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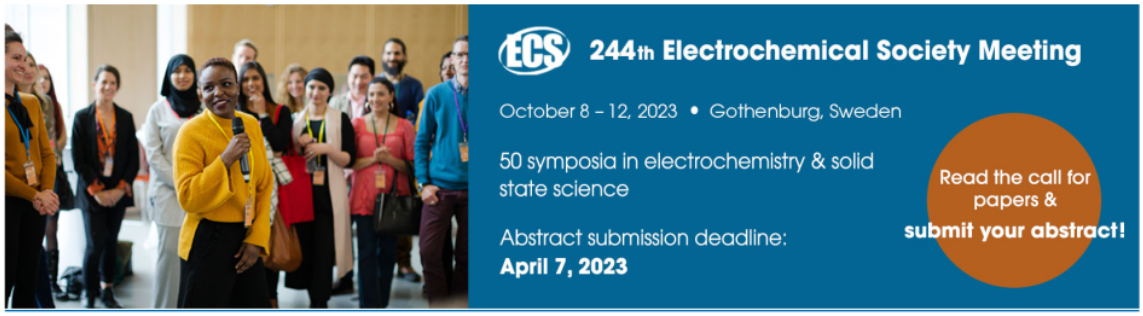

Traffic noise level handling on A P Pettarani road towards elevated toll road construction

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Abstract. The construction of the elevated toll road is part of the transportation network system, in addition to managing the traffic system in the area to be more integrated, the facility is also used to deal with congestion that often occurs, as well as the construction plan of elevated toll on Pettarani road is expected to reduce the level of congestion that occurs. Based on previous studies, the prediction of noise levels on AP. Pettarani roads when the elevated toll road is operating with a shift estimated of 25% of the vehicle's volume to the elevated toll road at 79.58 dB. Therefore, we need a way to handle the noise level on the AP Pettarani road if the elevated toll road is operating. Traffic load analysis is performed using the V-S-D (volume, speed and density) model analysis. The V-S-D model analysis consists of 3 models namely the Greenshield Model, the Greenberg Model, and the Underwood Model. The results of the V-S-D model analysis obtained are the Underwood Model at each point of the scenario so that it is used to calculate the average speed on the road segment according to the traffic volume. Then the results of the analysis and statistical tests through several variations of the simulation have obtained the best noise level handling by using traffic loading on the AP Pettarani Road through 50% motorcycle switch to the BRT (Bus Rapid Transyt) and can reduce the noise level by 3.05 dB.

1. Introduction

The construction of the elevated toll road is part of the transportation network system, in addition to managing the traffic system in the area to be more integrated, the facility is also used to deal with congestion that often occurs, as well as the construction plan of an elevated toll on AP. Pettarani road is expected to reduce the level of congestion that occurs.

Overall, the existence of the elevated toll road will have a positive impact. However, after the road is operated. It is estimated to have several impacts including a decrease in environmental quality, namely high noise levels. Traffic noise will cause environmental discomfort. Based on previous studies the average noise level on the AP. Pettarani road in 2011 was 74 dB, in 2014 it was 79.8 dB, and in 2017 it was 80.4 dB [1], [2]. Then based on previous studies the prediction of noise levels on AP. Pettarani roads is 79.58 dB when the elevated toll road operates with 25% shift estimated volume of vehicles to the elevated toll road [3]. This shows that the noise level on AP Pettarani increased Road during the three years of research and has exceeded the noise level standard according to Minister of Environment Decree No. Kep-48 / MENLH / 1/1996, namely 60 dB for Allotment of Government Areas and public facilities [4]. Then we need a way to handle the noise level on the AP. Pettarani road when it is operating.

2. Research method

Research conducted is a type of quantitative analysis. Primary data are data of road segments, road characteristics, and location points to measure traffic volume, vehicle speed measurements, and vehicle noise level measurements [5]. Secondary data are the AP Pettarani road map and technical specifications for the AP Pettarani Toll Road. Data analysis is performed in mitigating noise levels using the V-S-D method [6].

