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METHOD OF PREDICTION AND CONTROL OF ROAD TRAFFIC NOISE IN JAPAN

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Now in Japan, road traffic noise is one of the most important environmental noise sources. Before the construction of new road, it is becoming usual to make prediction of sound level which will be produced by the environmental noise standards, some noise control procedures should be adopted.

Thus, it is important to establish the method of precise prediction of road traffic noise for different road structure and traffic condition. For this purpose, a large number of theoretical, experimental and field investigations have been carried out.

PREDICTION OF FREELY-FLOWING ROAD TRAFFIC NOISE

In 1975, the technical committee of the Acoustical Society of Japan (Chairman: Prof.K.Ishii) published the method of prediction of sound level for freely flowing traffic flow. This work was done under the contract with the Japan Highway Public Corporation and related organizations. From that time, this method has been used widely in Japan.

For the evaluation and regulation of road traffic noise, sound level L_{50} has been used in Japan. For example, in the environmental noise standards which are adopted for the area bordering on the road, sound level L_{50} is provided as shown in Table 1. So, the basic prediction formula is represented as follows, by considering the traffic flow model which supposes a flow of vehicles spaced at equal intervals (1).

$$L_{50} = L_w - 8 - 20\log l + 10\log\left(\pi \frac{l}{d} \tanh 2\pi \frac{l}{d}\right) + \alpha_d + \alpha_i \qquad (1)$$

Here, L_w is the average sound power level of vehicles, l is the distance from the center of the traffic lane and d is the interval of succeeding vehicles which is determined from the traffic flow and vehicle speed. α_d and α_i are correction terms which will be discussed later. Average sound power level L_w can be obtained from the following formula.

$$L_w = 85 + 0.2V + 10\log(a_1 + 3.2a_2 + 16a_3) \qquad (2)$$

Here, V is the vehicle speed and a_1, a_2 and a_3 are the ratio of traffic flow of passenger cars, light trucks and heavy trucks to the total traffic flow. Above formula for L_w was obtained from the field measurements of sound level for single vehicle with different speed. Thus, the constant term and the coefficients for a_2 and a_3 should be reexamined periodically.

Table 1. Environmental Quality Standards for Noise (Areas Bordering on Roads)

in dB (A)

Categories of Areas	Division of Hours		
	Daytime	Morning & Evening	Night
Type A areas bordering on a two - lane road	55	50	45
Type A areas bordering ona more - than - two - lane road	60	55	50
Type B area bordering on a not - more - than - two - lane road	65	60	55
Type B area bordering on a more - than - two - lane road	65	65	60

First correction term α_d in Eq. (1) was introduced into the prediction formula, in order to include the effect of sound diffraction which appears during the noise propagation through the edge of the elevated road, depressed road, sound barrier and so on (Fig. 1).

In Fig. 2, correction term α_d is given as a function of path difference and can be applied directly for the A-weighted sound level, by considering average sound spectrum of traffic noise. Sound reduction in Fig. 2 was calculated from the basic chart for straight line source (2) and so this correction term α_d should be applied for the calculation of sound reduction in the case of fairly heavy traffic flow (more than 1000 vehicles/hour).

Sound level L_{50} which is calculated from Eqs. (1) and (2) without the correction term α_i does not agree with the measured value, especially in the areas apart

from the traffic lane.
This discrepancy would be caused by the excess attenuations through the ground surface and other unknown factors. Thus, the second correction term α_i was introduced in this prediction system as shown in Eq. (1). The values of α_i were determined as the average difference between calculated and measured values for different road structures as a function of distance from the edge of the road and of height from the ground, as shown in Fig. 3.

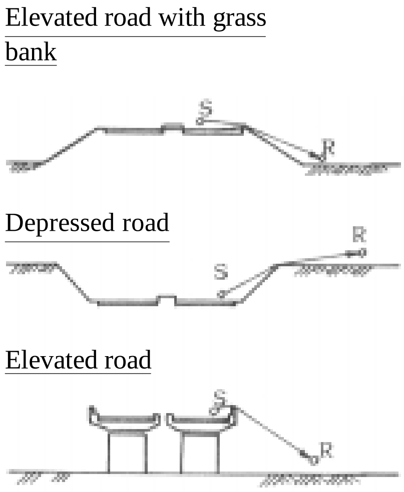

Fig. 1 Sound diffraction at the edge of road.

