RESEARCH ON THE ROAD TRAFFIC NOISE PREDICTION MODEL BASED ON IN SITE MEASUREMENT

Lijuan ZHANG, Ruixiang SONG, Jie YANG, Zhongxu KANG

Beijing Municipal Institute of Labour Protection, Beijing 100054, China

Email: zljxaoxiao@163.com

In order to study on a more accurate prediction model of the road traffic noise, this presented paper focused on optimizing the noise source model based on the measurement data collected from operated buses instead of using the standard noise source model from large vehicle as in the past. Therefore, a large scale of measurement campaign was conducted on the pass-by noise induced by two kinds of common used bus, including 537 buses in total. After removing invalid data and disposing background noise, the optimized noise source model was obtained by regression analysis. The results indicated that the measured acoustic energy is about 40% reduction in all the speed ranges than the standard noise source listed in the standard ‘‘Specifications for Environmental Impact Assessment of Highways’’.

Keywords: Noise Model; Noise Prediction; Bus; Regression Analysis

1. Introduction

The problem of the road traffic noise prediction has been paid more and more attention and has been actively studied. For example, the simplified calculation model of the change of traffic flow increase in traffic noise prediction is proposed, based on the traffic noise prediction model FHWA[1]; road traffic noise prediction used the neural network model of L-M algorithm[2], the model of GM (1, N) [3]and GIS [4].

FHWA highway traffic noise prediction model was released in the USA. Its evaluation index is the equivalent continuous A level (L_{Aeq}). After several improvements, it has become more and more perfect and widely used in the world. Makarewicz et al. studied the characteristics of the sound source, the prediction method and the prediction model in order to solve the traffic lights, traffic jams and other problems [5]. In China, FHWA, RLS90 and the model of” Specifications for Environmental Impact Assessment of Highways” in China are compared by Lina Cao et al. [6].

The model of FHWA and “Specifications for Environmental Impact Assessment of Highways” (China model) in China [7], road vehicles is divided into heavy, midsize, and small vehicles. In China, the traffic noise source test was carried out on the highway, and the noise source model of heavy, midsize, and small vehicles was obtained [8]. However, with the development of urban public transportation system, the buses have become one of the main noise sources. At present, in Beijing and other major cities, there are mainly buses, midsize and small vehicles on the road. Noise source model of medium and small vehicles have been given in the China model and FHWA, but the sound source model of buses has been used for heavy vehicles model. Buses are the public transportation vehicle, and widely apply in the city. Its sound source should be studied .In this paper, the noise source of the bus is measured and analysed.

2. Measuring conditions and procedures

2.1 Measuring conditions

The requirements of test site are as follows:

- Sound field condition: No obvious obstacles within the radius of 50m.
- Background noise: 10dBA lower than the measurement pass-by noise.
- Road surface condition: smooth surface, slope≤0.5%.
- Weather conditions: 10-20℃, wind speed ≤5m/s.

2.2 Testing instrument

（1）testing noise

The testing instrument is the handheld acoustic analyser - B&K 2250. The measurements shall be made using the frequency weighting A, and the time weighting F.

（2）testing speed

The testing instrument is Hand held radar speedometer- Bushnell 101911. Instrument parameters are as follows:

- 1) Measurement accuracy: ±1 MPH;
- 2) Unit of measurement: miles per hour (MPH), km/h (KPH);

The testing instrument is shown in figure 1.

a) B&K2250 b) Bushnell 101911

Figure 1: Testing instrument

2.3 Testing position

The instrument is located at the centre line of the road 7.5m; the microphone height is 1.2m. The measuring point is shown in figure 2.