2.1. Research location

The location of this research was carried out at 16 points on the AP Pettarani road, where on this road every day many motorized vehicles pass and other high public activities cause traffic noise on the road. Figure 1. The following research location.

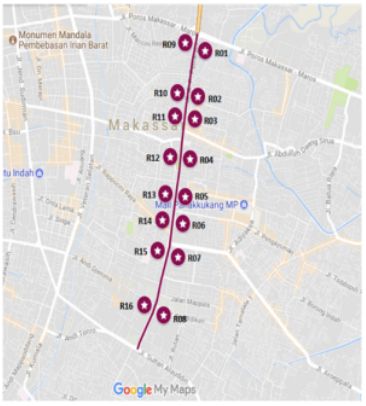

Figure 1. Location of AP. Pettarani roads.

2.2. Research time

The data collection process is carried out for 2 weeks, Monday - Thursday, starting at 07.00-17.00. Measurements are made every 1 hour where every 1 hour requires 10 minutes.

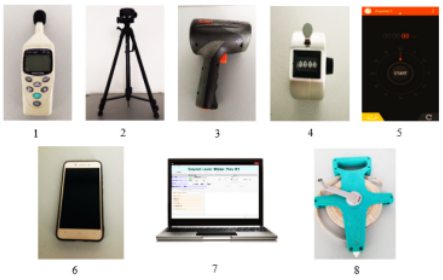

Figure 2. Tools.

Information:
1. Sound level meter tenmars TM-103
2. Tripod
3. Speed Gun.
4. Counter
5. Stopwatch
6. Mobile
7. Laptop
8. The meter

2.3. Noise level mitigation method

After obtaining the predicted noise level, the next step is to analyze the traffic load on the road network as an alternative solution to handling traffic noise on AP. Pettarani Road after the elevated toll road is operated [7]. Based on a simulation of traffic loading. The traffic loading simulation begins with a loading analysis through the measurement of traffic volume data that has been processed based on vehicle growth rates in Makassar City. Then the traffic volume is converted from vehicles/hour to smp / hour for all observation points on the road section. Traffic load analysis is performed using the V-S-D (volume, speed and density) analysis model [8]. The V-S-D analysis model consists of 3 models namely the Greenshield Model, the Greenberg Model, and the Underwood Model [9].

The traffic loading simulation is done based on a scenario. Scenarios for traffic loading are carried out through 4 variations. Simulation variations consist of:

Table 1. Variations a.

Simulation Variations A	
a1	the volume of LV (pete-pete) transferred to the BRT 20%
a2	the volume of LV (pete-pete) transferred to the BRT 40%
a3	the volume of LV (pete-pete) transferred to the BRT 60%
a4	the volume of LV (pete-pete) transferred to the BRT 80%
a5	the volume of LV (pete-pete) transferred to the BRT 100%

Table 2. Variations b.

Simulation Variations B	
b1	the volume of LV (Light-Vehicle) transferred to the BRT 15%
b2	the volume of LV (Light-Vehicle) transferred to the BRT 30%
b3	the volume of LV (Light-Vehicle) transferred to the BRT 50%

Table 3. Variations c.

Simulation Variations C	
c1	the volume of MC (Motorcycle) transferred to the BRT 15%
c2	the volume of MC (Motorcycle) transferred to the BRT 30%
c3	the volume of MC (Motorcycle) transferred to the BRT 50%

Table 4. Variations d.

Simulation Variations D	
d1	the volume of LV (Light-Vehicle) transferred to the BRT 30% volume of MC (Motorcycle) transferred to the BRT 30%
d2	the volume of LV (Light-Vehicle) transferred to the BRT 50% volume of MC (Motorcycle) transferred to the BRT 30%
d3	the volume of LV (Light-Vehicle) transferred to the BRT 30% volume of MC (Motorcycle) transferred to the BRT 50%

3. Discussion

3.1. Traffic loading simulation

Results Analysis of the V-S-D model obtained at each observation point illustrates the relation of volume, speed and traffic density so that the ideal traffic conditions are obtained. Based on the results of the analysis, the Underwood Model is obtained at each point based on the scenario so that it is used to calculate the average speed on a road segment in accordance with the volume of new traffic obtained based on traffic simulations conducted by trial and error, so as to produce the following analysis:

3.1.1. Variations A.

Based on the simulation variations in table 1, the noise level of the simulation variations a can be generated as can be seen in table 5.

