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NOISE REDUCTION BY A BARRIER

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1 INTRODUCTION

The use of a barrier to reduce the propagation of noise is a well known technique in noise control and barriers have application in a variety of circumstances ranging from open plan offices to motorways. This present investigation was prompted by the current interest in means of dealing with motorway noise. Of the noise control measures available for this purpose, least is known about the performance of barriers under practical conditions.

There is no shortage of papers dealing with the theoretical aspects of barrier performance and design charts have been put forward, based on theoretical considerations only and repeated in the text books (1 to 3). The most significant recent contribution has been made by Maekawa (4) who took account of the existing theoretical treatments together with his own experimental evidence, gathered mainly in an anechoic chamber, in putting forward a new design chart.

There have been several investigations of the screening performance of models in anechoic chambers and recently the CSTB in Paris (5) have completed a very thorough investigation of model sized barriers using an extended source to simulate a motorway.

The investigation reported here extends the study of barriers to the real life situation in which barrier performance can be affected by the presence of an absorbing ground and meteorological conditions. It is the first experiment in a short series, planned to provide realistic design rules for the performance of barriers in reducing traffic noise. Since the experiment used a point source of sound the results apply to the noise from localised sources only, such as the peaks of traffic noise. Further experiments are planned using a real motorway as the source to determine the effects of a barrier on both the peaks and the background of traffic noise, again under practical conditions.

2 EXPERIMENTAL DETAILS

The experimental barrier was 61 m (200 ft) long and was built on a grass covered part of an airfield. The grass was kept cut to not more than 100 mm (4 in) long and measurements were made with the barrier at 4.9 m (16 ft), 3.7 m (12 ft), 3 m (10 ft) and 1.8 m (6 ft) high, all under a wide range of wind conditions. In addition measurements were made without a barrier over the same site.

4. APPLICATION

Using the spectrum of the peaks of noise measured at 4 m from the edge of a motorway as the source spectrum, barrier performance in reducing motorway noise has been calculated, using both predicted and measured attenuations, for both source distances, for all receiver positions and for all barrier heights. Design charts have been prepared to predict the attenuations of motorway noise peaks to be expected with zero wind and an absorbent ground. About the zero wind values a strong wind opposing propagation increased attenuations by 0 to 5 dB(A) and a strong wind in the other direction decreased attenuations by 0 to 10 dB(A) (depending on receiver height and distances in both cases).

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A 0.7 m high loudspeaker source was used, which had been designed to be non-directional in the vertical plane and sufficiently directional in the horizontal plane to make negligible the sound energy diffracted around the ends of the barrier. Two source to barrier distances were used, 10 m and 25 m, to correspond to the extreme source to barrier distances for a six lane motorway. The source and microphone positions were in a plane at right angles to the centre of the barrier. The sound field on the shadow side of the barrier was mapped in two dimensions, the measuring positions being at 15 m, 30 m, 60 m and 120 m horizontally from the barrier and at the following heights, 1.5 m, 3 m, 6 m, 9 m and 12 m, at each distance.

Octave bands of random noise (equal energy per octave) were used as the measuring signal over the frequency range 125 Hz to 4 kHz.

3 EXPERIMENTAL RESULTS

As expected the results were strongly influenced by the effects of the ground and of the wind (6 to 10). As is well known, the propagation close to an absorbing ground surface is characterised by large attenuations over part of the frequency range. The frequency of maximum attenuation depends upon the nature of the ground, the heights of the source and receiver and the propagation distance. This ground effect is due to interference between the direct sound and that reaching the receiver via a complex reflection at the ground surface. The wind affects propagation by creating sound velocity gradients and these cause refraction of the sound paths resulting in the formation of wind created shadow zones upwind from the source. Temperature lapses have an effect similar to that of the wind but a temperature created shadow zone is symmetrical about the source.

(a) Effect of the Ground

The measured barrier attenuations, defined as the difference between the measured levels before and after the erection of a barrier, showed large differences from the attenuations predicted by Maekawa's method, even for zero wind. Typical departures were up to 10 dB on either side of the predicted values. In the zero wind results, the discrepancies between measured and predicted attenuations were due to the differences in the attenuations due to the ground between the propagation conditions, with and without barrier.

The effect of the ground on the measured attenuations can be greatly reduced if, instead of using the measured levels at the reception point without the barrier as the reference, a calculated level is used. This is based on the measured level just above the top of the barrier and the distance to the reception point. Attenuations, without wind, based on these calculated unscreened levels, agree much more closely with the predicted values. The remaining departures from the predicted values are mainly at the lower frequencies and these are due to the effect of the ground on propagation from the top of the barrier to the receiver positions. An additional small effect is the tendency for the attenuations at all frequencies to be about 2 dB greater than predicted. This is because zero wind conditions in the presence of a temperature lapse, the condition of these measurements, are slightly unfavourable to propagation.

(b) Effect of the Wind

Here again the effects were complex. In general the wind had most effect on the attenuations due to barriers at the higher frequencies, at the lower receiver positions and at the greater source to barrier and receiver to barrier distances. The results are in accordance with general concepts of the formation of shadow zones.