NOISE PREDICTION FOR ENVIRONMENTAL IMPACT ASSESSMENT IN JAPAN

PACS: 43.50.Ba, 43.50.Rq, 43.50.Sr

Tachibana Hideki
Institute of Industrial Science, University of Tokyo
Komaba 4-6-1, Meguro-ku, Tokyo
153-8505
Japan
Tel: +81-3-5452-6424
Fax: +81-3-5452-6426
E-mail: tachibana@iis.u-tokyo.ac.jp

ABSTRACT

In Japan, the "Environmental Impact Assessment Law" was issued in 1997 and enforced in 1999. According to this law, noise impact assessment has become mandatory for large-scale land use development projects. On the other hand, the "Noise Regulation Law" and three kinds of "Environmental Quality Standards" (for road traffic noise, aircraft noise and Shinkansen Super-express railway noise) are legislated, in which different noise indices are specified due to the difference of noise sources. This fact is a serious problem for noise prediction in environmental impact assessments. In this paper, representative noise prediction models in Japan are briefly introduced and the problems regarding noise indices are discussed.

INTRODUCTION

Japan has made great stride industrially and economically during its rapid industrial development in the decade from the middle of 1960s. During this high-growth of economy, various kinds of environmental pollution problems became obvious and the Japanese Government legislated the "Basic Environment Law" in 1968 (amended in 1993) and prepared anti-pollution regulations. Regarding the environmental noise problem, the "Noise Regulation Law" was originally enacted in 1968 (amended in 1999). This law regulates the noises from factories and other types of work sites as well as construction work, and sets maximum permissible levels of motor vehicle noise.

Besides the regulation law, three kinds of "Environmental Quality Standards" are legislated for road traffic noise, aircraft noise and Shinkansen Super-express railway noise. These "standards" are not regulations with penalties but administrative guidelines.

Based on the "Basic Environment Law", the "Environmental Impact Assessment Law" was issued and enforced in June 1999. According to this law, environmental impact assessment has become mandatory for large-scale development projects. To cope with this law, the related ministries are preparing practical prediction methods for environmental impact assessment.

In environmental impact assessment regarding noise, noise level is predicted by calculation and the result is assessed by referring the existing regulations/standards. Here, the problem is that the different noise indices are specified in different regulations/standards according to respective characteristic of each noise problem and all of these indices are not necessarily suitable for theoretical calculation.

In this paper, the legislative system for environmental noise problem in Japan is firstly presented (see Fig.1 and table 1) and the prediction methods for respective noises according to the existing regulations/standards are briefly introduced.

