GEOGRAPHIC INFORMATION SYSTEM FOR EVALUATION OF ROAD TRAFFIC NOISE ALONG THE ROAD

PACS: 43.50.Rq

Fujimoto, Kazutoshi; Anai, Ken
Department of Architecture and Urban Design, Faculty of Human-Environment Studies
Kyushu University
6-10-1 Hakozaki, Higashi-ku
812-8581 Fukuoka
JAPAN
Tel: +81 92 642 3337
Fax: +81 92 642 4113
E-mail: fujimoto@arch.kyushu-u.ac.jp (K. Fujimoto); anai@arch.kyushu-u.ac.jp (K. Anai)

ABSTRACT

Fukuoka City constructed a geographic information system for evaluation of road traffic noise along the road under the authors' guidance. This system is based on "the manual for evaluation of environmental quality standards for noise" issued by the Ministry of Environment in Japan, and the main function of it is to display and evaluate an estimated noise level for each building within fifty meters from a main road. This paper reports a basic function of the system and discusses how to apply the system to evaluate the residential environment along the road and proposes some ideas to put a noise-predicting function into the system.

INTRODUCTION

In Japan, about one hundred and ten million people reside in a narrow country and there are a lot of residential buildings located along arterial roads. These buildings are fiercely affected by road traffic noise and prompt measures to noise should be taken. To deal with such a situation, the Ministry of Environment revised "Environmental Quality Standards for Noise" [1] and enforced it in April 1999. As a result, noise shall be evaluated by the equivalent continuous A-weighted sound pressure level (L_{Aeq}), and especially for areas facing roads, achievement shall in principle be evaluated by obtaining numbers and rates of the buildings at which noise levels exceed environmental quality standards regarding the respective concerned areas. Here, the noise level can be estimated instead of actual measurement in case measurement is difficult. In addition, the Ministry of the Environment in Japan issued "the manual for evaluation of environmental quality standards for noise" [2] (abbreviated 'the Manual') and proposed a technique for predicting noise at each building in areas facing roads. In the Manual, the use of GIS (Geographic Information System) is recommended as an assessment tool of noise. Keeping step with such movement, the Acoustical Society of Japan (ASJ) proposed ASJ Prediction Model 1998 for Road Traffic Noise [3]. A method to predict excess attenuation due to buildings, which is necessary to predict the noise level in areas facing roads, is presented there. And the authors [4][5][6] also proposed another simple method to predict excess attenuation due to detached houses in areas facing roads.

On such a background, Fukuoka City (33,938 ha in the area and 1.34 million in the population) constructed the evaluation system of road traffic noise by using GIS (abbreviated 'the System') in order to improve the management of the measurement data of road traffic noise and the efficiency of its evaluation. This system, which basically follows the Manual, can display the noise level and the achievement of environmental quality standards of each residential building located along roads in Fukuoka on a map in GIS. It enables us to understand the noise distribution and the achievement of environmental quality standards on the whole area of Fukuoka City, and is expected to be an effective tool to examine the measure to noise comprehensively.

This paper introduces the outline of the System and discusses how to apply it to predict and evaluate road traffic noise.

FUNCTION OF THE SYSTEM

Noise Prediction Method In The Manual Fig.1 shows the outline of predicting method of road traffic noise at each building in areas facing roads proposed in the Manual. Firstly noise level at roadside is obtained by the measurement, and then noise level in each residential building located within 50m from the road is estimated based on it. The estimation is, as shown in Fig.1, executed from the parameters such as the situation of buildings adjacent to the road, the density of buildings on the area, and the prospective angle to the road from a predicting point.

Basic Data The basic data used in the System is shown in Table 1. The geographic data is data to draw a map of Fukuoka City. It consists of a background (boundary and district of Fukuoka City, etc.), building data (shape, coordinates, type, etc.), and road data (name, kind, road center, and road edge, etc.). These are obtained from topographical maps of a scale of 1 to 2,500 in 1998 version issued by Geographical Survey Institute of Ministry of Land, Infrastructure and Transport. The investigated data is obtained from the investigation that Fukuoka City performed deliberately on the purpose of the System. It consists of road information (width of sidewalk, number of lanes, etc.), measured noise levels at roadside, traffic data (traffic volume in each type of vehicles) and others (photograph of the current state of investigation points, etc.). The data for estimation is data which are necessary to estimate the noise level in each building located within 50m from the road. It consists of the town block which is a base unit for noise estimation, noise parameters (prospective angle to the road from a predicting point and the density of buildings on the area, etc.) and others (the environmental quality standards, etc.).

