A PREDICTION SYSTEM FOR ROAD TRAFFIC NOISE AND ITS APPLICATION

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Abstract: A prediction system for road traffic noise was developed according to ASJ (Acoustical Society of Japan) Model 1998. In this paper, the structure and predicting process of the system are described first, and the advantages of the system, such as the high degree of accuracy, user friendly interface, and good extensibility, are introduced then. Finally the system was used to analyze the effect of various measures for reducing the noise level, and effects of the measures are compared too.

Key Words: prediction system, road traffic noise, L_{Aeq} , L_{50}, ASJ Model 1998.

1. INTRODUCTION

With the changing of the Japanese environment standard from the middle value of noise level (L_{50}) to equivalent continuous A-weighted sound pressure level (L_{Aeq}), the road traffic noise prediction model of Acoustical Society of Japan (ASJ) has been changed from ASJ Model 1975 to ASJ Model 1998. A lot of new predicting models, such as the model that predicts the vibration noise generated from elevated bridge, and the model that predicts the reflection noise of the back side of a elevated bridge, have been added to the ASJ Model 1998.

In order to adapt to the new environment standard and the new ASJ Model, a prediction system was developed to calculate L_{Aeq} here. The system can deal with various predicting conditions, and are very user-friendly. The calculation results of our system have been compared with the resuits of other prediction systems and also the actual measured values, it shows that our system has a very high degree of accuracy. Comparing to other prediction systems, our system has a very easy-to-use interface, and can be easily extended to many complex road and ground surface configurations. The system can be used widely in many fields, such as road design, the design of noise barrier, and environmental assessment etc.

2. THE STRUCTURE AND FUNCTION OF THE PREDICTION SYSTEM

2.1 The Structure and The Process of The Prediction System

The basic structure of prediction system is as the graph.

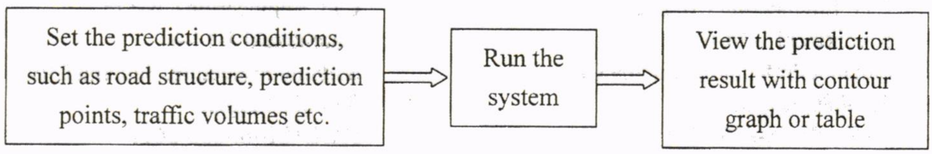

Figure 1 The Structure of The Prediction System

The basic process of the prediction is as following:

① Set the road structure (e.g. plane, elevated bridge, canal etc.), land use situation and ground situation of the roadside.

② Set the prediction points.

③ Set the location of the traffic lanes, and arrange the discrete sound source along the traffic lane.

④ Calculate the noise of the predication point propagated from the discrete sound source in every traffic lane.

⑤ Generate the unit pattern for every traffic lane and every vehicle type. Here the speed of each traffic lane and the power levels of every type of vehicle can be different.

⑥ Calculate the energy integration of the unit pattern for every traffic lane and every vehicle type. Here the traffic volumes of every traffic lane and every vehicle type are used.

⑦ Calculate the L_{Aeq} for each traffic lane.

⑧ Calculate the revised values, such as the vibration noise and the backside reflection noise of elevated bridge, the noise of the roadside reflection etc.

⑨ Integrate the noises from all traffic lanes.

2.2 The Advantages of The System

Our prediction system has the following advantages.

① It implements ASJ model 1998 correctly and extends its potential to a large degree.

- The road is modeled to be of an infinite length, the cross section of the road is the same along the length.
- There is no limitation on traffic volume.
- The speed for expressway and the highway with few traffic signal is limited to be 40~140 km/h, and the speed for the road in urban area with high density traffic signal is limited to be 10~60 km/h.

- There is no limitation on the prediction scope in principle.
- Since the equivalent continuous A-weighted sound pressure level (L_{Aeq}) is adopted as the international standard for the noise evaluation, our prediction system can be applied to not only Japan, but also other countries.
- Two kinds of vehicle classification are applicable: 4-type-classification (large-size car, medium-size car, small-size freight car, passenger motor car), and 2-type-classification (large-size car, small-size car).
- Four kinds of ground surface can be selected according the surface condition. i) Concrete or asphalt. ii) Ground with hard surface like sport ground. iii) Grass lawn, rice paddy, or grass land. iv) Agricultural field or land with soft surface.
- The B-method of ASJ Model 1998 is adopted.

② It can deal with many kinds of road, and can be easily expanded to new types of road.

