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Influence of vehicle noise emission directivity on sound level distribution in a canyon street. Part I: Simulation program test

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Abstract

Simulation programs may be useful tools for controlling an environmental noise. The computer simulation program PROP11 that enables predictions of the time-average sound level within an urban system is used here. A roadway as a noise source is represented by a sum of the sound exposures due to individual vehicle pass-bys. Different representations of equivalent point sources for various classes of vehicles are allowed including directivity characteristics other than omnidirectional. Propagation throughout an urban system contains multi-reflections from the walls and single and double diffraction at their edges. In this paper, the PROP11 program is used to predict the sound level between opposing façades of buildings in a canyon street. A multi-lane road is assumed to contain two classes of vehicles (light and heavy) ones. The equivalent source representing vehicles is defined by the source power spectrum, its position above the ground and directivity characteristics. The consequences of introducing equivalent source directivity are analyzed.

Keywords: Simulation; Urban noise; Street canyons

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1. Introduction

In cities, the most annoying environmental noise sources are vehicles moving along roads. Noise emitted by vehicles moving along city roads first depends on features of the source itself and on the other hand on emission conditions: road geometry, transportation organization and driver habits. The urban noise reaching inhabitants depends also on features of an urban structure surrounding a road, which establish the propagation conditions for sound from the defined source. Thus, to predict the urban noise an appropriate road model that includes vehicles' parameters as well as their streams' parameters and propagation model within an urban structure is required [1].

Here, as an appropriate prediction tool are suggested the simulation programs PROP(...) based on the environmental noise model previously presented [2–7]. In the environmental noise model a vehicle is replaced by an appropriate equivalent point source. Its pass-by, which goes to making the vehicles' flow at a road, has been modeled as a sequence of the point sources. In the propagation model of high accuracy in wave interaction description [5,7–9] a wave undergoes a chain of interactions: transmissions, reflections, and diffractions. A new concept of diffraction in which pure image method is applied allows an arbitrary order of all three kinds of interactions at any arbitrary place in the chain. For prediction of the time-average sound level within an urban system, the pressures of the waves reaching the observation point by different paths are summed not the energy. Thus, as phase differences are taken into account, it is possible to observe local maxima and minima in sound level distribution.

The previously prepared simulation program PROP7 allows prediction of the time-average sound level within a canyon-street as a typical for city-centers. The PROP7 programs did not include directivity of noise emission by vehicle while the present PROP11 has it included. In the both programs, a roadway is modeled as a sum of individual vehicle passes-by. During propagation, a wave interacting with obstacles undergoes multi-reflections from the walls and single and double diffraction at their wedges. A road of J lanes at a bottom of the canyon-street is assumed. The vehicles of the same class are represented by the equivalent point source characterized by statistically estimated position above the ground, the source power level and its spectral distribution with directivity of emission included for the PROP11. Vehicle streams on lanes are defined by the flow rates and the average speeds.

For previously used simulation programs PROP7, the influence of accuracy in a canyon modeling on the sound level distribution has been investigated [10]. To confirm the necessity of the simulation program application with accuracy by it provided, dependence of the sound level on the complex road model for interaction with diffracting elements has been shown [11]. As in diffraction the equivalent source positions and the emitted noise spectrum are the decisive parameters, the road model containing different vehicles representations for different classes of vehicles has been assumed. The equivalent sources representing classes of vehicles differ in the power spectrum and position above the ground. Next, how accuracy in modeling road lane structure and vehicles' streams parameters could affect the final results of the predicted sound level within a canyon-street has been investigated [12,13]. Since for such statistical source as road traffic the process of needed data collecting is time and money consuming, the set of data recommended to be used in a road model construction has to be limited to the most important ones. According to this, the vehicles' streams parameters on a road lane are described by their