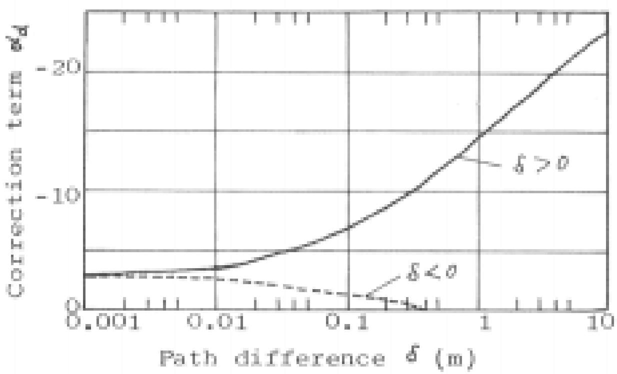

Fig. 2 Correction term α_d

RECENT WORKS FOR THE PREDICTION PROBLEM

In parallel with the establishment of the above prediction system, several approaches have been carried out on this problem.

a) <u>Free Traffic Flow</u> In order to make more precise prediction of road traffic noise, a large number of analytical studies are being carried out. Here, instead of equal interval traffic model which was adopted in the prediction formula (1), more practical traffic flow models, that is exponential distribution model and so on, have been introduced in the prediction formula (3). Compared with the case of equal interval model, these prediction formulae would be able to

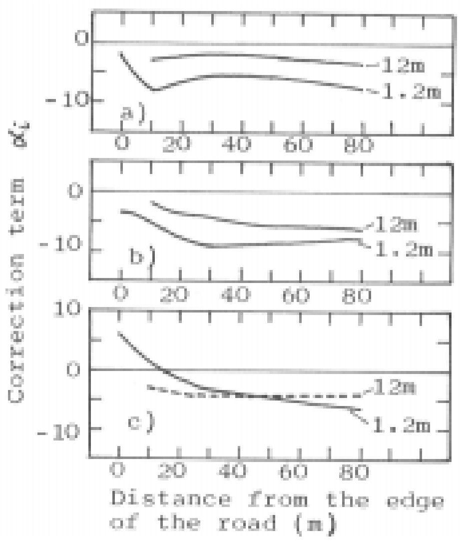

Fig. 3 Correction term α_i
a) Elevated road with grass bank
b) Depressed road
c) Elevated road

make more reasonable prediction of L_{50}, especially in the case of less traffic flow or of short distance from the road. In this case, the prediction of equivalent sound level L_{eq} was also studied and the relation between L_{50} and L_{eq} was investigated.

b) Non-Free Traffic Flow
For the prediction of sound level of non-free traffic flow which is usual situation in city areas, several investigations have been carried out. Here, the traffic conditions which include start, acceleration, deceleration, stop, change of traffic lane and/or left or right turn, are simulated in computer program. Radiated noise from each vehicle is calculated according to its type, speed and engine driving condition.

c) Effect of the Roadside Situation In city areas, not only the above-mentioned traffic condition but also roadside situations, especially the arrangement of buildings, would affect the traffic noise distribution. Sound reflection and diffraction caused by buildings have been investigated by theoretical studies and scale model experiments and the results have been introduced into the above-mentioned computer simulation program.

PRACTICAL PROCEDURES FOR THE CONTROL OF ROAD TRAFFIC NOISE

For the control of road traffic noise, it would be essential to reduce the emitted vehicle noise. Now in Japan, maximum allowable limit for vehicle noise is set up as shown in Table 2. This noise limit will be lowered in step by step, in accordance with the technical development. However, from the practical point of view, it seems to be insufficient to obtain the environmental traffic noise situation only through the regulation of noise emission from the vehicles.

