle is free from interference with unlawful acts and/or fear of traffic, as well as traffic safety and road transportation altogether, the risk of road traffic accidents involving people, vehicles, roads, and/or the environment;

According to Sujanto (Sujanto, 2010), that the safety of land traffic is determined by road facilities and infrastructure. By conducting identification, namely checking road equipment including traffic signs, road markings, traffic signaling devices, street lighting devices, road user control and safety devices, road monitoring and security devices, bicycle lane facilities, sidewalk lanes for pedestrians, people with disabilities. disability and other traffic support facilities. In order to be able to find out the causes that can cause accidents and evaluate the results of the inspection of road equipment in accordance with Article 25 of Law Number 22 of 2009 concerning road transport traffic. The level of road safety and accident rates can be reduced or the consequences are minimized in domino theory (Heinrich, 1931). Accidents occur not only because they are caused by one cause but also due to a series of combinations of effects of weaknesses or disturbances related to vehicle users and road conditions.

In accordance with the objectives of the General National Road Safety Plan (RUNK 2011-2035) (Indonesia Pemerintah, 2011) In order to realize traffic safety and improve traffic safety, the government seeks to realize five pillars that reflect the concept of a "traffic safety system" including:

1. Traffic Safety Management.

To support road safety management, the following activities are required:

a. Strengthening institutional capacity
b. Establishment of a coordinating body
c. Formulation of national traffic safety strategy.
d. Setting practical time targets
e. Development of traffic accident data system.

2. Traffic safety

Several activities are needed to support safe roads, including:

a. Increase safety awareness in planning and design.
b. Establish a traffic safety audit process.
c. Regular traffic safety assessment.
d. Accident expansion risk management program.
e. Setting safety priority at road construction site

3. Vehicle Safety

A safe support vehicle requires several activities such as:

a. Harmony of global standards
b. Establish a new vehicle evaluation program
c. Equip all new vehicles with safety features.
d. Encouraging car company managers to purchase, operate and maintain safe vehicles.

4. Road user safety.

To support safe road users, the following activities are required:

a. Strive for the creation of a Road Safety Law.
b. Improving the law enforcement system.
c. Increased public awareness about risk factors.
d. Carry out activities that minimize injuries while driving.
e. Improve Driving license (SIM) ownership procedure.

5. Post-accident response.

To support post-accident response, the following activities are required:

a. Development of hospital care system.
b. Development of a national emergency number.
c. Rehabilitation and support for injured traffic accident victims.

Traffic safety in the work area

Road maintenance activities are dangerous activities (Direktorat Jenderal Bina Marga, 2012). Although there is no official data on the number of accidents related to road maintenance work, it is

certain that the number of accidents at road work locations is quite high.

According to Ramadhani (Ramadhani et al., 2021), the implementation of road maintenance is an activity that can affect the safety level of road users.

Road maintenance work has a special nature, where the workplace is in an open space that is affected by weather, limited time, uses untrained workers, spends a lot of energy, and uses work equipment (Iqbal et al., 2018).

Based on a review of the literature obtained, then the variables and indicators that will be used will be made based on the previous research variables as instruments in this study. To be validated by experts who are competent and experienced in the field of maintenance and traffic services on toll roads. With instruments that will be a safety factor for road users. As in table 1 below.

Table 1. Cause Criteria

Cause	Indicator
Job Specification	1. According to Spec 2. Not Up To Spec 3. Spec Changes
Job Management	1. Material 2. Tools 3. Environment 4. Methods 5. Labor
Type of work	1. Street 2. Street Lights 3. Drainage 4. Landscape 5. Guardrail 6. Signs 7. Marks
Work time	1. Night 2. afternoon 3. Working Days 4. Holiday 5. Rain

To determine the factors causing the maintenance implementation activities that affect the safety of road users, in this study it was determined based on the analysis of the average with the highest score as an influential variable or as an independent variable (independent variable).