- Various road structures, such as plane, embankment, cut, elevated road, complex road with plane, elevated and ramp.
- Configuration of various ground surface.
- Various factors that influence the noise level, such as ground surface, the vibration noise produced by elevated bridge or the reflection noise of back side of a elevated bridge, and the reflection noise of fosse or the retaining wall.
- The effects of buildings on reducing noise.

③ The Windows-based interface is very user-friendly. Most of the necessary data are inputted intuitively.

3. ANALYSIS OF THE EFFECT OF THE MEASURES FOR REDUCING TRAFFIC NOISE LEVEL

The system is used to the prediction of the traffic noise for several projects, it shows that the system is of high accuracy. We also use the system to analyze the effect of various measures for reducing traffic noise, the results are reported as follows.

3.1 The Effect of Buffer Zone

As an effective measure to conserve the environment in urban area, the buffer zone of 10m~20m width is constructed popularly in Japan. The main effect of buffer zone for reducing noise is to increase the distance from road to residence. Therefore, we analyze the relationship between the noise level and the distance from road boundary.
We implement the case study by the conditions as Table 1, and the result is shown in Figure 2.

Table 1. The Calculation Conditions

Traffic volume	Small car = 1000 veh./hour Large car = 500 veh./hour
Speed	60 km/hour
The height of prediction point	1.2m
The height of noise barrier	0m

It can be seen that the noise level decrease rapidly as the increase of the distance from road boundary when the distance is below about 20 meters. Therefore, the effect of buffer zone is great when the width is about 10~20m.

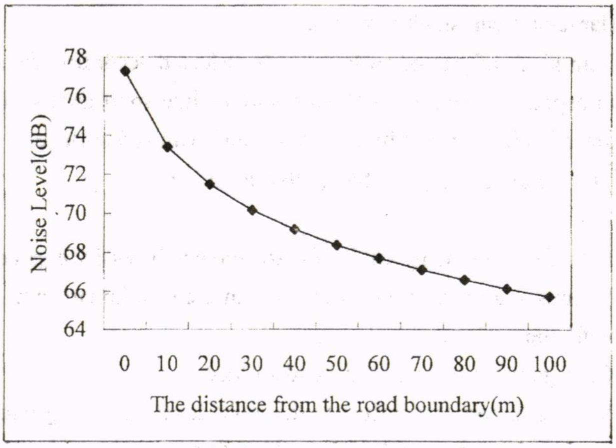

Figure 2. The Relationship Between Noise Level and The Distance From The Road Boundary

3.2 The Speed of Automobile

The change of noise level with the travel speed is shown as in Figure 3.

It can be seen that the noise level increases almost linearly with the increase of the travel speed. However, the noise level decrease only about 1 dB when the travel speed decrease 10km/h. Therefore, it is not an economic method to decrease the noise by controlling the travel speed of the vehicle.

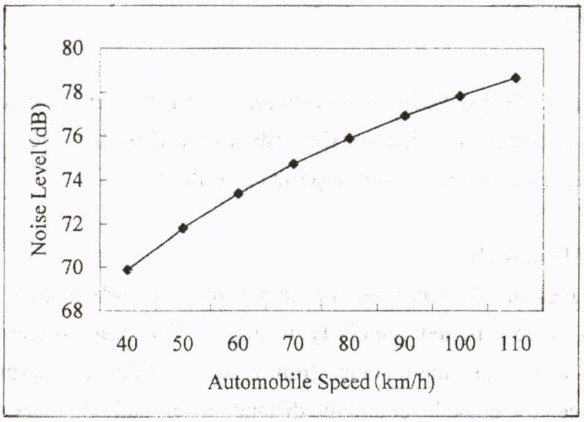

Figure 3. The Relationship Between The Noise Level and The Automobile Speed

(The calculation conditions are the same as in Table 1, but the distance from road boundary is 20 meters)

3.3 Traffic Volume

The change of noise level with the traffic volume is shown as in Figure 4.

It can be seen that the noise level increases almost linearly with the increase of the traffic volume. However, the noise level decreases only about 4 dB when travel volume decrease from 190veh./h to 90veh./h. Therefore, it is not an economic method to decrease the noise by controlling the traffic volume.

