New Mathematical Model to Estimate Road Traffic Noise in View of the Appearance Rate of Heavy Vehicles

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A new mathematical model is proposed to estimate road traffic noise at sites along a freeway where the traffic volume fluctuates from a maximum of 900 vehicles per hour in the daytime to a minimum of 300 vehicles per hour at night. The model considers traffic conditions such as the percentage of heavy vehicles, time interval between successive (two or more) heavy vehicles and measurement time interval. The A-weighted equivalent continuous sound pressure levels calculated from this model are in keeping with measured ones at several representative time intervals both in the daytime and nighttime.

1. INTRODUCTION

Road traffic noise is a type of random variable noise, and its magnitude is widely scattered according to traffic conditions such as traffic volume, traffic content, vehicle speed, and meteorological conditions. These conditions include the direction and velocity of the wind, temperature, humidity, and atmospheric pressure, as well as the distance and nature of the ground surface from the road to an observation point.[1–5] Although a mathematical model should consider as many of the aforementioned factors as possible, most models consider only a few factors due to estimation complexity.

Today when new roads are being planned, an environmental assessment concerning road traffic noise and vibration should be conducted. Accordingly, a model to predict road traffic noise (RTN) is essential. Although predicted estimates such as $L_{Aeq,T}$ and $L_{AN,T}$ must meet the environmental standards set up in each country, the accuracy of the prediction affects the assessment results.[6–9] Hence, many prediction models have been developed along with methods to calculate the RTN in each country.

For example, the CoRTN model was developed by M. E. Delany et al. of the Department of Environment in the United Kingdom. In this model the hourly value of L_{10} with corrections for mean speed, percentage of heavy vehicles, gradient, and feature of road surface is calculated first.[10,11] RLS 90 is the standard for noise prediction in Germany. The mean A-weighted sound pressure level is calculated as a function of emission level, attenuation due to ground and atmospheric effects, and the attenuation due to the topography and building dimensions.[12] On the other hand, the USA used to employ the FHWA Traffic Noise Prediction Model developed by Barry and Reagan of the Department of Transportation Federal Highway Administration.[13] This model has been published as Report No FHWA-RD-77-108 and includes a calculator program. However, the program has been developed successively under the title of STAMINA.[14] In this model, $L_{Aeq,1h}$ is estimated on the basis of the A-weighted average sound pressure level at the reference distance (usually 15 m). Version 3.0 is widespread at the moment.[15] The Acoustical Society of Japan published the first version of a method to predict RTN in 1975, which has been revised about every five years. The most recent version is the ASJ RTN-Model 2008, which was published in 2010.[16] The ASJ-Model adopts a method to obtain $L_{Aeq,T}$ based on a single event sound exposure level, L_{AE}.

The measured value of $L_{Aeq,T}$ depends not only on the nature of noise fluctuation but also on the measurement time interval T. However, the measurement time interval is not clearly specified in ISO 1996 and JIS Z 8731, and, thus, can be arbitrarily chosen (e.g., 1 hour, 24 hours, or a week). ISO 1996-Part 2 states that the measurement time intervals shall be such that all significant variations in noise emissions and transmissions are covered.[17–19]

This study has two main goals:

a) To propose a model that simply predicts RTN even at a road or for a time interval with light traffic.

b) To determine an appropriate method to select the measurement time interval T for obtaining a valid and accurate $L_{Aeq,T}$.

Previous models to predict $L_{Aeq,T}$ at a site along a highway assume that traffic volume, vehicle speed, percentage of heavy vehicles, and accompanying conditions are stable during the measurement time interval T. Thus, they are static models in which $L_{Aeq,T}$ [dB] is uniquely determined according to the given conditions. However, people dwelling in the area along roads having less traffic than 1,000 vehicles per hour are often annoyed by the passing of heavy vehicles, especially at nighttime, even though the daily L_{Aeq} or nighttime L_{Aeq}