

Evaluation of 'Environmental Quality Standards for Noise in Japan' in the Areas Facing Roads

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Abstract

It is necessary to predict the excess attenuation of road traffic noise by the buildings for the evaluation of 'Environmental Quality Standards for Noise in Japan' at the areas facing roads. Three kinds of predicting methods have been proposed by the Acoustical Society of Japan, the Ministry of Environment and the author. They have their own merits and demerits, and we need to understand them well when applying these methods to the evaluation of the Standards. Excess attenuation calculated by these methods is calculated by computer simulation and the results are compared. And the feature of each method is made clear, and the problems when applying them to the evaluation of the Standards are pointed out.

1. Introduction

According to the 'Environmental Quality Standards for Noise in Japan' [1] revised in 1998, the problem of environmental noise in the areas facing roads is evaluated by obtaining the numbers and the rates of the buildings at which noise levels exceed the environmental quality standards. The standards allow for the estimation of noise levels, instead of requiring actual measurements, in cases where taking the actual measurements would be difficult. In order to estimate noise levels, it is necessary to grasp the excess attenuation by the buildings. One method for it is presented in the Acoustical Society of Japan's Prediction Model 1998 for Road Traffic Noise [2], abbreviated as 'ASJ Model'. This predicts the average level of excess attenuation by the buildings in a section of predicting area. The Ministry of Environment presented another method [3], abbreviated as 'MOE', which is a simple version of ASJ Model. In addition, the authors [4] proposed an original method, which can predict the excess attenuation by detached houses at arbitrary points when the predicting point is lower than the height of the houses, abbreviated as 'F2002'. These three methods have their own merits and demerits, and we need to understand them well when applying these methods to the evaluation of 'Environmental Quality Standards for Noise' at the areas facing roads.

The object of this paper is to make clear the feature of

three methods and point out the problems when applying them to evaluate the Standards at the areas facing roads.

2. Excess attenuation by the buildings

There are actually various states of the building arrangement in the urban area. However, only the case where the buildings of size at detached house level are arranged near a road is focused in this study. The excess attenuations by the buildings, A-weighted sound pressure level, are calculated by ASJ Model, MOE and F2002 when the state of the building arrangement is variously changed, and the features of three predicting methods are examined by comparing the results. For this purpose, the excess attenuations are calculated when various states of the building arrangement are virtually generated in a computer.

2.1. Model of building arrangement

A rectangular area, 100m wide and 60m long, is assumed to be the noise evaluation area as shown in Fig.1. It consists of four rows in parallel to a road, and each row is divided into consecutive rectangular areas, 15m wide and W_s m (variable) long, in which one building is arranged. The seven lines, which are 80m long and whose perpendicular distances from the road are 15.0m, 22.5m, 30.0m, 37.5m, 45.0m, 52.5m, and 60.0m, are adopted as the noise predicting lines. The heights of receiving points and buildings are assumed to be 1.2m and 7.0m respectively. The value of W_s , assumed to be between 13m and 17m, is decided by a uniform random number generated by simulation.

Although the definition and expression of excess attenuation calculated by ASJ Model, MOE and F2002 are different, insertion loss, $I.L.$, which means the subtract of the noise level when the buildings do not exist from the one when they exist at the same point, positive in usual, is commonly used in this study. Both ASJ Model and MOE provide only one value of $I.L.$ at each predicting line and F2002 can predict $I.L.$ at arbitrary points. Considering it, all the points of every 0.5m points on each predicting line except when the point is within 1.0m from each building are adopted as the predicting point.