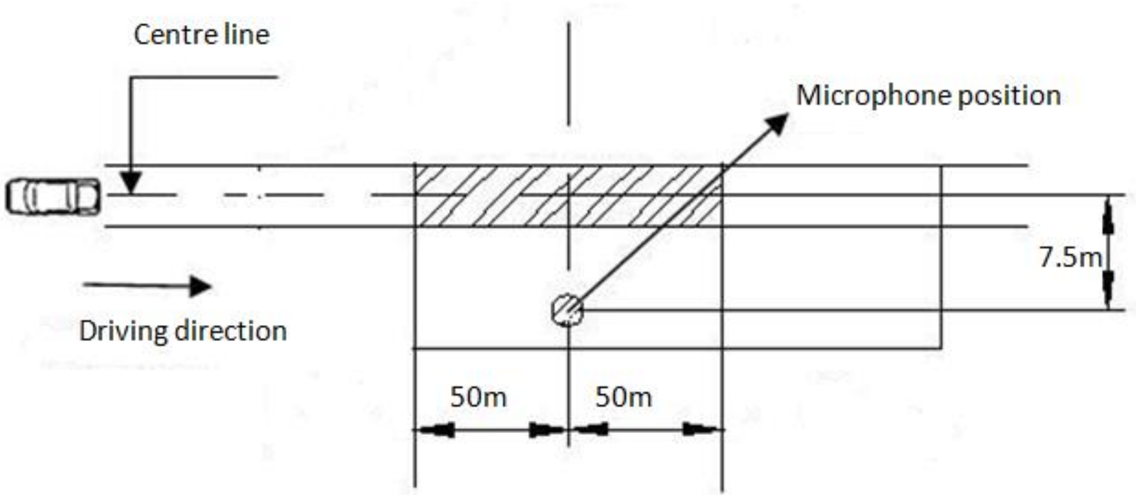

Figure 2: Testing position

2.4 Testing method

The bus passing noise was measure in different speeds at six different locations. The bus passing noise is recorded by 2250, and the time of passing the bus is recorded by a stopwatch. The speed of a vehicle passing is recording by Bushnell 101911.

When the bus passes through the Microphone position, it must be ensured that there is no vehicle passing within the radius of 50 m; otherwise the data will be regarded as invalid data.

3. Result analysis

The measurement campaign was conducted on the pass-by noise, including 537 buses in total. The range of bus pass-by noise is 64.0dBA-85.5dBA, and the speed range of buses is 20km/h-60km/h. The range of background noise is 55dBA -65dBA. The test results are corrected in table 1, when the D-value between bus pass-by noise and background noise is less-than 10dBA.

Table 1 the corrected value of background noise

D-value between bus pass-by noise and background noise /dBA	Corrected value
9-10	0.5
6-8	1
<6	--

3.1 Regression analysis

The regression analysis of the noise source and the vehicle speed use the least square method. Assuming Z is the logarithm of velocity, and the formula 1 is shown.

$$Z=\lg(V) \tag{1}$$

The linear regression model can be shown by the formula 2.

$$L_{\text{bus}}=\text{A}+\text{B}Z \tag{2}$$

In the formula 2: L_{bus}: sound pressure level of the pass-by noise, dBA ;V: speed, km/h; A: constant term; B: coefficient of independent variable Z.

The least squares method is used to analyse the data. The method of least squares is as follows.

The linear regression model is the formula 3.

$$Y=\beta_1+\beta_2X+\mu \tag{3}$$

In the formula 3: $\hat{\beta}_1$、 $\hat{\beta}_2$: the estimated value of β_1， β_2; $\hat{Y}$: the calculated value of Y。

Then, the regression model can be shown by the formula 4.

$$\hat{Y}=\hat{\beta}_1+\hat{\beta}_2X \tag{4}$$

There should be the estimated parameters of $\hat{\beta}_1$ and $\hat{\beta}_2$, and the sum of error square Q between Y and $\hat{Y}$ *is minimize.* The sum of error square Q is the formula 5.

$$Q=\sum(Y_{\text{i}}-\hat{Y}_{\text{i}})^2=\sum e_i^2=\sum(Y_{\text{i}}-\hat{\beta}_1-\hat{\beta}_2X_i)^2 \tag{5}$$

Then, the partial derivative of A and B for Q is solved. The partial derivative is shown by the formula 6.

$$\partial Q/\partial\hat{\beta}_1=0, \partial Q/\partial\hat{\beta}_2=0 \tag{6}$$

End, The estimated parameters of $\hat{\beta}_1$ and $\hat{\beta}_2$ are obtained.