Setting Of Road-Section 291 road-sections with a length of 422.1km in total were selected as an evaluation target from national roads, prefecture roads and city roads with more than four lanes which are specified for the census of road traffic. The selection was done so that each road-section might have a fixed condition through the section in consideration of the location of intersection, branch, traffic signal and the point in which the number of lanes or the pavement condition of road is changed.

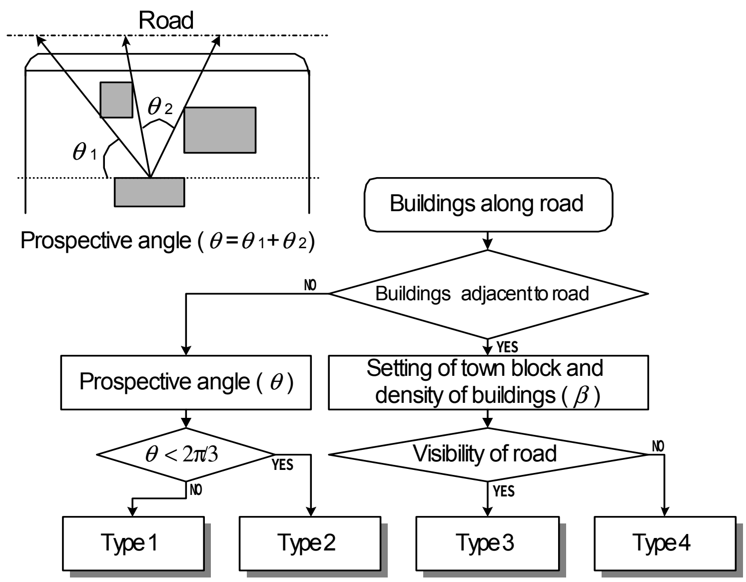

Fig. 1. Outline of predicting method of road traffic noise proposed in the Manual [2].

Table 1　Basic data in the System.

Geographic data	Background (boundary and district of Fukuoka City, etc.), Building data (in each evaluation area and in the whole area of the city, etc.), Road information (name, kind, road center, road edge, etc.)
Investigated data	Road information (width of sidewalk, number of lanes, running direction for each time zone, traffic light, etc.), Measured noise levels at roadside, Traffic data (traffic volume in each type of vehicles), Others (photograph of the current state of investigation point, etc.)
Data for estimation	Parameters for noise estimation (prospective angle, the density of buildings on the area, etc.), Estimated noise level, Others (the environmental quality standards, etc.)

<u>Setting of Town Block</u> According to the Manual, each road-section was divided into town blocks so that the density of buildings in each town block might be constant. At this time, each region delimited by roads was considered to be a separate block.

<u>Evaluation Points</u> Each evaluation point was assumed to be a point of 1.2m in height from ground. Neither the height nor the altitude of buildings is considered in the System.

<u>Basic Function Of The System</u> Main function of this system is to display the measured noise level at roadside and its evaluation of environmental quality standards, the noise level (estimated based on the Manual) of each residential building located within 50m from the road and its evaluation of the environmental quality standards, and the evaluation of environmental quality standards of a town block. Some examples are shown as follows.

Fig.2 shows 351 measuring points and the ranks of measured noise levels (L_{Aeq}) divided in 5dB step. And Fig.3 shows the evaluation of the environmental quality standards after each measured value was collated with the criteria. It is found that the noise level in daytime exceeds 70dB and the noise levels in both daytime and nighttime exceeds the criteria in half of road-sections.

Fig.4 shows the rank of noise level divided in 5dB step, which was estimated from the measured value at roadside, at each residential building located within 50m from the road. And Fig.5 shows the evaluation of the environmental quality standards after each estimated value was collated with the criteria. In this example, the noise level exceeds 70dB and also exceeds the criteria in both daytime and nighttime in almost all the buildings facing the road.