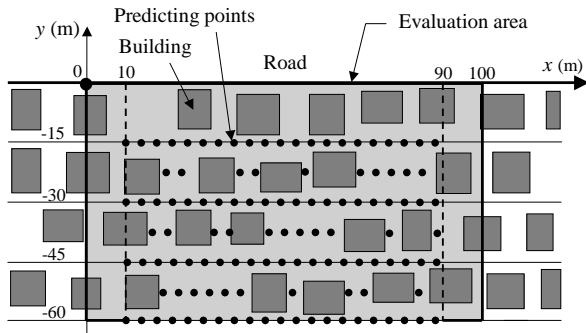


Figure 1: Building arrangement and predicting point

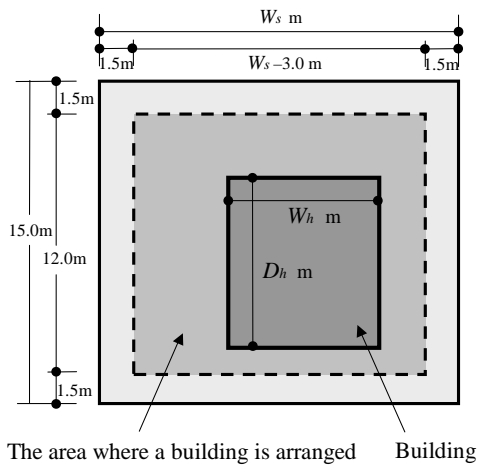


Figure 2: Size and location of a building

2.2. Size and location of a building

Another rectangle, 15m wide and W_s m (variable) long, is assumed to be a building area. This is a part excluded by inside of 1.5m from the area shown in Fig.2. Then one building is arranged in each building area. The width, W_h , and the depth, D_h , of each building are assumed to conform the normal distribution with $(W_s \times 0.6)$ m of mean and 1m of variance and that of 9m of mean and 1m of variance, respectively. Each value is decided by a random number. Here, the values whose difference from the mean are twice or more of the standard deviation and the values which exceed the concerned building area are excluded.

2.3. Building arrangement

To investigate $I.L.$ when the state of the building arrangement is variously changed, the building arrangement are set as follows: (1) when the buildings are randomly arranged in the evaluation area, (2) when an unoccupied area exists in the area. Fig.3 shows some examples. In the case of (1), the densities of buildings, B , which is a rate of the areas occupied by buildings to the whole evaluation area, are 0.25, 0.30 and 0.35. Here, the B s that are

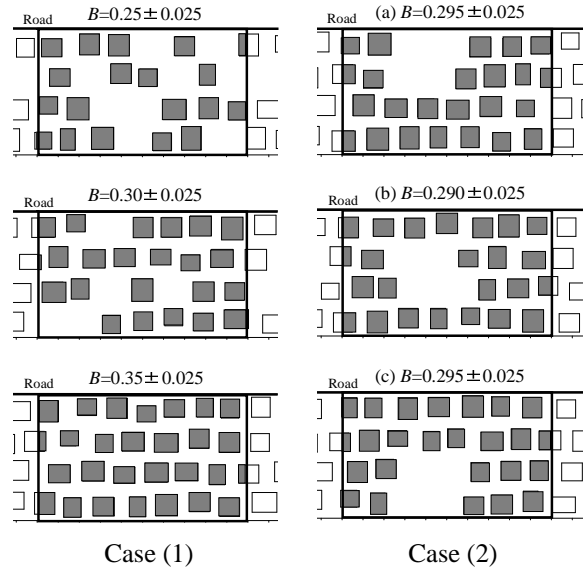


Figure 3: Examples of building arrangement

0.025 greater or less than concerned value are excluded. In the case of (2), by installing the area where no buildings are arranged, three types of the building arrangement are set as follows: (a) when an unoccupied area is located near the road, (b) when located in the center of the area, (c) where it parts from the road.

2.4. Simulation

$I.L.$ is calculated by computer simulation in the above all cases. As the value of $I.L.$ varies according to the state of the building arrangement and the predicting point, $I.L.$ is distributed widely. But the distribution of $I.L.$ is expected to converge to a certain probability distribution. The calculation of $I.L.$ is repeated many times by computer simulation and the convergency of the probability distribution of $I.L.$ is investigated. On the basis of the result, the calculation of $I.L.$ is repeated 500 times, when the distribution become efficiently stable. And the average and distribution of $I.L.$ are obtained.

3. Results and discussion

3.1. When the buildings are randomly arranged

The average values of $I.L.$ predicted by three methods are compared in Fig. 4. It is found that they are in good agreement with each other. This ensures that the three methods provide on average almost the same $I.L.$ when the buildings are randomly arranged.

To investigate $I.L.$ in detail, the probability distribution of $I.L.$ is calculated. Some examples are shown in Fig. 5. For ASJ Model and MOE, which provide only one value at each predicting line, the values of $I.L.$ are distributed around the mean value. On the other hand,