Thus, in parallel with the emission control of vehicle noise, several kinds of practical noise control

Table 2. Maximum Allowable Limit for Automobile Noise (Certification Test)

dB (A)

Classes of Motor Vehicles	Normal	Acceleration		
		Present	Future	
Medium, small and mini cars (except motor bicycles and passenger cars with a capacity of less than 10 persons)				
3.5 tons or more and 200 HP or more	80	89	86	83
3.5 tons or more and 200 HP or less	78	87	86	83
3.5 tons or less	74	83	81	78
Passenger cars with a capacity of less than 10 persons	70	82	81	78
Two-wheeled small cars (more than 250 cc)	74	83	81	78

procedures, that is acoustic barrier, bank, shelter and so on, should be applied.

a) Acoustic Barrier In Japan, the application of acoustic barrier is becoming the most common procedures for the control of road traffic noise. This is partly caused by the facts that buildings are situated rather close to the road, even in the case of intercity highway. At the end of March 1976, total lengths of acoustic barriers which were applied to the road of the Japan Highway Public Corporation have amounted to about 300 Km.

Two kinds of barriers, that is sound reflective type and absorptive type, are used in case by case, according to the situations. At the beginning of the application of sound absorptive barriers, many kinds of panels had been developed and so there had often been some confusions on the selection of suitable structures. So, in 1976 Japan Highway Public Cooperation has developed

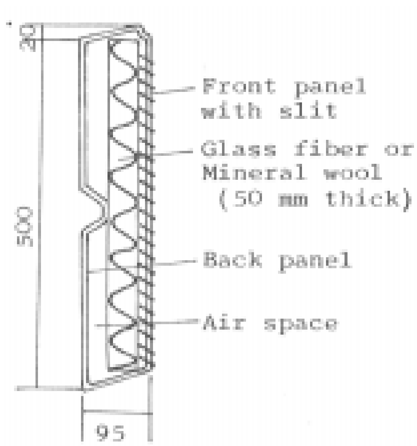

Fig. 4 Section of standard panel for acoustic barrier

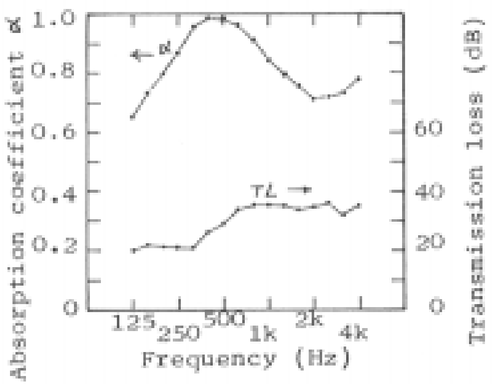

Fig. 5 Acoustic characteristics of standard panel

the standard type of sound absorptive panel. Sectional structure and its acoustic characteristics are shown in Figs. 4 and 5. In addition to the acoustic characteristics, it is important to obtain sufficient weather-proof property and sufficient strength against wind.

b) Acoustic Shelter If there are highrise buildings just bordering on the road, acoustic barrier would sometimes be insufficient for the control of traffic noise. Also, if it is necessary to obtain very high noise reduction, the use of acoustic barrier would not be suitable. In these cases, acoustic shelter would be constructed to cover the road completely, just like a tunnel. Practical example of acoustic shelter is shown in Fig. 6. By using this type of shelter, sound level L_{50} just outside the shelter would be lowered to 46 dB(A) or so. Of course, in this case sound absorbing treatment on the inner surface of the shelter would is radiated from the opening of the both ends of the shelter.

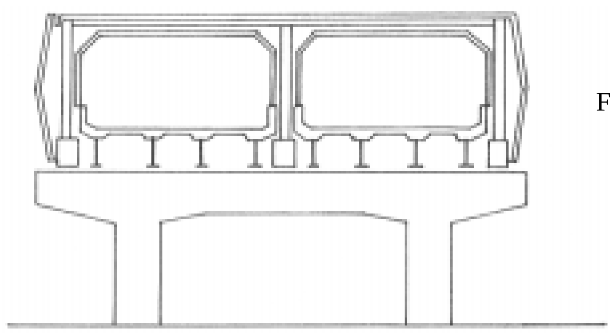

Fig. 6 Section of acoustic shelter for elevated road

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