Road traffic noise prediction model "ASJ RTN-Model 2013" proposed by the Acoustical Society of Japan – Part 1: Outline of the calculation model

Shinichi SAKAMOTO[1]; Toshio MATSUMOTO[2]; Terutoshi TAJIKA[3]; Akinori FUKUSHIMA[4]

[1] Institute of Industrial Science, The University of Tokyo, Japan

[2] Kobayasi Institute of Physical Research, Japan

[3] Environmental Technical Laboratory, Ltd., Japan

[4] NEWS Environmental Design Inc., Japan

ABSTRACT

The Acoustical Society of Japan organizes the Research Committee on Road Traffic Noise to develop a prediction model of the road traffic noise. As results of the continuous research activities, the road traffic noise prediction model has been continuously published. Especially since 1993, the model has been released every five years. In this April, the latest version, "ASJ RTN-Model 2013", was published. It is an up-grade version of the previous model, ASJ RTN-Model 2008, and it was revised based on new knowledge and novel technology. In this paper, the calculation principle, the general procedure of the prediction calculation, the outline of the revision of the ASJ RTN-Model 2013 are introduced.

Keywords: Road traffic noise, ASJ RTN-Model 2013

I-INCE Classification of Subjects Number(s): 76.1, 76.1.1

1. INTRODUCTION

Road traffic noise is one of the most representative environmental issues worldwide. In Japan, the Acoustical Society of Japan organized the Technical Committee on Road Traffic Noise, and the committee has continued research on the road traffic noise issue for over 40 years. As results of the research activity, the series of the prediction model of road traffic noise named ASJ Model (ASJ RTN-Model after 2003 version) have been published (1-6). The models have been applied to environmental noise assessment for a long time, and as the result, they considerably contribute to realization of quiet society. The latest version named "ASJ RTN-Model 2013" was published this April as the outcome of five years' research after the publication of former model (7). In this report (Part 1), the calculation principle, the general procedure of the prediction calculation and the outline of the revision are described. The calculation model of sound power levels of road vehicles and new knowledge on the noise reduction effects of low-emission vehicles are introduced in detail in Part 2 (8).

2. OUTLINE OF THE PREDICTION MODEL

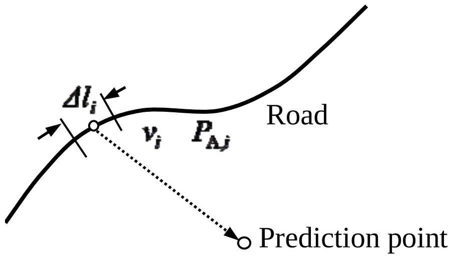
2.1 Principle of the calculation

ASJ RTN-Model computes the equivalent continuous A-weighted sound pressure level, L_{Aeq}, at a prediction point. As the first step to calculate L_{Aeq}, the "unit pattern", a time history of A-weighted sound pressure level at a prediction point is obtained as illustrated in Figures 1 (a) and 1 (b). Next, the unit pattern is integrated in terms of energy over the time of the passage of a vehicle to obtain the

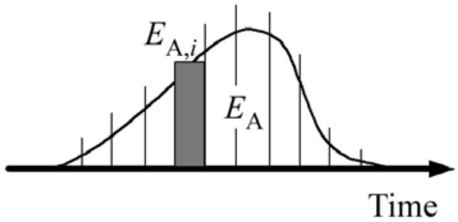
[1] sakamo@iis.u-tokyo.ac.jp
[2] matsumoto@kobayasi-riken.or.jp
[3] tajika@etlabo.co.jp
[4] fuku-new@wonder.ocn.ne.jp

single-event sound pressure exposure level, L_{AE}. By applying the traffic volume N_T, which means number of vehicles in T seconds, to the above value, $L_{Aeq,T}$, is calculated by the following formula.

$$L_{\mathrm{Aeq},T} = 10\lg\left(10^{L_{\mathrm{AE}}/10} \cdot \frac{N_T}{T}\right) = L_{\mathrm{AE}} + 10\lg\frac{N_T}{T} \quad (1)$$



(a) A source position and a prediction point



(b) Unit pattern

Figure 1– Sound propagation from a sound source to a prediction point.

