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The influence of vegetation on acoustic properties of soils. Measurements of acoustic impedances of outdoor surfaces with application to traffic noise reduction

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Abstracts. The acoustic impedance and specific air flow resistance of 23 outdoor surfaces were measured. Vegetations have a large influence on the sound absorption characteristics of these surfaces. However, this has almost no consequences for the A-weighted total sound pressure level of traffic noise.

Key-words: soil acoustics, outdoor sound propagation, acoustic impedance, specific air flow resistance, traffic noise.

Introduction. The influence of vegetation on the propagation of outdoor sound is subject to a continuing controversy. Especially the advocates of the 'green solution' to the traffic noise problem expect miracles from the laying out of belts of trees along traffic roads (Martens, 1981). Vegetation changes the propagation of sound by two mechanisms: scattering, reflection and absorption of sound by the living trunks, branches, leaves or needles; and reflection by the ground. This article describes their relative contributions to absorption.

Outdoor measurements of acoustic soil impedances. The reflection of sound at soils is best described by the specific acoustic impedance, Z_s, i.e. the complex ratio of air pressure and air particle speed just inside the soil. Z_s was calculated for frequencies between 200 and 1600 Hz from on-the-spot measurements of sound interference patterns above different surface types, including barren sandy plains, lawns, meadows, deciduous, fir and pine forests. The method used was an inclined track of 30 microphones at distances from the sound source varying from 6.54 m to 16.95 m and heights from 0.56 m to 4.35 m. Z_s was found by minimization of the differences between the measured and a model sound field, calculated according to Chessel (1977).

Barren sandy plains are found to be acoustically hard, grass-covered surfaces moderately hard and forest floors soft. For soft surfaces, the real part of $Z_s/\varrho c$ is almost constant (1.0-4.0). The imaginary part is 4.0-12.0 at 200 Hz and 0.0-4.0 at 1600 Hz. This flat real and sloping imaginary part is explained by the layered character of forest floors. The reflective properties of soils are fully determined by the organic layer; the mineral soil underneath has no influence. Wet soil reflects more sound than dry soil. No influence was found of the angle of sound incidence.

Indoor measurements of acoustic soil impedances. In an anechoic room the reflective properties of soil layers on a hard backing were investigated between 500 and 8000 Hz with a short sound pulse. Z_s was calculated from the differences in phase and amplitude between the direct and the soil-reflected sound pulse. The impedances of sand, peat, grass sod and oak leaf layers were in accordance with the outdoor measurements.

Relation between specific air flow resistance and Z_c. The Delany & Bazley (1970) formulas, used to describe the relation between Z_c, the characteristic acoustic impedance, and R_s, the specific air flow resistance, were tested for soils. Values for R_s were derived from the interference patterns and measured directly on soil samples (ISO/DIS 4638).

Acoustically derived R_s values for outdoor surfaces include: 31.0×10^3 (oak/fir forest floor), 506.0×10^3 (lawn), 832.0×10^3 and 2137×10^3 (barren sandy plains) and 34.5×10^3 Pa·s·m^{-2} (beech forest floor).

The directly measured R_s values were slightly dependent on the air flow through the sample. Some results are: 22×10^3 (wet peat mul), 240×10^3 (dry shifting sand), 366×10^3 (barren sandy oil) and 530×10^3 Pa·s·m^{-2} (grass-grown compact sandy soil). The agreement between directly measured and acoustically derived R_s values was good.

Implications for traffic noise reduction. The results of the measurements were used to predict the influence of the soil on the propagation of sound through forests. Below 2 kHz, this influence is strongly dependent on the geometry of the sound source and receiver and on Z_s. Above 2 kHz, only the geometry is of importance. A 1/3-octave model was found to be appropriate as a ground correction factor in measurements aimed at the determination of the influence of living plant parts on the propagation of sound through forests.

A traffic noise model was used to predict the influence of acoustic characteristics of soils and of the impedance discontinuity at the aphalt-soil boundary on the A-weighted immission L_{eq} level of car and truck noise. The results indicate that, notwithstanding the large differences in acoustic characteristics of forest floors and grass-fields, these levels are hardly influenced by the type of soil adjacent to the road.

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