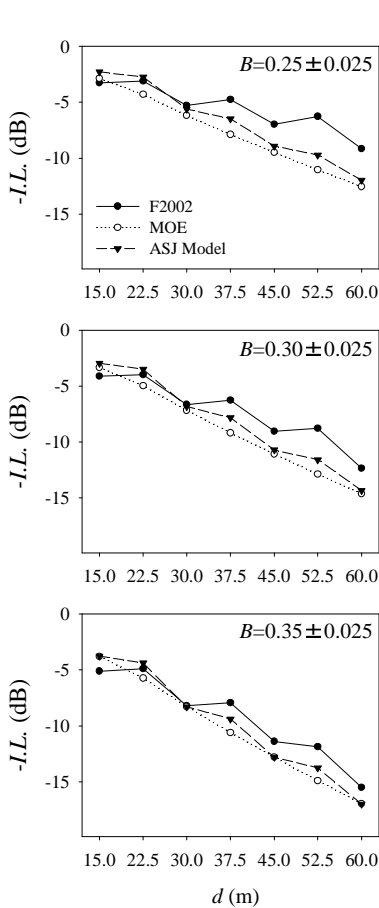


Figure 4: Average value

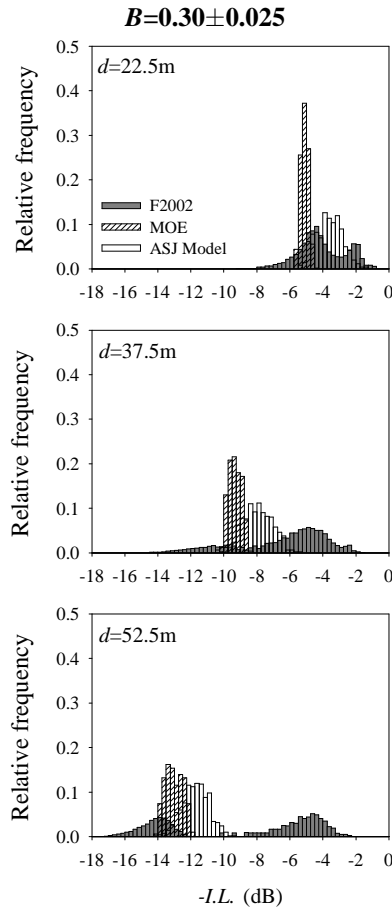


Figure 5: Probability distribution

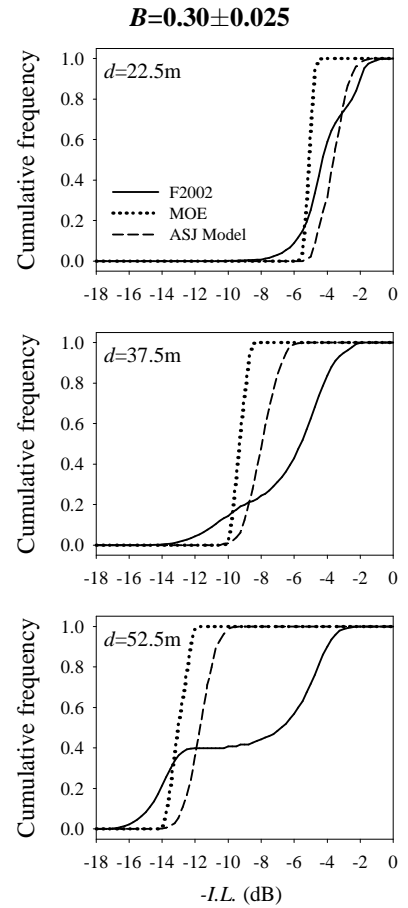


Figure 6: Cumulative distribution

for F2002, which can predict $I.L.$ at the arbitrary points in the area, the value of $I.L.$ greatly differs whether a road is visible at the predicting point or not. The values of $I.L.$ is distributed widely and the distribution of $I.L.$ has two mountains except when the predicting point is near the road and the density of buildings is low. This suggests that there is a possibility that ASJ Model and MOE can not evaluate the ‘Environmental Quality Standards for Noise’ correctly.

To consider in further detail, the cumulative distribution of $I.L.$ is calculated. Some examples are shown in Fig. 6. We try to evaluate ‘Environmental Quality Standards for Noise’ by using this figure. Let us take notice of the case when d is 22.5m. When the standard value is -8dB or less, the noise is judged ‘not achieved’, and when the standard value is -1dB or more, the noise is judged ‘achieved’ whenever any method is used. On the other hand, when the standard value is between -1dB and -8dB, for instance if it is -5dB, the noise is judged ‘not achieved’ by ASJ Model, and contrary to this it is judged ‘achieved’ by MOE. And F2002 presents the rate of ‘achieved’ is 40%. Such a difference of the judgment appears remarkably as the distribution of $I.L.$ expands wide and are divided into two mountains. For example, it

is distinctly found in the lowest figure of Fig. 6, when d is 52.5m, that a great difference of the judgment between ASJ Model, MOE and F2002 appears when the standard value is between -14dB and -3dB. This means that in such a case, even when the judgment by ASJ Model or MOE is ‘achieved’, the ‘not achieved’ points exist actually, and *vice versa*. We need to consider this when applying ASJ Model and MOE to the evaluation of ‘Environmental Quality Standards for Noise’.