According to the least squares method, the regression model of noise source and speed is shown by the formula 7.

$$L_{\text{bus}}=21.402+34.907\times\lg(V) \tag{7}$$

In the formula 7: L_{bus}: sound pressure level of the bus noise source, dBA ; V: speed, km/h.

The relationship between the regression model and the noise source is shown in figure 3. From Figure 3, the regression model is in good agreement with the pass-by noise. The correlation coefficient of regression analysis was 0.8.

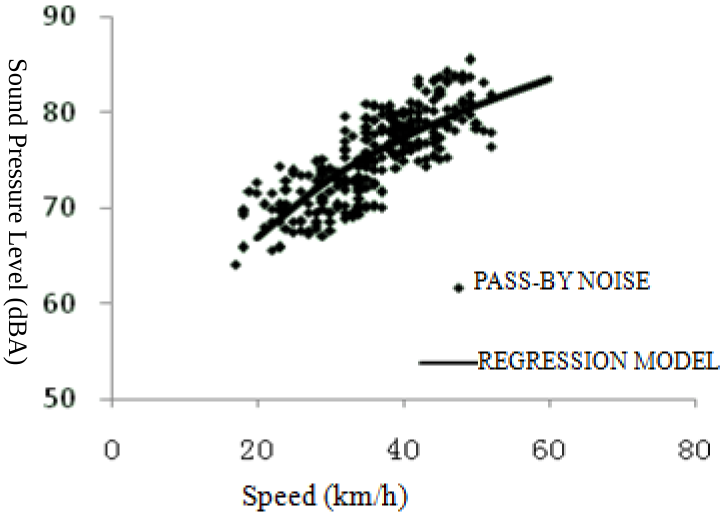

Figure 3: The relationship between regression model and pass-by noise

3.2 Comparative analysis

The noise source strength model of heavy vehicle was proposed by the formula 8 in the standard of "Specifications for Environmental Impact Assessment of Highways".

$$L_H=22.0+36.2* \lg(V) \quad (8)$$

In the formula 8: L_H: sound pressure level of the heavy vehicle pass-by noise, dBA ; V: speed, km/h.

The comparison of noise source between the bus and the heavy vehicle is shown in Figure 4.

From Figure 4, the acoustic energy of bus pass-by noise in the speed range of 20-60km/h is 40% lower than the heavy vehicle in china model. Therefore, in order to make the forecasting result more accurate, the noise source intensity model should be chosen reasonably in the prediction of urban road traffic noise.

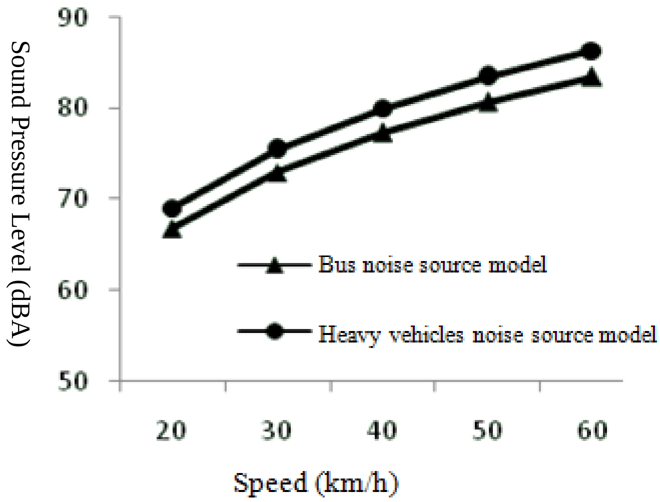

Figure 4: The comparison of noise source between the bus and the heavy vehicle

4. Conclusions

Based on the measurement of analysis the bus pass-by noise, the noise source model of bus is obtained by using the linear regression method.

Compared with the noise source model of the buses and the heavy vehicles in “Specifications for Environmental Impact Assessment of Highways”, the acoustic energy of buses pass-by noise in the speed range of 20-60km/h is 40% lower than the heavy vehicles .It is necessary to take into account the difference between the buses and the heavy vehicles in the prediction of urban road traffic noise. The appropriate model of noise source is adopted in order to make the prediction results more accurate.

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