二輪車のパワーレベル（インドネシアMakassar市における測定）

Power Level of Motorcycle in Makassar City, Indonesia

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Since the traffic behavior is heterogeneous and the number of motorcycle (MC) is dominant on the roads at Makassar City in Indonesia, to grasp the characteristic of the road traffic noise (RTN) such as the power level of the MC is needed when predicting the RTN at roadside areas in Makassar City. This paper shows the sound power level of the MC in Makassar City. The measurement of power level of MC is carried out at three roads in Makassar City. The peak level and the speed of vehicle are measured to obtain the power level for MC. 425 data for MC with the dominant size of engine of 110cc and the speed between 20-40km/h are measured. The statistical analysis shows the power level has a good relationship with the speed. The results follow the trend of the power level in steady condition presented in the ASJ RTN-Model 2008 when the speed of vehicle is under 40 km/h. It coincides with the authors' previous research work. The prediction of the RTN by using the power level of motorcycle obtained in this paper provides more precise noise value.

Keywords: Road traffic noise, Power level of motorcycle, Makassar City

1. Introduction

1.1 Background

Nowadays, in many cities in Indonesia, one of the Asian developing countries, the environmental quality is gradually degrading due to the rapid increase of the number of vehicles. This leads the increase of the road traffic noise (RTN) in the cities. To develop the prediction model of the RTN and establish a noise policy becomes an urgent issue in Indonesia to abate the RTN.

Regarding to the above condition, the authors conduct a research on the issue of the RTN in order to find optimal solution for the problem of the RTN focusing Makassar City, which is one of the largest cities in Indonesia. In order to achieve the main aim of the research, the authors conduct three steps research in three years, based on the reference scheme conducted in Japan. In this context, the steps of the research are to grasp the present condition of the RTN in Makassar, to construct the GIS of the RTN in Makassar, and to examine how to reduce the RTN in Makassar City. The outputs of the research consist of the present condition of the RTN, Makassar noise map, and guidelines for the reduction measures of the RTN in Makassar City.

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As the first step, in order to grasp the present condition of the RTN in Makassar City, the authors have performed a noise survey at thirty-five main roads which almost cover the whole areas in Makassar City [1][2]. The results show that the noise levels at roadside of these roads is very high and the average value is 74dB from morning until evening. This value exceeds the highest value of the Environmental Standard for Noise in Indonesian. In addition, motorcycles dominate the traffic fleet whereas heavy vehicles are very few. As a result of such conditions, the average speed of the vehicles is less than 40km/h, a low speed category. Nevertheless, the traffic flow seems still in steady state condition. Due to the above condition, the drivers generate the horn many times to keep safety; the time of horns widely changes from 13times/10minutes to 149times/10minutes.

The authors predicted equivalent continuous A-weighted sound pressure level in a day ($L_{Aeq,day}$) assuming the non-steady traffic condition by using the ASJ RTN-Model 2008 [3]. However, it was found that all the predicted $L_{Aeq,day}$ are greater than the measured ones. This suggests the necessity to explore the cause and take them into consideration for a good prediction of the RTN.

Therefore, the authors try to elaborate some efforts to find a good prediction of $L_{Aeq,day}$. The first is to consider the actual traffic condition. The traffic should be assumed to be
steady traffic flow at low vehicle speed. The second is the effect of the horns sound which apparently influences the noise level. And the last is the power level of motorcycle which the dominant traffic in Makassar City.

On the point of traffic flow, the authors predicted \( L_{A_{eq,day}} \) assuming steady traffic flow and the actual vehicle speed condition (28 km/h) based on the ASJ RTN-Model 2008 and the difference between predicted \( L_{A_{eq,day}} \) and measured ones is 2.33 dB on average \(^3\). This result is reasonable and better than the previous one when non-steady traffic flow is assumed. Then, in order to improve the noise prediction, the authors tried to examine a method to take the effect of horns on noise level into consideration \(^4\). When considering the effect of horn sound, the power level of horn sound is a problem because it is not shown in the ASJ RTN-Model 2008. The authors imitated the Asakura’s method \(^5\), and as a result we could make the predicted of \( L_{A_{eq,day}} \) close to the measured value. To verify this method to consider the effect of horn sound on the RTN, we carried out two additional noise surveys (2nd and 3rd surveys) in Makassar City. The results in these two surveys verified the validity of the proposed method to consider the effect of horn sound on RTN.

