Road traffic noise prediction model “ASJ RTN-Model 2003”
proposed by the Acoustical Society of Japan – Part 1:
The framework and the calculation scheme

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Abstract
The Acoustical Society of Japan (ASJ) has published a new version of road traffic noise prediction method “ASJ RTN-Model 2003” in this April. Although the calculation principle and field of application are almost the same as in the last model “ASJ Model 1998”, the method of providing sound power levels of vehicles and the calculation of sound propagation have been much sophisticated to improve the prediction accuracy. The new model is introduced in three papers with the same main title and other related papers in this congress. In this paper, the calculation principle, general procedure of prediction calculation and the outline of the revision in the “ASJ RTN-Model 2003” are presented.

1. Introduction
In 1999, the Acoustical Society of Japan (ASJ) published a road traffic noise prediction model named “ASJ Model-1998”, in which equivalent continuous A-weighted sound pressure level \(L_{A_{eq}}\) is obtained. This prediction model has been widely used for the prediction and assessment of road traffic noise in Japan. After the publication, the Research Committee of Road Traffic Noise in ASJ has been continuing the work to improve the prediction accuracy and to extend the applicability of the calculation model. As a result, the Committee has published a new version named “ASJ RTN-Model 2003” in this April [1]. In this paper (Part 1), the calculation principle, general procedure of prediction calculation and the outline of the revision in the new calculation model are introduced. The calculation models of sound power levels of road vehicles and calculation methods of sound propagation in the new model are introduced in Part 2 [2] and Part 3 [3], respectively, in this congress.

2. Principle of the calculation
The calculation principle of the ASJ RTN-Model 2003 is energy-base as well as the former model and equivalent continuous A-weighted sound pressure level \(L_{A_{eq}}\) is obtained. In the calculation of road traffic noise based on \(L_{A_{eq}}\), it is the point to obtain “unit pattern”, the time history of sound pressure, at an arbitrary prediction point when a road vehicle runs on a traffic lane of the road under consideration. By squaring and integrating the unit pattern, the sound exposure is obtained and then by considering the traffic volume and by averaging the total sound exposure, \(L_{A_{eq}}\) is obtained (see Fig.1). By performing the calculation for all lanes of the road under consideration and for all vehicle types, and by summing up these results on energy-base, \(L_{A_{eq}}\) at the prediction point is obtained.

![Calculation principle of road traffic noise in “ASJ RTN-Model 2003”](image-url)
3. Field of application

The calculation conditions and the field of application of the ASJ RTN-Model 2003 are as follows.

(1) Road type: general roads (flat, bank, cut and viaduct), special parts (interchange, depressed or semi-underground, vicinity of a tunnel mouth, parts where viaduct and flat road exist together, and double-deck viaduct)

(2) Traffic volume : unlimited

(3) Vehicle running speed : 40 to 140 km/h for freeways and urban roads under steady running condition, 10 to 60 km/h for urban roads under unsteady running condition including acceleration and deceleration, and 0 to 80 km/h for such special parts as interchange.

(4) Prediction area : as far as 200 m in horizontal distance from the road under consideration and up to the height of 12 m from the ground. (Although there is no restriction in the calculation principle, the calculation accuracy of the model has been examined for the limited areas mentioned above.)

(5) Meteorological condition : the condition of no wind and no strong temperature inversion is assumed as the standard meteorological condition.

4. Calculation procedure

As reported in Part 2 [2], noise emission of road vehicles much depends on the difference of vehicle type and running condition. In the ASJ RTN-Model 2003, road vehicles are classified into four-types (large-sized vehicles, medium-sized vehicles, small-sized vehicles and passenger cars). Besides, two type classification (heavy vehicles and light vehicles) is also prepared for the convenience of actual noise impact assessment. For each vehicle type and for each running condition (steady condition, unsteady condition, acceleration, deceleration or stop), the sound power level is provided in A-weighted value under the condition of running on dense asphalt concrete pavement. In addition, the effects of noise reduction by drainage pavement, road gradient and noise radiation directivity of road vehicles are considered as the correction terms.

The outline of the calculation procedure is as follows (see Fig.2).

(1) Calculation conditions:
Geometrical data regarding the road construction and surrounding terrain and building conditions are set.

(2) Setting hypothetical traffic-lanes:
A hypothetical lane is set on the center line of each traffic-lane of the road under consideration. In almost all cases, it may be sufficient to set two respective lanes representing the up and down lanes.

(3) Setting discrete sound source positions:
Discrete sound source positions are located on the hypothetical lane at an interval less than $\ell$ (the shortest distance from the prediction point to the lane) over the distance of $\pm 20\ell$ from the center point on the lane.