3.2. When an unoccupied area exists

Some examples of the probability distribution of $I.L.$ when an unoccupied area exists in the area are shown in Fig. 7. The effect of an occupied area can be recognized in the comparison of Fig. 5 with Fig. 7 while the density of buildings, B , is almost the same value. In the case (a), where an unoccupied area is located near the road, the difference in the distribution form of $I.L.$ predicted by ASJ Model or MOE cannot be found between them. On the other hand, a clear difference can be found in the distribution of $I.L.$ predicted by F2002. It is thought that in this case, the rate of the points at which the road is visible increases and consequently the probability of small

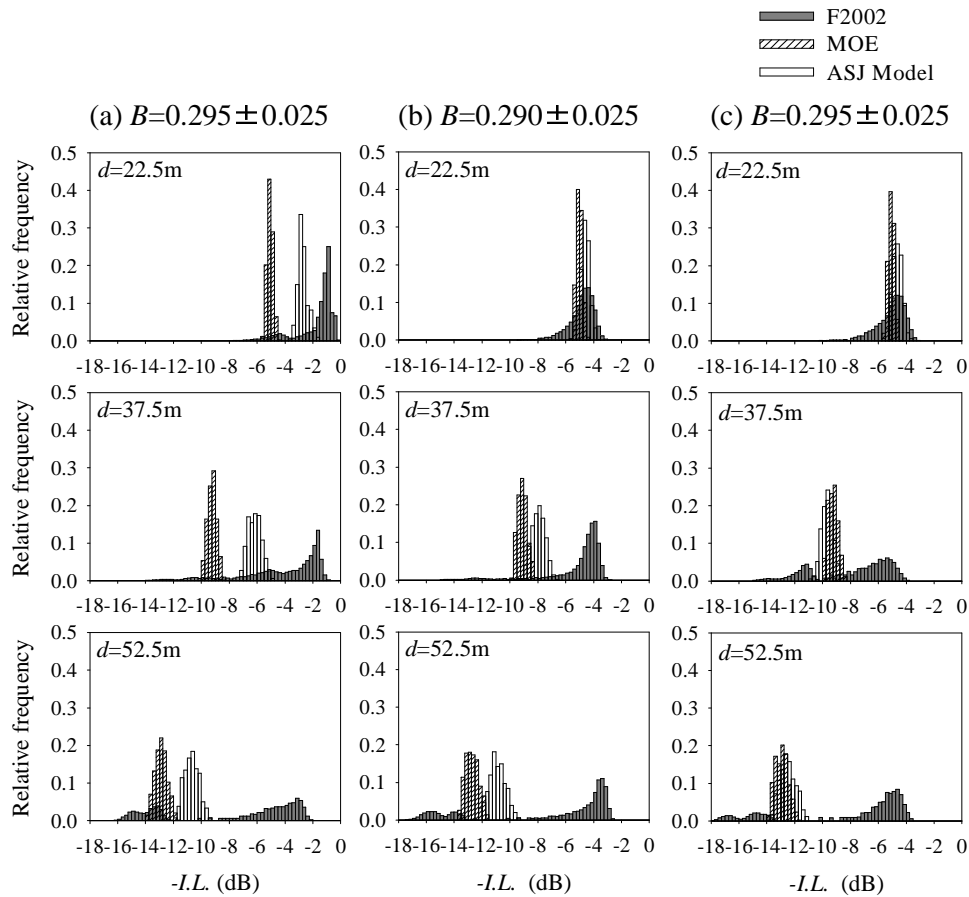


Figure 7: Probability distribution when an unoccupied area exists

attenuations increases because there are no buildings in the first row and the second one, up to about 35m apart from the road in the area as found in Fig. 3. Namely, this shows that F2002 can grasp such an irregular distribution, but neither ASJ Model nor MOE can do that. Any distinct differences are not found when d is 52.5m. In the case (b), where an unoccupied area is located in the center of the area, and the case (c), where it parts from the road, any distinct differences are not found between Fig. 5 and Fig. 7.

The above is summarized that there is a possibility of false evaluation when applying ASJ Model or MOE to ‘Environmental Quality Standards for Noise’ when an unoccupied area is located near the road.

4. Conclusions

The excess attenuation of road traffic noise by buildings, $I.L.$, in the area near a road was simulated by three methods; ASJ Model, MOE, F2002. The results show that three methods provide almost the same value on average, and the distribution of $I.L.$ has two mountains except when the predicting points are near the road and the density of buildings is low. F2002 can grasp such a distribution. On the other hand, ASJ Model and MOE, which provide only the average value of $I.L.$, cannot do that.

Therefore, we should notice this fact when we apply ASJ Model or MOE to the evaluation of ‘Environmental Quality Standards for Noise’.

5. Acknowledgments

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6. References

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