However, for predicting road traffic noise more precisely, to grasp precise power level of horn sound and vehicle, especially for motorcycle, is needed. The authors tried to grasp the acoustic characteristics as well as the power level of horn sounds \(^6\). The acoustical measurement is performed in 2nd and 3rd surveys. Open and quiet place was selected as a measuring point in the campus of Hasanuddin University in Makassar City. The power level and the frequency characteristics for motorcycles and light vehicles are obtained by using test vehicles. As a result, it was found that the characteristics of horn sounds are not always stable (the characteristics of horn sounds might be different for each horn) and it can be thought that the characteristics of horn sounds should be grasped statistically.

Further examination and survey to grasp the characteristics of the RTN’s component such the power level of vehicle is needed \(^7\), because the motorcycle is dominant vehicle in Makassar City and the type of motorcycle in Makassar is difference from Japanese motorcycle. On this background, the authors focus on the sound power level of the motorcycle in this paper.

1.2 Object

On the above background, this paper aims to grasp the sound power level of motorcycle in Makassar City, Indonesia.

2. Measurement of Motorcycle’s Power Level

2.1 Method

In order to grasp the power level of motorcycle in Makassar City, 4th survey was carried out. That survey focus on a measurement of power level of motorcycle. Three roads; Tanjung Street, Baddoka Street and Hasanuddin University Street, were selected for the survey in Makassar City. These roads were fit to the criteria for the measurement of power level. That is, they were open and quiet areas to escape from the effect of background noise. Ambient noise levels at the sites were less than 35dB. Also the roads were straight to allow the vehicle to pass through with a constant speed. And number of traffic is very small to enable us to measure each target vehicle sound separately. Fig.1 shows the roads for the measurement.

The measuring arrangement is shown in Fig.2. The markers were set at points A and B with the distance of 20m, and the measurement point was set in the center of AB.
Sound level meter (SLM) was set at the position with the distance of 1.0m from the road edge and height of 1.2m above the ground. And A-weighted sound pressure level was observed when only one vehicle was passing through zone AB at the measurement point by SLM (RION NL-32) and $L_{A,max}$ (peak level while a vehicle is passing through zone AB) was measured.

The speed of vehicle ($V$ [km/h]) was measured by a speed gun and the distance from the measurement point and the vehicle ($d$ [m]) were also measured.

2.2 Calculation of Power Level of Vehicle

Table 1 shows the number of data obtained in the measurement. As is found here, the number of data for the speed vehicle between 20-30km/h and 30-40km/h is dominant than the others. On the contrary the data for more than 60km/h are very small, this shows the actual situation of road traffics in Makassar City. The average speed of the vehicles is less than 40km/h, this agrees with the result of the authors' previous survey. Considering another side, the majority of engine type of motorcycle is 110cc and the percentage of the data is 85%.

Then A-weighted power level of vehicle $LW$ is calculated by Eq.(1)

$$LW = L_{A,max} + 20\log_{10}d + 8 \quad (1)$$

Here, $d$ is the distance between a sound source and a measuring point.

3. Result and Discussion

3.1 Result

After calculation of the power level, we made the distributions of them for each 10km/h band in speed and for each type of vehicle engine of motorcycle. Here the data for the speed more than 60km/h and the type of engine other than 110cc are ignored because the number of data is very small. The authors focus on the motorcycle data with the speed between 10km/h until 60km/h and type of engine only 110cc to determine the motorcycle's power level.

Fig.3 shows the distributions of power level. It is clearly found that power level distributes widely in each speed band. Therefore, a selection of data is needed to make the data more precise. After some examinations, the authors resulted in adopting the data of 80% range as effective data for the subsequent analysis. Dark bars show selected data in Fig.3.

3.2 Relation Between $LW$ and $V$

Fig.4 shows the relationship between vehicle power levels of the selected data and vehicle speed of motorcycle.

