Road traffic noise prediction in the vicinity of signalized intersections in urban areas

Koichi YOSHIHISA
Faculty of science and technology, Meijo University
yosihisa@ccmfs.meijo-u.ac.jp

Yasuo OSHINO
Japan Automobile Research Institute

Kohei YAMAMOTO
Kobayasi Institute of Physical Research

Hideki TACHIBANA
Institute of Industrial Science, University of Tokyo

Abstract

According to the ASJ RTN-Model 2003, the calculated equivalent continuous A-weighted sound pressure level $L_{Aeq}$ at roadsides using the calculation formula for sound power levels under transient running condition become independent of the running speed of road vehicles under some simple conditions. Therefore, $L_{Aeq}$ at roadsides in the vicinity of an intersection where the road vehicles run under transient running condition is considered to be almost constant regardless of the distance from an intersection. Concerning this point, we made a series of measurements of road traffic noise at roadsides in the vicinity of three different intersections. $L_{Aeq}$ at roadsides were measured at distances of 50m, 100m, 150 and 200m from an intersection under various traffic conditions. The result of the measurements shows that $L_{Aeq}$ at roadsides is almost independent of the distance from an intersection. It has been said that the ASJ RTN-Model 2003 is applicable to the prediction of road traffic noise in the vicinity of an intersection.

1. Introduction

There are many intersections in urban areas in Japan. It is important to predict road traffic noise in the vicinity of the intersections, in addition to noise from vehicles running under the steady state condition. The calculation formula for sound power levels of road vehicles under transient running condition including acceleration and deceleration have been proposed in ASJ RTN-Model 1998 and 2003, in addition to that for sound power levels under steady running condition. We made a series of measurements with three different urban roads to grasp the property of noise near an intersection and the applicability of the prediction model for predicting noise at roadsides near an intersection has been examined.

2. Field measurements

Field measurements were carried out on three different straight roads with sidewalks in Nagoya city. Nagoya is the third largest city in Japan, having a population of 2.2 millions.

2.1. Outline of the measurements

In these measurements, $L_{Aeq}$ at a height of 1.5m, the running speed of road vehicles and the traffic volume were measured. Receiving points were located at a distance of 0m, 50m, 100m, 150m, 200m, 300m and 500m from a stop line on the intersection in the roads, as shown in figure 1. The receiving points at a distance of 500m or 300m were set to know $L_{Aeq}$ under steady running condition. Road A, B and C has 2, 4 and 6 traffic-lanes, respectively. Table 1 shows typical values of traffic volume and running speed of road vehicles measured on each road during daytime. In order to obtain the data with wide variety of traffic conditions, the measurements were made during day and night. On the Road C the measurements during the New Year’s holiday on which the heavy vehicles ratio is extremely low were made in addition to ordinary days.
2.2. Measured Results on ordinary days

Figure 2 shows an example of running speed of road vehicles measured at each receiving point on Road C during daytime by using laser speed meters. It can be seen that the running speed increases with increasing the distance form an intersection. The running speed at 200m does not agree with that at 500m which is considered to be under steady running condition.

Figure 3 shows measured $L_{Aeq}$ during day and night on ordinary days. Measuring time period of $L_{Aeq}$ was 20 minutes in which traffic signals change more than 7 times at least. It has been found that the $L_{Aeq}$ at roadsides in the vicinity of an intersection is almost constant although the distance from the intersection and the running speed of vehicles are different at each receiving point.

2.3. Measured Results on a special day

Measurements were made on New Year’s holiday in 2000 and on February 21st on the Road C.

Table 2 shows the measured traffic volume and the running speed. The heavy vehicles ratio on the New year’s holiday was almost 1% and very small compared with that of 16% on ordinary day.

Figure 4 shows the comparison of measured $L_{Aeq}$ on New Year’s holiday and on ordinary day. It has been seen that the $L_{Aeq}$ in deceleration section is smaller than that in acceleration section which is almost the same of $L_{Aeq}$ under steady running condition. The reasons of this exceptional phenomena might be that there are few large sized vehicles which generate large noise when the vehicles start and accelerate.