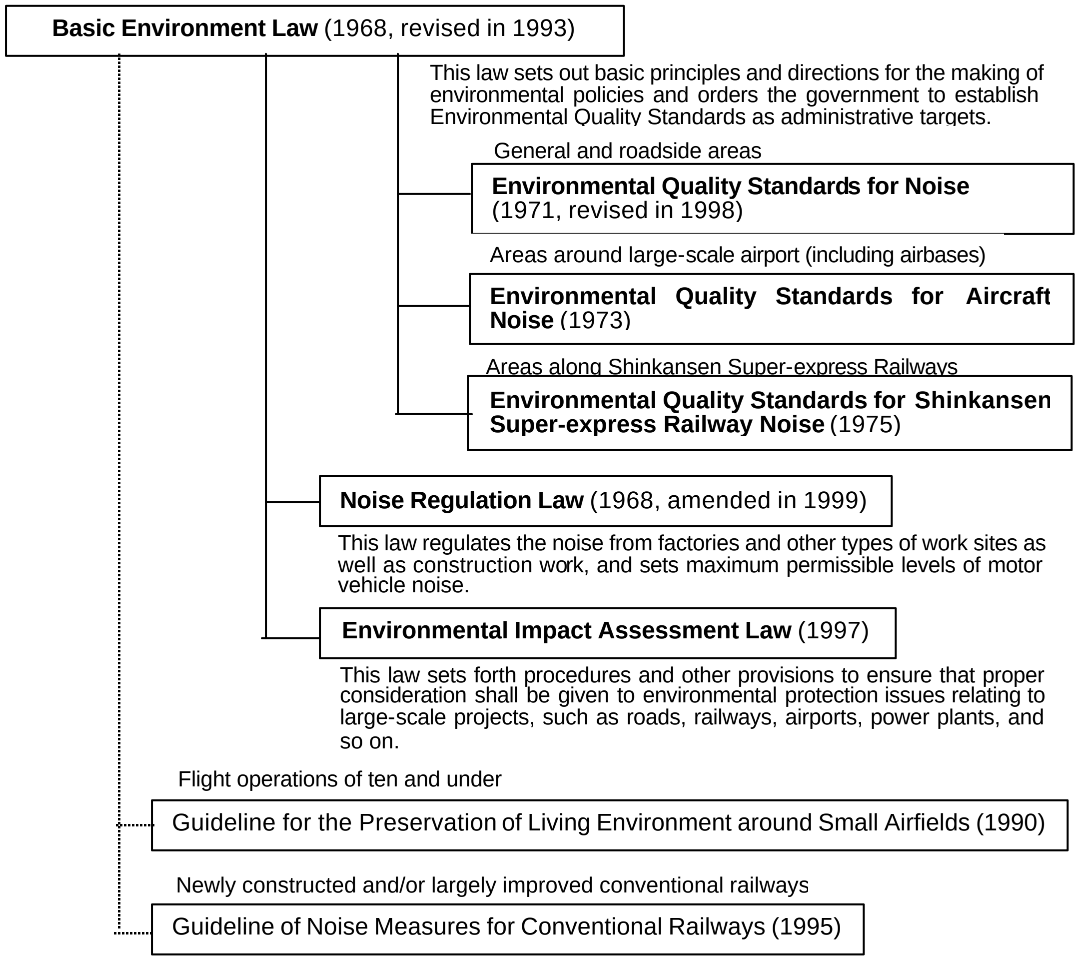


Fig.1 Legal system for environmental noise in Japan

Table 1 Assessment methods specified in laws/standards for environmental noises in Japan

Noise sources	Law/Standards	Noise indices	Assessment time
Roads	Environmental Quality Standards for Noise	$L_{Aeq,T}$ *1	Daytime (6:00-22:00) Nighttime (22:00-6:00)
Shinkansen super-express railways	Environmental Quality Standards for Shinkansen Super-express Railway Noise	$L_{A,Smax}$ *2	Every event
Conventional railways	Guideline of Noise Measures for Conventional Railways	$L_{Aeq,T}$	Daytime (7:00-22:00) Nighttime (22:00-7:00)
Aircrafts	Environmental Quality Standards for Aircraft Noise	WECPNL *3	Time weighting
	Guideline for the Preservation of Living Environment around Small Airfields	L_{den} *4	
Construction works	Noise Regulation Law (Specific noise sources)	According to time variation, ● L_A *5 ● $L_{A,Fmax}$ *6 ● L_{A5} *7 ● $L_{A,Fmax,5}$ *8	Not specified.
Factories			
Large-scale retail stores	Law concerning the measures by large scale retail stores for preservation of living environment		Every event.

*1 $L_{Aeq,T}$: Equivalent continuous A-weighted sound pressure level
*2 $L_{A,Smax}$: SLOW maximum value of A-weighted sound pressure level
*3 WECPNL : Weighted Equivalent Continuous Perceived Noise Level (calculated from $L_{A,Smax}$)
*4 L_{den} : Day/evening/night equivalent continuous A-weighed sound pressure level
*5 $L_{A,Fmax}$: FAST maximum value of A-weighted sound pressure level
*6 L_A : A-weighted sound pressure level
*7 L_{A5} : Upper value of the 90 percent range of A-weighted sound pressure level
*8 $L_{A,Fmax,5}$: Upper value of the 90 percent range of the FAST maximum A-weighted sound pressure level

LEGAL SYSTEM FOR ENVIRONMENTAL NOISE PROBLEMS IN JAPAN

Environmental Quality Standards

In the "Basic Environment Law", the "Environmental Quality Standards" (E.Q.S.) are defined as "*the standards whose maintenance is desirable for the preservation of the living environment and conductive to protection of human health*". For environmental noise problems, the three E.Q.S. shown in Fig.1 and Table 1 are legislated according to the law [1-3]. The "standards" are not "regulations" with penalties but almost "guidelines" or "target values". In the process of environmental impact assessment, however, these standards are often used as the criteria.