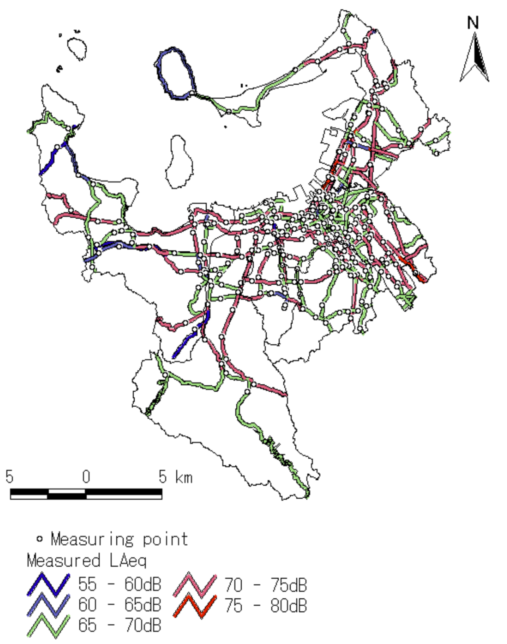

Fig.2. Measured noise levels (L_{Aeq}) at roadside.

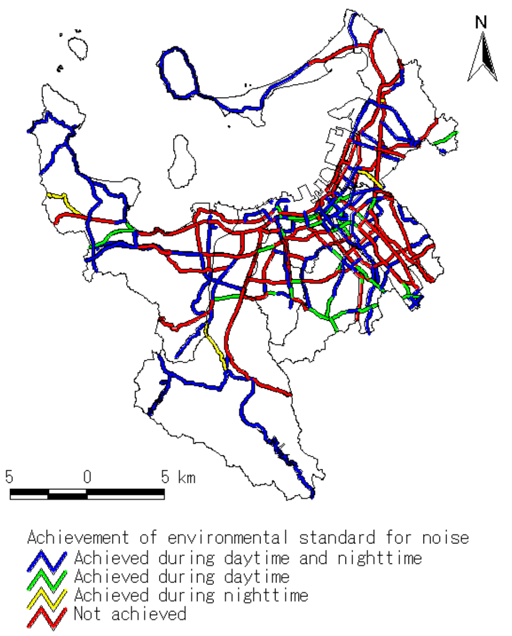

Fig.3. Evaluation of environmental quality standards at roadside.

APPLICATION OF THE SYSTEM

The most distinguished feature of GIS is that GIS can easily display data on a map and connect and pull up target data by their attributes. Some ideas to apply the System to the measure to road traffic noise at areas along roads by using such feature were discussed as follows.

<u>Display Of Road At Which Noise Level Is High</u> It is an appropriate policy to give priority to the road at which the noise level is high when the measure to noise in areas along roads is examined. The System can search easily the road-sections which has high noise level as an attribute. As a result by connecting the searched road-sections, the roads at which the noise level is high is revealed. Fig.6 shows an example of searched roads on condition that the noise level in daytime is 70dB or more. National roads No.3 and No.202 which are main arterial roads in Fukuoka City were pulled up.

<u>Evaluation Corresponding To Usage Of Building</u> In the Environmental Quality Standards for Noise, six kinds of criteria are provided according to a regional type (patterns AA, A/B, C) and time zone (daytime, nighttime), and the System conforms to this standard (actually only four kinds because there is no AA pattern in Fukuoka City). However, finer evaluations corresponding to the real situation is necessary in order to apply the System to the environmental preservation in the areas along roads. For example, medical facilities and educational facilities need more quiet environment than ordinary houses.

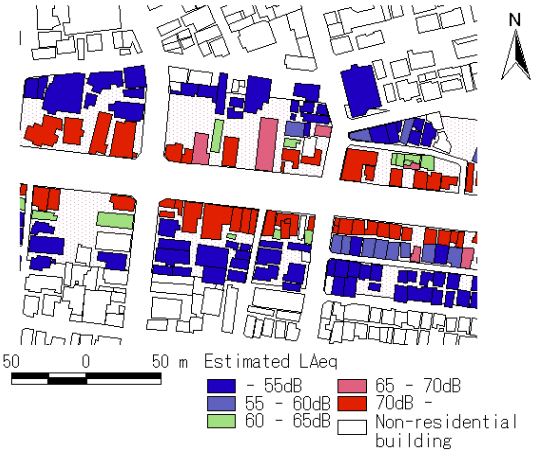

Fig. 4. Estimated L_{Aeq} at residential buildings.