2.2 Scope

The conditions applicable to ASJ RTN-Model 2013 are as follows.

(1) **Types of road**: General roads (flat, bank, cut and viaduct) and special road sections (interchanges, junctions, signalized intersections, road tunnels, depressed/semi-underground roads, flat roads with overhead viaducts and double-deck via-ducts).

(2) **Traffic volume**: No limitation.

(3) **Running speed of vehicles**: 40 to 140 km/h for sections of steady traffic flow on expressways and general roads, 0 to 60 km/h for sections of non-steady traffic flow section on general roads, 0 to 80 km/h for acceleration/deceleration sections on expressways such as interchanges, 0 to 60 km/h for acceleration/deceleration sections on general roads such as in the vicinity of signalized intersections.

(4) **Prediction range**: Up to a horizontal distance of 200 m from the road under consideration and up to a height of 12 m above the ground.

Note: The validity of the model has been examined for this prediction range; however, the model is applicable without any limitation on the calculation range.

(5) **Meteorological conditions**: No wind or strong temperature profile is assumed as the standard condition.

2.3 Calculation procedure

Basic framework of the procedure of the calculation of road traffic noise is the same as that of the former model, ASJ RTN-Model 2008, and the general flow for the calculation is shown in Figure 2. The outline of the calculation procedure is as follows.

(A) Setting of the road structures, the roadside conditions and the prediction point

The first step of the procedure is to set the road structure, the position of the source, the prediction point, the acoustical obstacles and ground surface conditions over the propagation path.

(B) Setting of the position of the lanes

The lane position for noise calculation is arranged one by one at the center of an each actual center lane. However, it is possible to combine two or more lanes into one hypothetical lane. For instance, a hypothetical lane can be arranged both at the center of an up and a down lane, respectively.

(C) Setting the discrete source points

Discrete source positions are arranged. Generally the range is within ±20l (l: the shortest distance from the calculation lane to the prediction point) at an interval of l or less. At special road sections, where the running speed of vehicles changes by acceleration/deceleration and the propagation property rapidly changes with the position of the sound source and the prediction point, it may be necessary to shorten the intervals of the discrete sources.

(D) Setting of the power level of the source

Sound power level of the source, L_{WA}, is set considering the running condition of the vehicle, the running speed of the vehicle and the corrections.

(E) Calculation of the unit pattern

The unit pattern is calculated separately by lane and by vehicle type, when one vehicle runs on the objective road.

(F) Calculation of the energy summation of the unit pattern and L_{Aeq}

Time integration value of the unit pattern is calculated. The value corresponds to a single event sound exposure level, L_{AE}. Finally, the equivalent continuous A-weighted sound pressure level, $L_{\mathrm{Aeq},T}$, is calculated considering the traffic volume during the time interval as the time energy mean level.

(G) Calculation of total noise level

The calculation procedure from (A) to (F) is done by lane and by vehicle type, and the calculated values are added in energy-base in order to obtain the total noise level from the entire road at the prediction point. If necessary, structure borne noise from viaduct, attenuation due to buildings and influence by meteorological conditions are considered.