Environmental Impact Assessment Law

The Japanese government introduced the idea of environmental impact assessment (EIA) firstly in 1972 and the Cabinet approved guidelines "On Environmental Conservation Measures Relating to Public Works". However, the guidelines did not describe any specific EIA procedure. Responding to the urgent need of having a uniform EIA procedure, the Cabinet approved the guidelines for the uniform EIA procedures titled "On the Implementation of Environmental Impact Assessment" in August 1984. These guidelines prescribed specific rules to be followed for large-scale development projects.

In 1993, the "Basic Environmental Law" was established, in which reconsidering existing EIA system was specified. According to this law, the EIA system was examined in a study commission. Based on its report, the bill on EIA was submitted to the National Diet in March 1997 and the "Environmental Impact Assessment Law" was finally enforced in June 1999.

The purpose of this law is to establish the procedures for conducting EIA on large-scale projects which may have significant impact on the environment and to specify measures in order to provide necessary input into the decision-making process of the projects. As an item handled in the EIA, noise is included as a factor of atmospheric environment together with air quality, vibration, odor, etc.

Noise Regulation Law

The purpose of this law is "*to preserve living environment and contribute to protection of the people's health by regulating noise generated by the operation of factories and other types of work sites as well as construction work affecting a considerable area, and by setting maximum permissible levels of motor vehicle noise*". The main contents of this law are as follows.

1) Regulations regarding specified factories:

"Specific facilities" are defined and the values of "regulatory standards" are provided for each of four area categories and for each time category (daytime, morning/evening, and nighttime). Regarding the measurement of noise, the following procedures are specified (see Table 1).

- In case when the fluctuation of sound level is fairly small, the indicated value is to be read.
- In case when the sound level fluctuates periodically or intermittently and the maximum levels are almost constant, the mean value of the maximum levels is to be obtained.
- In case when the sound level by fluctuates randomly and widely, the upper value of the 90 percent range is to be obtained.
- In case when the sound level fluctuates periodically or intermittently and the maximum level varies, the upper value of the 90 percent range of the maximum levels of each event is to be obtained.

2) Regulations regarding specified construction work:

"Specific construction work" is defined and 85 dB is provided as the value of "regulatory standard" for all areas on the boundary line of the construction work site. The measurement procedure of noise is the same as in the regulation for specified factories.

3) Maximum permissible levels of motor vehicle noise:

This specification consists of two contents; one is vehicle noise emission limits and the other is regulation for actual road traffic noise.

NOISE PREDICTION METHODS IN JAPAN

Road Traffic Noise As the method for the prediction of road traffic noise in Japan, the Acoustical Society of Japan (ASJ) proposed the first calculation model in 1975 (ASJ Model 1975). At that time, L_{50} was used for the assessment of general environmental noises and this model was constructed to predict L_{50}. To prepare the introduction of L_{Aeq} , the Technical Committee Road Traffic Noise in the ASJ started a new research work in 1987. In the process of this work, the first energy-base prediction model for general types of roads of simple construction has been completed in 1993 (ASJ Model 1993). In succession, the committee has continued the work to extend the applicability and to improve the prediction accuracy and proposed a new calculation model "ASJ Model 1998" in 1999 [4-13]. Since this model was published just the same time as the revision of the "Environmental Quality Standards for Noise" in which L_{Aeq} has been firstly adopted, the model is now being widely used as the standard method for predicting road traffic noise in Japan.

Aircraft Noise In the Environmental Quality Standards for Aircraft Noise in Japan, *WECPNL* is used. To predict the noise contour based on this noise descriptor around airports, several methods are being used in related agencies and authorities (Civil Aviation Bureau, the Ministry of Transport, Defense Facilities Administration Agency, New Tokyo International Airport Authority, and Kansai International Airport Co., Ltd.). These prediction methods are introduced in reference 14.