Table 2. Independent variable (X)

Variables	Indicator
X1 Work Material Management	1) Doesn't last long 2) Leftovers make the lane dirty 3) Not according to spec 4) Come late 5) Placement close to the fast lane 6) Splattered on the traffic lane 7) Closing the traffic lane
X2 Work Environment Management	1) Narrow lane 2) Work without security 3) Toll exit/entrance junction 4) Road users have difficulty determining the direction of the bow 5) Traffic speed is still quite high (≥60 km/h) 6) Wet locations maintenance work continues 7) Loss of standard roughness/flatness 8) Nights without work lighting
X3 Work Tools Management	1) Causing shock (shock) road users 2) Testing and checking readiness at the job site 3) Not in accordance with the standard requirements 4) Not having the most up-to-date model 5) Unable to speed up work time 6) Requires wide lanes when used 7) Difficult to control by workers 8) Work equipment is not equipped with safety standards. 9) Workers' vehicles park in the fast lane 10) Operational vehicles without rotary lights
X4 Management of Work Method	1) Early warning signs at least 100M before the location does not exist. 2) Without using job security signs 3) Dirty, illegible and unreflective work warning signs 4) Installation and opening of work signs without prioritizing road users 5) Signs installed but not visible at night 6) The size and type of signs installed are not up to standard
X5 Human / labor management	1) Officers don't help regulate traffic 2) Workers often cross the lane 3) Workers don't care about traffic speed 4) Workers are less agile and fast at work 5) Workers work activities at work locations without safety signs 6) Workers rest using fast lane shoulder 7) Worker activities break the concentration of road users 8) Workers ignore traffic safety. 9) Workers only prioritize work 10) Workers without using Personal Protective Equipment as needed 11) No K3 Supervisor / Foreman is responsible and is at the maintenance site

Table 3. Dependent variable (Y)

Criteria	Indicator
Y1 Very Unsafe	1) The speed of vehicles at the maintenance site is very unstable 2) The average traffic speed at the maintenance site is still very high (≥100 km/hour). 3) Open and close the lane is very dangerous 4) When activities can cause accidents. 5) Very worrying.
Y2 Not Safe yet	1) The vehicle speed at the maintenance site is less stable 2) The average traffic speed at the maintenance site is still high (≥80 km/hour). 3) Open and close the lane is quite dangerous 4) When enough activity can cause accidents. 5) Enough to worry.
Y3 Safe Enough	1) The speed of vehicles at the maintenance site is quite stable. 2) The average traffic speed at the maintenance site is quite low (≥60 km/hour). 3) Open and close the lane is less dangerous 4) Lack of activity can cause accidents. 5) Less worrying.
Y4 Already Safe	1) The vehicle speed at the maintenance site is stable. 2) 2) Average traffic speed at low maintenance sites (≥40 km/hour). 3) 3) Open and close Lane no harm 4) 4) When the activity does not cause an accident. 5) 5) Don't worry.
Y5 Very Safe	1) The vehicle speed at the maintenance site is very stable. 2) Average traffic speed at maintenance site Very low (≥20 km/hour). 3) Open and close the lane is very harmless 4) When the activity does not cause an accident. 5) Not very worrying.

MATERIALS & METHODS

The population in this study. The agency that is the object of research is the Toll Road Business Entity (TRBE) PT. Jasa Marga (Persero), respondents consisting of Traffic Service and Maintenance Officers, Area Managers and Head of the Maintenance Department in the Jabodetabek Toll Road area. Write here procedure/ technique of your research study.

The users of the Jakarta-Tangerang toll road segment, who are respondents and are used as samples in this study.

This study uses a quantitative method by distributing questionnaires to respondents who are directly involved in the implementation of maintenance and users of the Jakarta-Tangerang toll road.

The research variables based on previous research are the management of work materials (X1), management of the work environment (X2), management of work equipment (X3), management of work methods (X4) and labor management (X5), all of which are independent variables.