Curve lines show the regression lines assuming that $Lw$ has a relationship of Eq.(2) with $V$. In spite of the selected data, $Lw$ still distributes widely around the regression curve as found in Fig.4.

$$Lw = a + b\log V \quad (2)$$

Then, energy-averaged levels in each speed band were calculated, and the relationship between averaged $Lw$ and $V$ was analyzed again. The results were shown in Fig.5 and regression coefficients $a$ and $b$ are shown in Table 2. The results show that $Lw$ has a good relationship with $V$.

<table>
<thead>
<tr>
<th>Table 1 Number of data</th>
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<tr>
<td>Speed of vehicle (km/h)</td>
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<th>Table 2 Result of regression analysis</th>
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<tr>
<td>Regression coefficient</td>
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<td>-------------------------</td>
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<tr>
<td>$a$</td>
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<tr>
<td>All data</td>
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<tr>
<td>Average data</td>
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### 3.3 Comparison with ASJ RTN-Model 2008

The results obtained in 3.2 were compared with the ASJ RTN-Model 2008 [3]. Here two traffic conditions; steady and non-steady traffic flow conditions, were examined in comparing with the ASJ RTN-Model 2008.

Fig. 6 shows the comparisons between the author’s result and the ASJ RTN-Model 2008. In this figures, black curve shows power level in steady traffic condition in the ASJ RTN-Model 2008 and dashed curve shows the expansion of its which is not guaranteed by the ASJ.

It can be found that power level obtained in this paper follow the trend of steady condition of the ASJ RTN-Model 2008 when the speed of vehicle is under 40 km/h for motorcycle.
motorcycle with high engine size produces high noise even if the speed is low.

Lastly, the result of the measured $L_w$ is similar to the value calculated by the ASJ RTN-Model 2008 assuming that traffic flow is steady, coincides with the consideration in our previous research work \cite{4}.

3.4 Applying the Power Level of Motorcycle to Predict the RTN

In order to verify the validity of power level of motorcycle obtained in 3.3, the authors apply the power level of motorcycle to predict the traffic noise level ($L_{A_{eq,day}}$). The RTN prediction is based on the ASJ RTN-Model 2008 under steady traffic condition and actual speed of vehicle (28 km/h) \cite{5} when the power level obtained in 3.3 is used for motorcycle. The comparison between predicted $L_{A_{eq,day}}$ and measured ones are shown in Fig.7 and Fig.8.

Fig.7 shows the prediction by using ASJ's power level of motorcycle (93.1 dB). It was found that the predicted $L_{A_{eq,day}}$ are smaller than the measurement ones. The difference between them is 2.33 dB on average.

Whereas, Fig.8 shows the prediction by using measured power level of motorcycle (92.8 dB). The result is generally same with the Fig.7 although the difference between them is 2.53 dB on average.

Overall, the prediction results as shown in Fig.7 and Fig.8 are almost same. This is because although the power level of motorcycle obtained in this paper is difference with the power level by ASJ RTN Model 2008, but both power levels are mostly similar at the speed of vehicle 28km/h.

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Although the power level of motorcycle in Makassar is appropriate to that of the ASJ Model when traffic is in steady condition, it is larger than that of ASJ Model when the speed of the motorcycle is lower than 30 km/h. Meanwhile, the power level of Makassar’s motorcycle is below that ASJ Model when the speed more than 30 km/h. This can be understood by considering that most of motorcycles in Makassar have about 110cc of engine, while 50cc is dominant in Japan.

As is well known, motorcycle with low engine size produces small noise when the speed is low, and louder noise is generated as the speed increase. On the contrary,
4. Conclusion

A-weighted sound pressure level emitted from a single motorcycle running at the actual road in Makassar City was measured and the power level is examined in order to grasp the power level of motorcycle more precisely in Makassar City, Indonesia. The relation between the power level and the speed was analyzed and compared with the ASJ RTN-Model 2008.

The results show that the relation between the power levels and speed correlate significantly to their speeds. The power level follows the trend of steady condition of the ASJ RTN-Model 2008 when the speed of vehicle is under 40 km/h. This result coincides with our previous work.

Although the power level of motorcycle in Makassar City is almost same with that presented by the ASJ when the speed is 28km/h which is an actual speed in Makassar City, the power level that obtained in this paper is appropriate to use in Makassar’s RTN prediction than that of the ASJ Model, because of the difference type of engine between Makassar’s motorcycle and Japanese one.

References


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