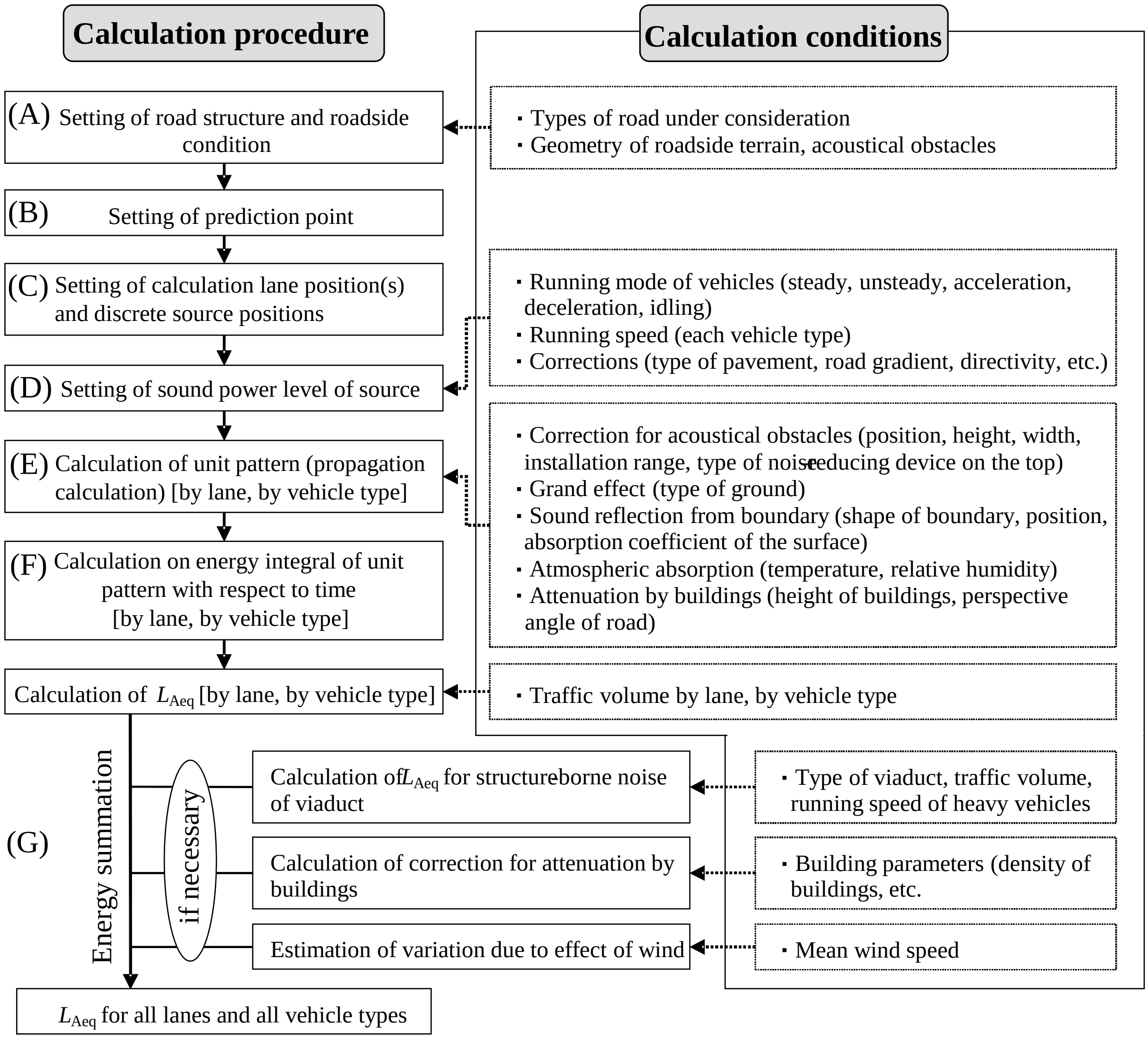


Figure 2– General procedure of the predictive calculation of road traffic noise

3. OUTLINE OF REVISIONS

The present model is developed based on the previous version, ASJ RTN-Model 2008 (1), and the following points are the revisions made to the previous version.

(1) Sound power description

Formulae and the values of their coefficients are not changed, but latest knowledge on A-weighted sound power levels from the low-emission vehicles which are being developed recently is described, and sound reduction effects by double layered drainage asphalt pavement are introduced as references.

(2) Calculation of sound propagation

The correction due to sound attenuation by absorptive barriers is newly added. Calculation of frequency-dependent propagation and calculation method by using the wave-based numerical analysis are updated in appendices.