Meanwhile, as the dependent variable (Y) the level of road user safety, these variables are described by operational concepts through dimensions and indicators.

Distribution of questionnaires to respondents with the aim of knowing how much influence the factors causing the road safety level are affected by the implementation of maintenance. The data was processed using Excel and SPSS version 21 for multiple linear regression analysis.

The stages of data testing are (i) validity and reliability test, (ii) classical assumption test consisting of normality test, multicollinearity test, heteroscedasticity test, and autocorrelation test, (iii) multiple linear regression analysis with simultaneous F test and partial t test.

From the results of the validity and reliability tests for all research instruments and variables, they must meet the requirements for entering the valid and reliable categories. The criteria for the validity and reliability test results are assessed as follows:

a. If $r_{count} > r_{table}$, the result is a valid instrument.
b. If $r_{count} \leq r_{table}$, the result is that the instrument is declared invalid.
c. If the instrument is valid, then the interpretation criteria with the correlation index (r) are seen as follows:

Table 4. Correlation Index (Arikunto, 1993)

Correlation Index	Interpretation Criteria
0,800 – 1,000	Very high
0,600 – 0,799	high
0,400 – 0,599	High enough
0,200 – 0,399	Low
0,000 – 0,199	Very low

Reliability Test with Cronbach's Alpha Method Calculations using the Cronbach's Alpha formula are accepted, if the calculation of $r_{count} > r_{table}$ 5%.(Ghozali, 2018)

Statistical Analysis

The data in this study came from questionnaires for stage I and stage II, where stage I = 9 expert respondents and stage II = 52 respondents from road users.

For the first phase of the questionnaire, it will be analyzed using Microsoft excel to get the average value.

And in the second stage of the questionnaire, it will be analyzed by classical assumption test and multiple linear regression using SPSS version 21.

RESULT AND DISCUSSION

1. Questionnaire analysis stage I

Figure	:	Graph of the factors that affect the safety of road users during maintenance
Amount of data	:	9 people
Population	:	Experts / Toll Road Traffic Maintenance and Service Officers (Jasa Marga)
Analysis	:	Microsoft excel

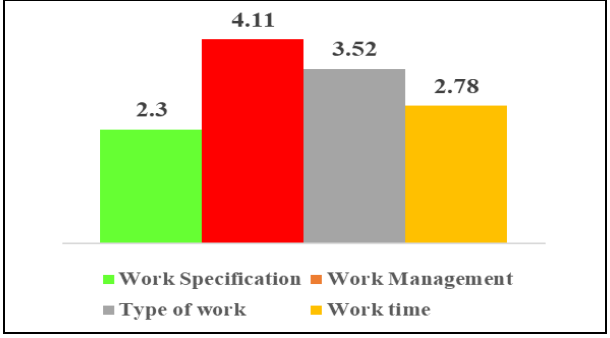

Figure 3. The graph of the decision factors that cause maintenance have an effect.

The result of the analysis in Figure 2 shows that the causal factor affecting the safety of road users is the work management factor, which gets the highest score of 4,11.

2. Results of Phase II questionnaire analysis

Validity and Reliability Test.

Quantitative data from the distribution of the questionnaires were tested in stages, namely (i) validity and reliability tests, (ii) classical assumption test consisting of normality, heteroscedasticity, multicollinearity and autocorrelation tests, and (ii) multiple linear regression with simultaneous (f) and autocorrelation tests. (t) partial. From the tests carried out, it was found that all data obtained rcount > rtable and Cronbach's alpha value > 0.6. (Dewi, 2018)

So the result of the analysis is that all data can be categorized as valid and reliable. For the results of the validity and reliability tests, see Table 5 below.