Table 5. Noise level results of simulation variations A.

Code	LAeqDay Existing Predictions (dB)	LAeqDay Pre simulation Pettarani (dB)	LAeqDay The traffic loading simulation Pettarani (dB)				
			a1	a2	a3	a4	a5
R01	78.60	78.50	77.9	77.9	77.9	77.9	78.3
R02	80.90	80.80	80.2	80.2	80.2	80.1	80.5
R03	80.40	80.30	79.7	79.7	79.7	79.7	80.1
R04	80.10	80.00	79.3	79.3	79.3	79.3	79.7
R05	79.80	79.70	79.1	79.1	79.1	79.1	79.4
R06	79.70	79.60	79.1	79	79	79	79.4
R07	78.00	77.80	77.2	77.2	77.2	77.2	77.6
R08	79.60	79.40	78.9	78.9	78.9	78.8	79.2
R09	80.30	80.20	79.6	79.6	79.6	79.6	79.9
R10	81.30	81.10	80.5	80.5	80.5	80.5	80.9
R11	79.90	79.80	79.2	79.2	79.2	79.2	79.6
R12	78.50	78.40	77.8	77.8	77.8	77.8	78.2
R13	77.30	77.20	76.5	76.5	76.5	76.5	76.9
R14	79.30	79.10	78.6	78.6	78.6	78.5	78.9
R15	76.90	76.80	76.2	76.2	76.2	76.2	76.6
R16	79.00	78.80	78.3	78.3	78.3	78.3	78.6
Average	79.51	79.38	78.79	78.78	78.78	78.76	79.14
Difference		0.13	0.72	0.72	0.72	0.75	0.37

In table 5 variation a. Simulation scenario occurs in 5 variations by switching LV (pete-pete) to BRT ranging from 20% -100% through 5 variations. It can be seen that the highest reduction in pete-pete volume can reduce the noise level by 0.37 dB - 0.75 dB. This shows that shifting the volume of LV (pete-pete) to BRT by up to 100% can reduce noise levels.

To find out how the value of the noise level between the scenario simulation and the predicted noise level is different or not, a statistical test with the hypothesis to be tested is as follows in table 6.

Ho: There is no significant difference between the results of existing predictions and the results of simulation variations.

Ha: There is a significant difference between the results of existing predictions and the results of simulation variations.

Table 6. Variation Statistical Test Results.

No.	Variations	*Sig.(2-tailed)*	*Taraf Sig.*	*Description*
1	a1	0.145	0.05	Ho is accepted
2	a2	0.143		Ho is accepted
3	a3	0.135		Ho is accepted
4	a4	0.133		Ho is accepted
5	a5	0.128		Ho is accepted

Based on the hypothesis test, it can be seen that the variations in a1 to a5 produce a significance value or sig. (2-tailed)> 0.05 means no significant decrease in noise level due to a reduction in the volume of LV (pete-pete) transferred to the BRT. This shows the value of the noise level between the predicted results and the results of the simulation scenario have not been able to reduce the noise level.

3.1.2. Variations B.

B Simulation variations scenario results of noise level can be seen in table 7. Based on table 7 variation b. The simulation scenario occurs in 3 variations with the object shifting the volume of LV (light vehicles) to BRT by 15% - 50% it can be seen that there is a reduction in the noise level of 0.39 dB - 0.75 dB on A.P Pettarani road. To find out how the noise level value between the variation of simulation and the value of the predicted noise level is different or the same, a statistical test with the hypothesis to be tested is as follows in table 8.

Ho: There is no significant difference between the results of existing predictions and the results of simulation variations.

Ha: There is a significant difference between the results of existing predictions and the results of simulation variations.

Table 7. Noise results from variations B.