Railway Noise For the prediction of railway noise, several calculation models were proposed before, but since the generation mechanism of train noise is much complicated and the types of train and railroad construction are much varied, any standard model has not yet been established.
Regarding Shinkansen Super-express Railways, a noise prediction model has been developed in a committee sponsored by the Environment Agency, Japan [15]. In the model, the train noise is divided into four components (noise generated from the lower part of train, aerodynamic noise generated from the upper part of the train, pantograph noise, and noise generated from the back surface of elevated-structures) and they are assumed as an array of point sources. The sound power level of each sound source is assumed according to the varieties of running speed, type of train, track and structure and the unit-pattern (time history of A-weighted sound pressure level) for single train pass is calculated in almost the same way as in the road traffic noise prediction model "ASJ Model 1998". From the result, $L_{pA,Smax}$ (SLOW maximum value of A-weighted sound pressure level) is obtained since this noise descriptor is prescribed in the Environmental Quality Standards for Shinkansen Super-express Railway Noise. This model is based on the energy-base calculation and L_{Aeq} can easily be estimated.

Construction Work Noise As an item of noise prediction in the environmental impact assessment, it has become necessary to predict the noises generated by construction works. For this aim, the calculation method is now being investigated in the Technical Committee for construction work noise in the ASJ. The most difficult point in this problem is that a variety of machines and devices with different noise radiation characteristics, temporally and spatially, are used in construction works. Another point is that different indices are used for noise assessment in the "Noise Regulation Law" as mentioned above. Therefore, in the prediction model proposed by the ASJ, noise sources are classified into three categories according to their temporal variation characteristics and the ways to express each acoustic radiation are prescribed as shown in Table 2. Table 3 shows the definition and actual measurement method for each index (see Fig.2).
In the prediction model, two kinds of calculation methods are prepared: one is to predict L_{Aeq} by energy-base calculation, and the other is to predict each noise index specified in the "Noise Regulation Law" according to the difference of temporal characteristic of noise sources by simple calculation considering the sound pressure level decreases in propagation distance, by diffraction and by the ground effect.

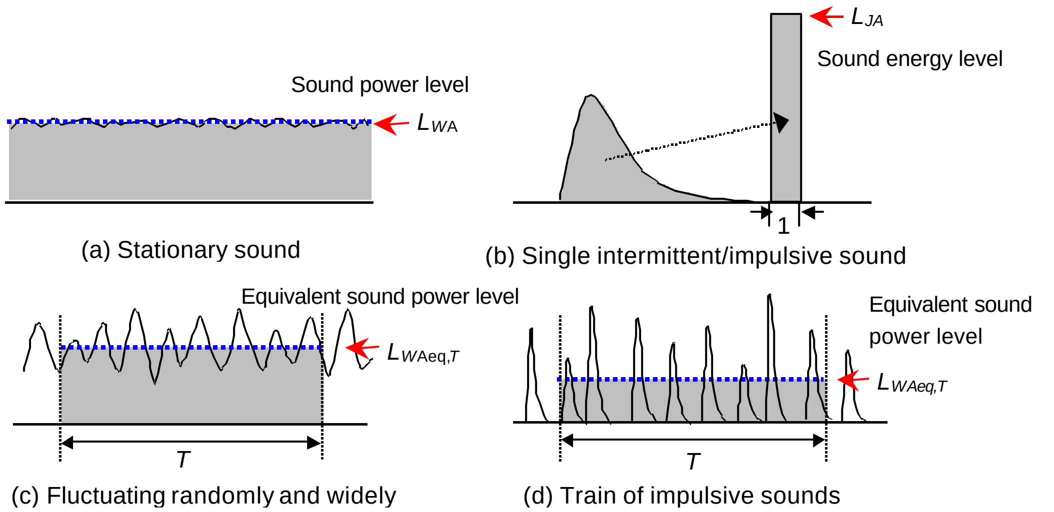
Noises Generated by Large-scale Retail Stores According to the "Law concerning the measures by large scale retail stores for preservation of living environment" enacted in June 2000, it has become necessary to predict noises generated by large scale retail stores. For this aim, almost the same prediction model as that for construction works is proposed.