(4) Calculation of sound propagation from each source position to the prediction point:
The A-weighted sound pressure at the prediction point caused by each sound source is calculated by the method presented in Part 3 based on geometrical acoustics and empirical formulas [3]. The calculation is base on the inverse-square law for a point source on a hemi-free field and such factors influencing the sound propagation as diffraction over barriers, ground attenuation and atmospheric absorption are considered as correction terms in the basic formula. In the new model, the calculation methods for double diffraction and diffraction over drainage pavement and edge-modified barriers are newly included. By performing the calculation for all source positions, the unit-pattern at the prediction point is obtained for each lane. From the result, the A-weighted sound exposure at the prediction point is calculated.

(5) Calculation of $L_{\text{Aeq}}$
By considering the traffic volume in vehicle type composition, $L_{\text{Aeq}}$ for each lane is calculated. Then, by summing up the values for all lanes on energy-base, the final result of $L_{\text{Aeq}}$ at the prediction point caused by the road under consideration is obtained.

(6) Consideration of the meteorological effects:
Since the influence of meteorological condition on sound propagation outdoors is much complicated, the condition without strong temperature gradient is assumed as the standard condition in ASJ RTN-Model 2003 and a simple formula for the estimation of the effect of wind is presented as a function of vector wind and approximate variation range of $L_{\text{Aeq}}$ by the wind effect is indicated in tabular form for the propagation distance of 50, 100 and 200 m. Regarding the effect of sound absorption by air, the calculation method is specified based on ISO 9613-1.

(7) Special parts:
In actual road traffic noise prediction, noise propagation from such special parts as interchange, depressed or semi-underground road, peripheral area of a tunnel mouth and area under a viaduct have to be calculated. For this purpose, the following procedures are specified.

a) Interchange:
When dealing with interchange, the sound power level of vehicles during acceleration, deceleration and stop have to be considered. In the ASJ RTN-Model 2003, acceleration/deceleration during the transient process near a interchange for the estimation of the change of the running speed, stopping time of vehicles at the toll-
gate, and the sound power levels during each of these transient running conditions are provided [2].

b) Depressed and semi-underground roads:
For the calculation of noise propagation from a depressed or semi-underground road, the reflection by the side-walls has to be considered. For this purpose, the “slit method” is described, in which the reflection surfaces are assumed to be acoustical slits and the reflections are calculated as the diffraction through the slits based on geometrical acoustic [3]. In addition to this calculation method, the hypothetical point source method [5] is newly included for the case where the opening of the upper part of the semi-underground road is relatively small.

c) Peripheral area of tunnel mouth:
In the calculation of noise radiation from a tunnel mouth, the noise is divided into two components; the direct sound from the vehicle in the tunnel and the diffuse sound excluding the direct sound [9].

d) Reflection from the back surface of a viaduct:
For the cases of double-deck viaduct road and the part

![Diagram of calculation process and conditions for calculation](image)

**Fig.2** Procedure for the calculation of road traffic noise (ASJ Model 1998)
where a viaduct road and a flat road exist together, the reflection from the back surface of the construction has to be considered. For this purpose, the back surface is simplified as a plain reflection surface and the reflection is calculated by the “slit method”. In this calculation, three kinds of propagation paths (the direct sound, the first-reflection by the back surface of the construction and the reflection between the back surface and the ground surface) are considered. In addition to this method, a method of calculating scattering reflection based on the Lambert’s law is prepared for the case where the reflecting surface can not be regarded as plain [3].

(8) Structure borne noise generated from a viaduct:
In the area near to a viaduct road, the noise generated from the back surface of the slab of the viaduct structure excited by running vehicles should be considered. For this aim, a simple calculation model was specified in the ASJ Model 1998. In the new model, the calculation method has been improved based on the results of the recent researches. That is, the sound power level of the structure borne noise heard under a viaduct generated by a running vehicle on it is formulated as a function of running speed ($V$ in km/h) in the form of $30 + \lg V$. This model is only for heavy vehicles because the noise generated by passenger cars can be neglected. In the model, the types of viaduct constructions are classified into five categories and the value of A-weighted sound power level is given to each category.

(9) Sound propagation behind buildings:
According to the new “Environmental Quality Standards for Noise” (1998) in Japan, road traffic noise has to be evaluated not only in roadside areas but also in the areas behind buildings and built-up areas. For this aim, a method of calculating the shielding effect by single building and the noise reduction by multiple buildings are presented in the ASJ RTN-Model 2003 [3].

6. Conclusions
As mentioned above, the “ASJ RTN-Model 2003” is an energy-base calculation method based on $L_{\text{Aeq}}$ and can be applied to almost all types of roads, in principle. This prediction model will be effectively used in the Environmental Impact Assessment for road traffic noise in Japan. At the same time, this model can be used for noise mapping of the existing environment. However, there still exist various kinds of problems that should be solved in the future. For this aim, the Research Committee of Road Traffic Noise in the Acoustical Society of Japan will continue the research work.

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8. References