Code	LAeqDay Existing Predictions (dB)	LAeqDay Pre simulation Pettarani (dB)	LAeqDay The traffic loading simulation Pettarani (dB)		
			b1	b2	b3
R01	78.60	78.50	77.9	78.2	78.2
R02	80.90	80.80	80.1	80.5	80.5
R03	80.40	80.30	79.7	80.1	80.1
R04	80.10	80.00	79.3	79.7	79.7
R05	79.80	79.70	79.1	79.4	79.4
R06	79.70	79.60	79	79.4	79.4
R07	78.00	77.80	77.2	77.6	77.6
R08	79.60	79.40	78.8	79.2	79.2
R09	80.30	80.20	79.6	79.9	79.9
R10	81.30	81.10	80.5	80.8	80.8
R11	79.90	79.80	79.2	79.6	79.6
R12	78.50	78.40	77.8	78.1	78.1
R13	77.30	77.20	76.5	76.9	76.9
R14	79.30	79.10	78.5	78.9	78.9
R15	76.90	76.80	76.2	76.5	76.5
R16	79.00	78.80	78.3	78.6	78.6
Average	79.51	79.38	78.76	79.12	79.12
Difference		0.13	0.75	0.39	0.39

Table 8. Variation statistical test results B.

No.	Variasi	*Sig.(2-tailed)*	*Taraf Sig.*	*Adjective*
1	b1	0.413	0.05	Ho is accepted
2	b2	0.382		Ho is accepted
3	b3	0.382		Ho is accepted

In testing the hypothesis table 8 can be seen in the variation of b1 to b3 produce a significance value or sig. (2-tailed)> 0.05 means that there has not been a significant decrease in noise level due to the reduction in the volume of LV (light vehicles) diverted to the BRT. This shows the value of the noise level between the existing prediction results and the results of the simulation scenario have not been able to reduce the noise level.

3.1.3. Variations C.

C simulation noise level variation result can be seen in table 9. Based on table 9 variations c. Simulation variations occur in 3 variations with the object of reducing the volume of MC (motorcycle) by 15% - 50% transferred to BRT. The results of the noise level can be seen switching the volume of MC to BRT can reduce up to 3.05 dB in the C3 variation. This shows that the reduction in the volume of MC (motorcycles) up to 50% is able to influence noise levels.

To find out how the noise level value between the variation simulation and the predicted value of the noise level occurs or not, a statistical test with the hypothesis to be tested is as follows in table 8. Ho: There is no significant difference between the results of existing predictions and the results of simulation variations. Ha: There is a significant difference between the results of existing predictions and the results of simulation variations.

Table 9. Noise results of c variation simulation.

Code	LAeqDay Existing Predictions (dB)	LAeqDay Pre simulation Pettarani (dB)	LAeqDay The traffic loading simulation Pettarani (dB)		
			c1	c2	c3
R01	78.60	78.50	77.6	76.9	75.6
R02	80.90	80.80	79.9	79.1	77.8
R03	80.40	80.30	79.5	78.7	77.4
R04	80.10	80.00	79.1	78.3	77
R05	79.80	79.70	78.8	78.1	76.8
R06	79.70	79.60	78.8	78	76.7
R07	78.00	77.80	77	76.2	74.9
R08	79.60	79.40	78.6	77.8	76.5
R09	80.30	80.20	79.3	78.6	77.3
R10	81.30	81.10	80.2	79.5	78.2
R11	79.90	79.80	78.9	78.2	76.9
R12	78.50	78.40	77.5	76.7	75.5
R13	77.30	77.20	76.3	75.5	74.2
R14	79.30	79.10	78.3	77.5	76.2
R15	76.90	76.80	75.9	75.2	73.9
R16	79.00	78.80	78	77.2	75.9
Average	79.51	79.38	78.51	77.75	76.46
Difference		0.13	0.99	1.76	3.05

Tabel 10. C statistic result variation

No.	Variasi	*Sig.(2-tailed)*	*Taraf Sig.*	*Adjective*
1	c1	0.135		Ho is accepted
2	c2	0.000	0.05	Ha is accepted
3	c3	0.000		Ha is accepted

Based on the hypothesis testing, it can be seen that variation data on C1 variations produce significance values or sig. (2-tailed)> 0.05 meaning that there has not been a significant reduction in noise levels due to a 15% reduction in MC (motorcycle) volume that was diverted to the BRT. Then in the variations of C2 and C3 produce a significance value or sig. (2-tailed) <0.05 means that there is a significant decrease in noise level due to a reduction in the volume of MC (motorcycle) by 30% - 50% which is diverted to the BRT. This shows the value of the noise level between the predicted results and the results of the simulation scenario can reduce the noise level.

