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ACOUSTIC PROPAGATION OVER PERIODIC AND QUASI-PERIODIC ROUGH SURFACES

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1. INTRODUCTION

Transport noise is an ever present concern in urban areas affecting the quality of life for millions of people. The traditional noise barrier is not always a convenient method of noise control and can divide communities. As a result, other types of barrier have been sought. Considerable interest has been devoted to the use of arrays of vertical cylinders[1-3] especially as a result of the publication of the measured transmission spectra of a minimalist sculpture[4]. A particular advantage in using such arrays instead of conventional noise barriers is that they are relatively transparent and could be formed from natural means such as trees. However, such arrays do still present a barrier to pedestrian movement. Another approach is to use arrays of cylinders arranged horizontally on grounds near the noise source, the advantage being that they would allow greater pedestrian access and would be less intrusive. Such arrays effectively introduce a roughness to the ground, which is known to have a significant influence on near-grazing sound propagation[5]. Here we present a theoretical and experimental investigation of this influence on sound propagation and its potential for transport noise reduction.

A theoretical treatment for analysing the sound propagation over such rough grounds considers the multiple scattering of cylindrical acoustic waves by an array of finite impedance semi-cylinders embedded in a smooth acoustically hard surface[6] and is based on a treatment for the problem of plane wave scattering by finite arrays of hard cylinders in water[7] and on a treatment for identical finite impedance cylinders[8]. Results from this treatment demonstrate good agreement between predictions and measured relative sound pressure level spectra for a range of different array distributions and with boundary element calculations. It is this treatment that we adopt in this study.

In section 2, we present an overview of this multiple scattering treatment. In section 3, we present results of this theoretical treatment for different source-receiver geometries, forms and sizes of both cylinders and semi-cylinders together with results of some simple laboratory measurements. An important challenge for this technique is to determine the optimum cylinder geometry which reduces noise over a large bandwidth without introducing low-frequency surface waves. In section 4, we review the potential for this technique as a way of reducing transport noise and propose some suggestions for further research.

2. THEORY

The theoretical development presented in this article follows that of a multiple scattering approach presented previously[6]. Here, we consider a cylindrical wave incident from a single source on an array of N rigid semi-cylinders (instead of N different finite impedance semi-cylinders) of variable radii that are embedded in a flat hard plane and arranged perpendicularly to the direction of propagation. Figure (1) shows the geometrical arrangement of the source, receiver and rigid semi-cylinders embedded in a plane boundary.

The total field at the receiver is the sum of a direct field contribution, a contribution from the plane boundary and a contribution from the semi-cylindrical scatterers and must satisfy the Helmholtz equation

$$\nabla^2 P + k^2 P = 0 \,. \qquad (1)$$