Table 5. Analysis of the validity and reliability of research variables

Data source		**Phase I Questionnaire**		
Number of Respondents		**52 people**		
Population		**Jakarta - Tangerang toll road users**		
Analysis		**SPSS version 21**		
r_{tabel}		**0,285**		
No	**Variable**		**Validity test**	**Reliability Test**
1	X1	Material Management	>0,285	> 0,6
2	X2	Management of the environment	>0,285	>0,6
3	X3	Equipment Management	>0,285	>0,6
4	X4	Management Method	>0,285	>0,6
5	X5	Manpower Management	>0,285	>0,6
6	Y	Road User Safety	>0,285	>0,6

Information: N = 52 respondents, r_{table} = 0.285 (sig 5%), Valid ($r_{count} > r_{table}$), Reliable (Cronbach alpha > 0.6)

Classical assumption test is done by:

a) The normality test used the Kolmogorov-Smirnov test where the Asymp results were obtained. Sig. (2-tailed) 0.607 > 0.05 which means that the data is normally distributed

b) The multicollinearity test was measured from the tolerance value and the VIF. value

c) Heteroscedasticity test using the Scatterplot test

d) The autocorrelation test was carried out using the run test method

Table 6. Classical assumption test results

Classic assumption test	Results	Information
Normality test	*Asymp. Sig.* (2-*tailed*) = 0.607 > 0.05	Normal distribution
Multicollinearity Test	mark tolerance > 0.1 and is at VIF value < 10	no symptoms multicollinearity
Heteroscedasticity Test	scatterplot test	There are no symptoms of Heteroscedasticity
Autocorrela tion Test	run test method	No symptoms of autocorrelation

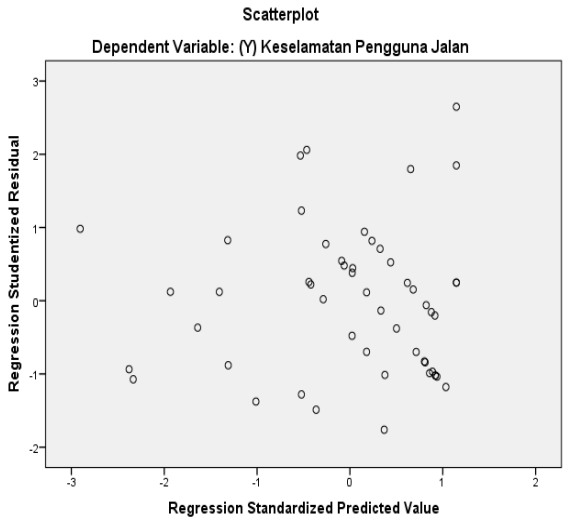

Figure 4. Heteroscedasticity Test Results Using Scatterplot.

Table 7. Run Test

Runs Test	
	Unstandardized Residual
Test Value[a]	.08313
Cases < Test Value	26
Cases >= Test Value	26
Total Cases	52
Number of Runs	25
Z	- .560
Asymp. Sig. (2-tailed)	.575
a. Median	

Simultaneous F Test

Table 8. Simultaneous F Test Results

Model	*Sum of Squares*	df	*Mean Square*	F	Sig.
Regression	183.6	5	37.1	23.2	.000[b]
Residual	73.3	46	1.6		
Total	**258.9**	**51**			

a) Dependent Variable: Road User Safety
b) Predictors: (Constant), Manpower Management, Material Management, Environmental Management, Equipment Management, Method Management

The basis for making decisions on the simultaneous F test are:

a) If the value of sig. <0.05 then the independent variable (X) partially affects the dependent variable (Y)
b) If $F_{count} > F_{table}$, where it is known that $F_{table} = (k; n-k) = (5; 110-5) = (5; 105) = 2{,}302$

From table 8 above, it can be seen that the significance value is 0.000, which is below 0.05 and the Fcount = 23,2 which is greater than Ftable = 2.302. This means that all variables measured simultaneously or together have a significant influence on the safety of road users.