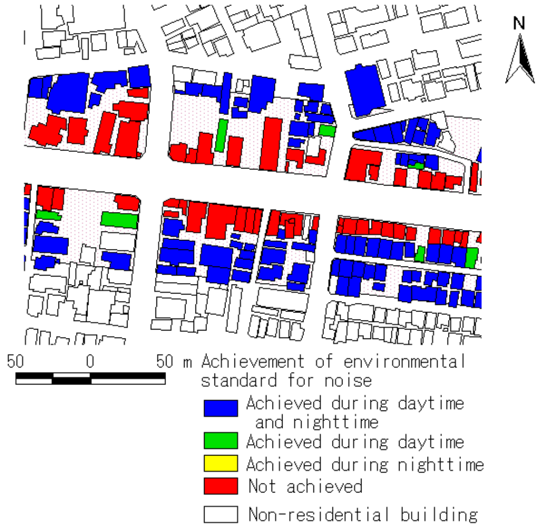

Fig. 5. Evaluation of Environmental Quality Standards at residential buildings.

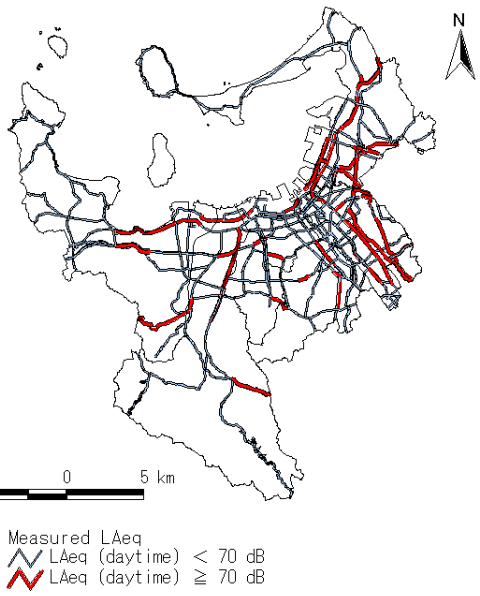

Fig. 6. Roads where L_{Aeq} is 70dB or more.

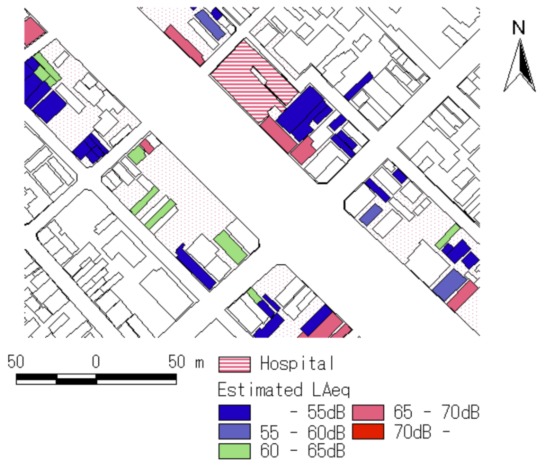

Fig. 7. Example of hospital pulled up.

Fig.7 shows an example of hospital pulled up. L_{Aeq} in daytime of this hospital is, as shown in the figure, estimated to be 65dB. This is under the criterion of areas facing roads (70dB), and consequently the environmental quality of this hospital is evaluated as ‘achieved’. However, pulling up this hospital as facilities in which quietness is required reveals that it is a specified building to which the measure to noise should be taken.

Such a function can be realized only by adding a kind of building to the attribute data of buildings.

Application To Sound Insulation Design Since the noise level in each building is individually estimated in the System, the amount of necessary sound insulation in each building can be obtained by adding the indoor permissible noise level to the attribute data of buildings. It can present an appropriate measure to noise in each building.

Fig.8 shows an example of necessary sound insulation of buildings, in which the ranks divided in 5dB step are illustrated. It can be found that sound insulations of about 30dB and about 10dB in the area near the road and at the point 50m apart from the road are required respectively.

Evaluation Corresponding To Resident In addition, it becomes possible to evaluate the noise corresponding to residents by adding resident's information to the attribute data of buildings. For instance, an idea to pull up the houses where pregnant women or senior citizens reside as buildings where the measure to noise should be taken is considered.

NECESSITY FOR EXPANSION OF THE SYSTEM

The present system displays the inputted data and compares them with the criteria of the environmental quality standards. These functions are realized only by basic functions of GIS.

To estimate the noise level for each house, it is necessary to input the parameters required for the prediction into the System by handwork and calculate the noise value independently from the GIS system. Therefore, it is impossible to apply the present system to predict the noise level due to the changes of environmental conditions along the road such as traffic volume and buildings along the road or the construction of a new road.

However, a function of noise estimation is indispensable in order to apply the System to examine the measure to noise along the road. Then, concrete functions required for it is discussed as follows.