3.1.4. Variations D.

D Variation is a variation with the scenario of switching LV (light vehicle) to BRT volume plus the switching of MC volume to BRT (motorcycle) volume.

Based on table 11. Variations in the simulation scenario occur in 3 variations with the object of volume reduction occurring in the volume of LV (pete-pete) moved to BRT plus the reduction in volume of LV (private vehicle) and MC volume with various percentages can reduce the noise levels by 0.62 dB - 2.31 dB.

To find out how the value of the noise level between the variation simulation and the predicted noise level value there is a difference or not a statistical test with the hypothesis to be tested is as follows in table 10.

Ho: There is no significant difference between the results of existing predictions and the results of simulation variations.

Ha: There is a significant difference between the results of existing predictions and the results of simulation variations.

Tabel 11. Noise level of simulation results variation d

Code	LAeqDay Existing Predictions (dB)	LAeqDay Pre simulation Pettarani (dB)	LAeqDay The traffic loading simulation Pettarani (dB)		
			d1	d2	d3
R01	78.60	78.50	78	77.2	76.4
R02	80.90	80.80	80.3	79.5	78.6
R03	80.40	80.30	79.8	79	78.1
R04	80.10	80.00	79.5	78.6	77.8
R05	79.80	79.70	79.2	78.4	77.6
R06	79.70	79.60	79.1	78.3	77.4
R07	78.00	77.80	77.4	76.5	75.7
R08	79.60	79.40	79	78.1	77.2
R09	80.30	80.20	79.7	78.9	78
R10	81.30	81.10	80.6	79.8	79
R11	79.90	79.80	79.3	78.5	77.6
R12	78.50	78.40	77.9	77.1	76.2
R13	77.30	77.20	76.7	75.9	75
R14	79.30	79.10	78.6	77.8	76.9
R15	76.90	76.80	76.3	75.5	74.6
R16	79.00	78.80	78.4	77.5	76.6
Average	79.51	79.38	78.89	78.07	77.20
Difference		0.13	0.62	1.44	2.31

From the results of hypothesis testing (t test) using the SPSS program where the test results can be seen in Table 12.

Tabel 12. D variation statistic result

No.	Variasi	*Sig.(2-tailed)*	*Taraf Sig.*	*Adjective*
1	d1	0.139		Ho is accepted
2	d2	0.017	0.05	Ho is accepted
3	d3	0.000		Ha is accepted

Based on the hypothesis test in table 10, it can be seen that scenario data on the D1-D2 variation produces a significance value or sig. (2-tailed)> 0.05 which means there is no significant decrease in noise level due to the reduction in the volume of motorcycle and light vehicles diverted to the BRT. Then in the scenario of variation D3 produces a significance value or sig. (2-tailed) <0.05 which means there is a significant decrease in noise level due to the reduction in the volume of motorcycles

and light vehicles that are diverted to the BRT. This shows that the D3 variation is a simulation variation that is able to reduce the noise level.

4. Conclusions

Results Analysis of the V-S-D model obtained at each observation point illustrate the relationship of volume, speed and traffic density so that the ideal traffic conditions are obtained. Based on the results of the analysis, the Underwood Model is obtained at each point of the scenario so that it is used to calculate the average speed on the road segment in accordance with the new traffic volume obtained based on traffic simulations conducted by trial and error. Then the results of the analysis and statistical tests through several variations of the simulation have obtained the best noise level handling by using traffic loading in the AP Pettarani Road through a 50% motorbike diversion to the BRT (Bus Rapid Transyt) and can reduce the noise level by 3.05 dB.

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