(3) Noise at special road sections

For calculation of noise at interchanges, running speed and acceleration/deceleration of vehicles passing the tollgate which is equipped with the electronic toll collection (called ETC in Japan) system is provisionally set based on in-situ measurement results.

Regarding the hypothetical point source method for calculation of noise around semi-underground road, the expression of the correction related to the dimension of the road structure is revised to enhance the applicability, and the new correction term related to noise reduction effect due to absorptive louvers is added.

(4) Noise behind a single building and in build-up areas

For noise in build-up area, sound source was limited to a line source condition in the previous version. In the latest version, prediction method for a point source is newly added to enhance its applicability.

The latest version, ASJ RTN-Model 2013, has already published in Japanese, and its English version will be published in early 2015.

4. CONCLUSOINS

Regarding the prediction model of road traffic noise, ”ASJ RTN-Model 2013”, its calculation principle, general procedure of the prediction calculation and the outline of the revision are introduced in this report. Technologies on the vehicles and the transportation systems are rapidly developing in order to enhance the energy saving and to realize low-carbon society. Under such a circumstance, various situations related to the road traffic noise must change in the future. To continue to develop the accurate prediction model, our effort to continuously collect the latest data of noise sources and propagation is important. For this aim, the Research Committee on Road Traffic Noise in the Acoustical Society of Japan will continue the research work.

ACKNOWLEDGEMENTS

This project was financially supported by the organizations in Japan listed below.

- National Institute for Land and Infrastructure Management
- Nippon Expressway Research Institute Co., Ltd.

REFERENCES

1. K. Yamamoto, “Road traffic noise prediction model “ASJ RTN-Model 2008”: Report of the Research Committee on Road Traffic Noise,” *Acoust. Sci. & Tech*., 31, 2-55 (2010).
2. K. Ishii, “Prediction of road traffic noise (part 1), method of practical calculation,” *J. Acoust. Soc. Jpn*. (*J*), 31, 507-517 (1975) (in Japanese).
3. H. Tachibana, “Energy-base prediction method of road traffic noise from general types of roads (Report from Research Committee of Road Traffic Noise in Acoustical Society of Japan),” *J. Acoust. Soc. Jpn*. (*J*), 50, 227-252 (1994) (in Japanese).
4. Research Committee of Road Traffic Noise in Acoustical Society of Japan, “ASJ Prediction Model 1998 for Road Traffic Noise - Report from Research Committee of Road Traffic Noise in Acoustical Society of Japan -,” *J. Acoust. Soc. Jpn*. (*J*), 55, 281-324 (1999) (in Japanese).
5. Research Committee of Road Traffic Noise in the Acoustical Society of Japan (a Chairman: H. Tachibana), “Road traffic noise prediction model ’ASJ RTN-Model 2003‘ proposed by the Acoustical Society of Japan,” *J. Acoust. Soc. Jpn*. (*J*), 60, 192-241 (2004) (in Japanese).
6. The Research Committee on Road Traffic Noise in the Acoustical Society of Japan (the Chairman: K. Yamamoto), “ASJ Prediction Model 2008 for Road Traffic Noise: Report from the Research Committee on Road Traffic Noise in the Acoustical Society of Japan,” *J. Acoust. Soc. Jpn*. (*J*), 65, 179-232 (2009) (in Japanese).
7. The Research Committee on Road Traffic Noise in the Acoustical Society of Japan (the Chairman: S. Sakamoto), “ASJ Prediction Model 2013 for Road Traffic Noise: Report from the Research Committee on Road Traffic Noise in the Acoustical Society of Japan,” *J. Acoust. Soc. Jpn*. (*J*), 70, 172-230 (2014) (in Japanese).
8. Y. Okada, Terutoshi Tajika and Shinichi Sakamoto, “Road traffic noise prediction model “ASJ RTN-Model 2013” proposed by the Acoustical Society of Japan –Part 2:Study on Sound emission of road vehicles,” Proc. INTER-NOISE 2014; Melborne, Australia 2014.