Generation Of Parameters Required For Noise Prediction As for the method for noise prediction in areas facing roads, the Manual issued by the Ministry of Environment in Japan [2], the ASJ Model 1998 [3] and the authors’ method [4][5][6] are well known. For the predicting calculation, the above methods need the parameters such as the distance between an evaluation point and a sound source or a road, the density of buildings, the distinguish proximate buildings from back ones and the prospective angle to the road from a predicting point. Among them, the distance and the area can be generated by the basic function of GIS, but the angle and the parameters that require judgment cannot be obtained.

To make the System applicable to noise prediction, a function to generate the parameters required for noise prediction from the GIS data such as road information and building data must be equipped in the System.

Estimation Of Noise Level At Higher Point Since a lot of mid-to-high-rise houses exists along the road, the estimation of the noise level at points higher than 1.2m is required in order to estimate individual noise level in each story.

As for the method to predict noise level at higher points, ASJ Model 1998 and the authors’ method are well known. However, ASJ Model 1998 is not suitable for estimating the noise level of each building, because it aims at estimating an average value over the evaluation area.

An example of noise distribution along the road predicted by the authors’ method is illustrated in

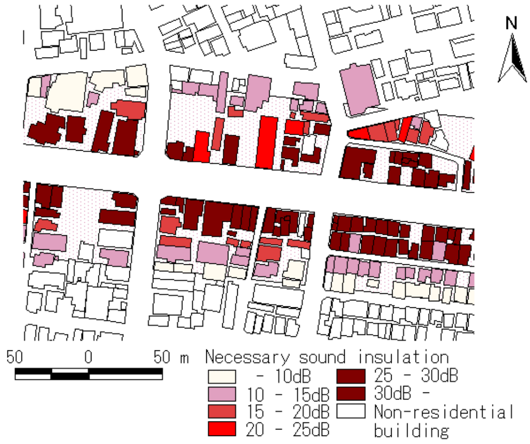

Fig. 8. Example of necessary sound insulation of buildings.

Fig. 9. Example of noise distribution along the road predicted by the authors' method.

Fig.9. It shows the contour in 5dB step of the noise level L_{pA} in the area within 50m from the road. The noise level L_{pA} in the distance d from the center of a road was calculated by the equation: $L_{pA} = L_{WA} - 8 - 10*\log_{10} d + \Delta L_{AE} + \Delta L_g$, where L_{WA} shows A-weighted sound power level of road traffic noise (0dB/m), ΔL_{AE} shows excess attenuation due to detached houses proposed by Fujimoto *et al.* and ΔL_g shows compensation of effect by ground surface (3dB as a semi-free sound field).

Since the noise prediction needs a new procedure greatly different from the present system whichever any predicting method is adopted, significant revision of the System is required.

CONCLUSION

This paper introduced the basic function of the evaluation system for road traffic noise in areas facing roads by using GIS constructed by Fukuoka City and prospected some application of the system to the preservation of sound environment. In addition, this paper pointed out the necessity of adding the function of noise prediction to the system which could make the application of the system extend greatly. It seems to be difficult to realize the enhancement of the system only by the basic function of the present GIS system. However, the development is indispensable for applying the System to the examination of the measure to road traffic noise.

BIBLIOGRAFICAL REFERENCES

[1] Notification No. 64 of Environment Agency in Japan, "Environmental Quality Standards for Noise." (1998) (in Japanese).
[2] The Ministry of Environment in Japan, "The Manual for Evaluation of Environmental Quality Standards for Noise." (2002) (in Japanese).
[3] Research Committee of Road Traffic Noise in Acoustical Society of Japan, ASJ Prediction Model 1998 for Road Traffic Noise. J. Acoust. Soc. Jpn., **55** (1999) 281-324 (in Japanese).
[4] Fujimoto, K., Yasunaga, K., Esaki, K. & Ohmori, H., Attenuation of Road Traffic Noise by Detached Houses. J. Acoust. Soc. Jpn., **56** (2000) 815-824 (in Japanese).
[5] Fujimoto, K., Esaki, K. & Ohmori, H., Level Attenuation of Road Traffic Noise by the Detached Houses. The Seventh Western Pacific Regional Acoustics Conference, 125 (2000) 1-4.
[6] Anai, K. & Fujimoto, K., Prediction of Excess Attenuation of Road Traffic Noise by Detached Houses. Proc. FORUM ACUSTICUM 2002, (2002) (This issue).