Partial t test

The basis for making partial t test decisions are:

a. If the value of sig. <0.05 then the independent variable (X) partially affects the dependent variable (Y).
b. If $t_{count} > t_{table}$, where it is known that $t_{table} = (\alpha/2; n-k-1) = (0.05/2; 52-5-1) = (0.025; 46) = 2.013$

Table 9. Partial t-Test Results

Model	t	Sig.
(Constant)	3.259	.002
(X1) Material management	.454	.652
(X2) Environmental management	3.369	.002
(X3) Equipment management	1.531	.133
(X4) Management method	.129	.898
(X5) Manpower management	.381	.705

The results of the analysis in the table. 9 sig values. = 0.002 obtained (X2) the result of the decision that partially the environmental management variable (X2) which has a significant individual effect on the safety of road users. This is indicated by the value (X2) t_{count} (3.369) > t_{table} (2.013) with a significance value of <0.05.

Factors Affecting Road User Safety

Based on the results of the first phase of the questionnaire analysis above, the factors that can affect the level of safety of road users during road maintenance are work management factors. And from the questionnaire analysis phase II through multiple linear regression analysis that has been described, it can be seen that simultaneously, the factors causing the implementation of maintenance to affect the safety of road users are: (i) material management, (ii) environmental management, (iii) management of equipment, (iv) management of methods, (v) management of labor have a joint influence on the safety of road users. This has been proven from the results of the F test which shows the value of Fcount (22.236) > F_{table} (2.417). This means that all variables measured simultaneously or

together have a significant influence on the occurrence of disturbances in the level of road user safety.

From multiple linear regression analysis, the following equation is generated:

Y= 4.844 - 0.024X1 + 0.212X2 + 0.076X3 + 0.038X4 + 0.041X5

Formula explanation:

a) This means that if there is an addition to the value of X1 by 1%, the value of Y will decrease by 0.024, and vice versa if the value of X1 decreases by 1%, the value of Y will increase by 0.024.
b) And for X2, X3, X4, and X5 if there is an increase in the value of each 1%, then Y will increase according to the value of the increase (in the same direction), on the contrary if it decreases, the value of Y will also decrease by the value of the decrease.
c) According to 52 respondents, it was stated that together the entire X variable affected the Y value, both negatively and positively.

Factors causing maintenance activities that can affect the safety of road users are work management factors in accordance with previous research conducted by (Ramadhani et al., 2021) and (Tri et al., 2017), which state that materials, environment, resources (labor) are factors that affect the safety of users. road during road maintenance work.

Individually Most Influential Factors for Road User Safety

All factors have an influence on the safety level of road users, both positive and negative, but only 2 factors, namely the management of the work environment (X2). This is indicated by a significance value of (X2) 0.002 (< 0.05) and a tcount value of 3.273 (>ttable = 2.013).

These factors consist of indicators: Management of the work environment consists of:

a. Narrow lane
b. Work without security
c. Toll exit/entrance junction
d. Road users have difficulty determining the direction of the bow
e. Traffic speed is still quite high (≥60 km/hour)
f. Wet locations maintenance work continues
g. Loss of standard roughness/flatness
h. At night without work lighting.

CONCLUSION

From the results of the analysis above, it can be concluded:

1. The causative factor that influences the safety of road users when carrying out maintenance is the work management factor.
2. Factors that influence the safety of road users when carrying out maintenance are: (i) material management, (ii) environmental management, (iii) equipment management, (iv) method management, and (v) energy management work.
3. The most dominant factors that influence the individual for the safety of road users when carrying out maintenance are: work environment management.

SUGGESTIONS

The results of research and data analysis carried out, it is recommended the following:

1. For further researchers, it is recommended to conduct a study of the same theme, in order to add theory, and is expected to be able to improve it with various research methods that have not been included in this study.
2. The BUJT Jasa Marga Jakarta - Tangerang pay more attention to the variables that influence this research, so that maintenance remains in a condition that ensures the safety of road users remains high.
3. Propose that the Jasa Marga BUJT will make the latest standard (SOP) to adapt to the latest transportation conditions.

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