<table>
<thead>
<tr>
<th>Road</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of lanes</td>
<td>2</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Width of the road</td>
<td>143</td>
<td>18.5</td>
<td>36</td>
</tr>
<tr>
<td>Width of sidewalk</td>
<td>2.6</td>
<td>2.6</td>
<td>32</td>
</tr>
<tr>
<td>Traffic Volume [vehicles/hour]</td>
<td>528</td>
<td>225</td>
<td>912</td>
</tr>
<tr>
<td>Heavy Vehicles ratio [%]</td>
<td>22</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>Running speed [km/h]</td>
<td>46</td>
<td>54</td>
<td>57</td>
</tr>
</tbody>
</table>

Table 1 Characteristics of the roads chosen for the measurements (D: day, N: night)

![Fig.1 Measuring geometry for three different urban roads](image)

![Fig.2 Measured running speed of road vehicles on Road C](image)
3. Prediction Model

3.1. Propagation on the semi free field

In the case that a nondirectional point source generating constant sound power \( W_A \) is traveling straight at a constant speed \( v \) [m/s] (\( V \) [km/h]) on the reflective plane, sound exposure level \( L_{AE} \) at a distance \( \ell \) from the running path, the following relation exists.

\[
L_{AE} = L_{WA} + 10 \log_{10} \left( \frac{1}{2\pi T_0} \int_0^\infty \frac{dt}{\ell^2 + (v \cdot t)^2} \right)
\]

\[= L_{WA} + 10 \log_{10} \left( \frac{1}{2 \ell \cdot v \cdot T_0} \right)\]  

where, \( T_0 = 1 \) [s].

\[N_T\] point sources are traveling during a time period \( T\), equivalent continuous A-weighted sound pressure level \( L_{Aeq,T} \) is expressed by the following expression.

\[
L_{Aeq,T} = L_{AE} + 10 \log_{10} \frac{N_T}{T} = L_{WA} - 10 \log_{10} \ell - 10 \log_{10} V + 10 \log_{10} N_T + 10 \log_{10} \frac{3.6}{2T} \]  

(2)

3.2. Calculation formulas for Sound Power level

The calculation formulas for sound power levels of road vehicles in ASJ RTN-Model 2003 are presented as follows.

On freeways and urban roads under steady running condition, vehicles run at top gear position in the speed
range higher than 40km/h. For this condition, the expression of \(30\log_{10} V\) is adopted as the speed dependence. On the other hand, for the case of urban roads where vehicles accelerate and decelerate in the speed range lower than 60km/h, the expression of \(10\log_{10} V\) is adopted. The calculation formulas for each running condition and \(L_{Aeq}\) at roadsides are expressed as follows.

1) For transient running condition on urban roads

\[
L_{WA} = a + 10\log_{10} V : \quad 10\text{km/h} < V < 60\text{km/h}
\]

\[
L_{Aeq,T} = a - 10\log_{10} \ell + 10\log_{10} N_T + 10\log_{10} \frac{3.6}{2T}
\]  

2) For steady running condition on freeways and urban roads

\[
L_{WA} = a + 30\log_{10} V : \quad 40\text{km/h} < V < 140\text{km/h}
\]

\[
L_{Aeq,T} = a - 10\log_{10} \ell + 20\log_{10} V + 10\log_{10} N_T + 10\log_{10} \frac{3.6}{2T}
\]

According to the formula (4) for transient running condition, \(L_{Aeq}\) depend on the distance \(\ell\) and the traffic volume \(N_T\), but not the running speed \(V\). It can be said that \(L_{Aeq}\) at roadsides in the vicinity of intersection where vehicles run under transient running condition does not depend on the running speed. In other word the \(L_{Aeq}\) is considered to be constant regardless of the distance from an intersection. This tendency is good agreement with the results observed in the actual measurements mentioned previously.

4. Comparison between measured and calculated \(L_{Aeq}\)

In the series of measurements under the wide variety of traffic conditions, 181 data of \(L_{Aeq, 20\text{min.}}\) were obtained. Figure 5 shows the comparison between measured and calculated \(L_{Aeq}\) for the running speed range from 40km/h to 60km/h. There is a tendency that the \(L_{Aeq}\) calculated by using Eq.(6) for sound power level under the steady running condition are lower than the measured \(L_{Aeq}\). On the other hand, the \(L_{Aeq}\) calculated by using Eq.(4) for transient running condition agree well with the measured \(L_{Aeq}\). Figure 6 shows the comparison between measured \(L_{Aeq}\) and those calculated by using Eq.(4) for the running speed range lower than 60km/h and Eq.(6) for that more than 60km/h. It can be said that the calculated results show a good agreement with measured results from the engineering point of view.

5. Conclusion

A series of measurements in the vicinity of intersections were performed in urban areas and measured results were compared with those calculated by ASJ RTN-Model 2003. It has been found that the road traffic noise in the vicinity of an intersection is almost independent of the distance from an intersection and can be predicted by ASJ RTN-Model 2003.

6. References