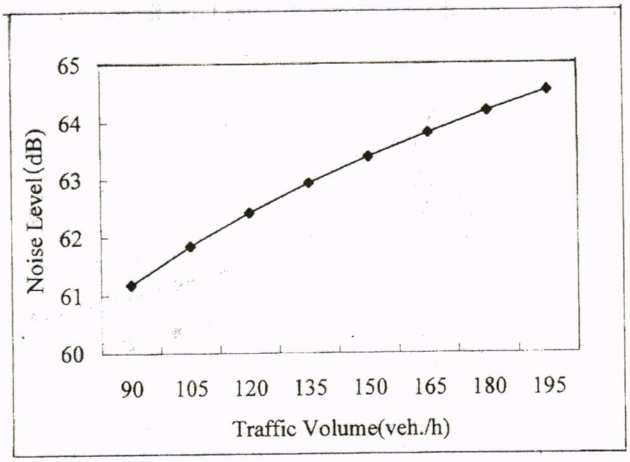

Figure 4. The Relationship Between The Noise Level and The Traffic Volume

(The calculation conditions are the same as in Table 1, but the distance from road boundary is 20 meters)

3.4 Noise Barrier

As the most popular measure for reducing noise level, noise barrier is widely used in Japan. We will discuss the effect of noise barrier here.

Figure 5 shows the relationship between noise level and the height of the noise barrier. It can be seen that the noise barrier is very effective in reducing noise level. In the sample case, the noise level decreases from 63 dB to 52 dB when the noise barrier with the height of 2 meters is constructed.

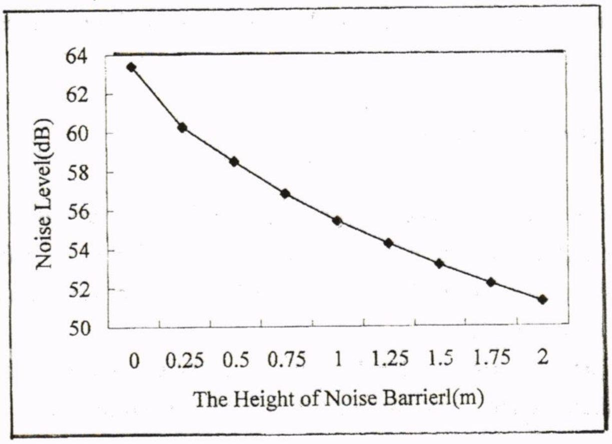

Figure 5. The Relationship Between Noise Level and The Height of Noise Barrier

(The calculation conditions are the same as in Table 1, but the distance from road boundary is 20 meters)

3.5 Drainage Pavement

We compared the effect of drainage pavement. It shows that the drainage pavement has the effect to decrease about 4 dB of the noise level for every distance from the road boundary.

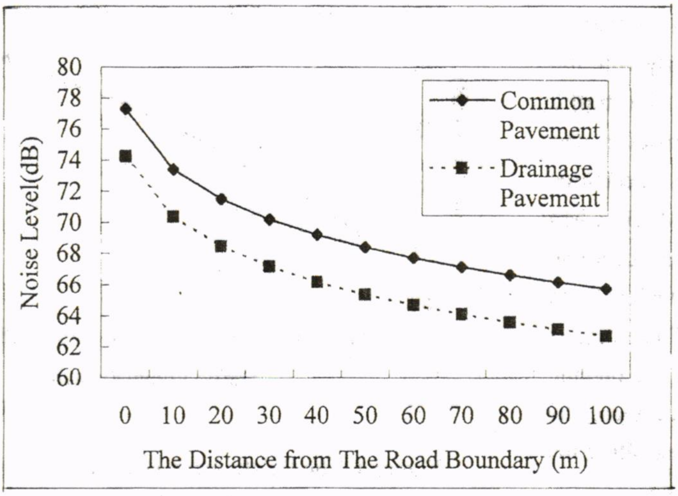

Figure 6. The Effect of The Drainage Pavement
(The calculation conditions are the same as in Table 1)

3.6 The Comparsion of The Effect of The Measures for Reducing Noise Level

Comparing the effect of the measures mentioned above, it can be seen that noise barrier is most effective for reducing noise level, buffer zone and drainage pavement follow. However the control of the travel speed or traffic volume is not very effective for reducing noise level.

4. CONCLUSION

The prediction system can be applied widely to various kinds of roads, and can evaluate the effect of various measures for reducing noise level. Furthermore, since the international standard of level (L_{Aeq}) is adopted, the system can be applied to not only Japan, but also other countries

The comparison of the effect of various measures shows that the noise barrier, buffer zone and drainage pavement are effective for reducing noise level.

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