Table 2 Classification of noise sources and indices for expressing acoustic radiation

Temporal variation	Indices for expressing acoustic radiation	
	Sign	Terms
Stationary	L_{WA}	A-weighted sound power level
	$L_A(r_0)$	A-weighted sound pressure level at the reference distance (r_0=1m)
Fluctuating randomly and widely	$L_{WAeq,T}$	Equivalent sound power level
	$L_{A,5}(r_0)$	5 percent value of A-weighted sound pressure level at the reference distance (r_0=1m)
Intermittent Impulsive	L_{JA}	A-weighted sound energy level
	L_{WAeq}	Equivalent A-weighted sound power level
	$L_{AE}(r_0)$	Single event sound exposure level at the reference distance (r_0=1m)
	$L_{A,Fmax}(r_0)$ $L_{A,Smax}(r_0)$	FAST or SLOW maximum value of A-weighted sound pressure level at the reference distance (r_0=1m)

Table 3 Indices for expressing acoustical radiation of noise sources

Indices	Definition	Measurement method
L_{WA}	$L_{WA} = 10\lg\frac{P_A}{P_0}$ Here, $P_0 = 1$pW See Fig.2 (a).	$L_{WA} = L_A(r) + 20\lg\frac{r}{r_0} + 8$ Here, $L_A(r)$ is the A-weighted sound pressure level measured at a distance of r, $r_0 = 1$m
$L_{WAeq,T}$	Equivalent A-weighted sound power level applied to fluctuating, intermittent and impulsive sounds. See Fig.2 (c) and (d).	$L_{WAeq,T} = L_{Aeq}(r) + 20\lg\frac{r}{r_0} + 8$ Here, L_{Aeq} is the equivalent continuous A-weighted sound pressure level measured at a distance of r. $L_{Aeq} = 10\lg\left[\frac{1}{T}\int_{t_1}^{t_2}\frac{p_A^2(t)}{p_0^2}dt\right]$ Here, T (t_1 - t_2) is averaging time (s), $p_0 = 20$ì Pa
L_{JA}	$L_{JA} = 10\lg\frac{E_A}{E_0}$ Here, $E_0 = 1$pJ See Fig.2 (b).	$L_{JA} = L_{AE}(r) + 20\lg\frac{r}{r_0} + 8$ Here, L_{AE} is the single event sound exposure level measured at a distance of r. $L_{AE} = 10\lg\left[\frac{1}{T_0}\int_{t_1}^{t_2}\frac{p_A^2(t)}{p_0^2}dt\right]$ Here, $T_0 = 1$s , t_1 - t_2 is the time including the event (s).
$L_A(r_0)$ $L_{A,Fmax}(r_0)$ $L_{A,Smax}(r_0)$	A-weighted sound pressure level converted to the value at the reference distance (r_0=1m)	$L_A(r_0) = L_A(r) + 20\lg\frac{r}{r_0}$ Here, $L_A(r)$ is the A-weighted sound pressure level measured at a distance of r.



(a) Stationary sound

(b) Single intermittent/impulsive sound

(c) Fluctuating randomly and widely

(d) Train of impulsive sounds

Fig.2 Expression of acoustic radiation for noise sources with different temporal variations

CONCLUSIONS

In this paper, the legal system for environmental noise problems in Japan has been introduced by attaching importance to noise prediction for environmental impact assessment, and some examples of noise prediction methods are outlined.

In the discussion on noise prediction for environmental impact assessment, the most serious point is that all legal regulations/standards for environmental noises are prescribed for monitoring of the existing noises and different noise indices are specified according to respective noise problems, whereas in the cases of noise prediction, it is difficult or almost impossible to predict maximum levels or statistical indices like percent level (L_{AN}). On the other hand, if L_{Aeq} is used as the noise index, the prediction can be performed very easily, in principle, by energy-base calculation.

At present in Japan, noise monitoring is usually being performed by actual field measurements using sound level meters, but it should also be performed by numerical estimation in the future.

Another point is the difference between "emission" and "immission". In Japanese noise regulations/standards introduced in this paper, the "Noise Regulation Law" prescribes the "emission" levels to regulate noise sources, whereas the "Environmental Quality Standards" prescribe the "immission" levels to preserve actual living environments from noises. This difference should be carefully considered in environmental impact assessment.

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