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SCALE MODEL STUDIES OF HIGHWAY NOISE BARRIER INSERTION LOSSES

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INTRODUCTION

It is now well established that the presence of a ground surface can affect noise control barrier insertion losses markedly as a function of frequency. This phenomenon was observed by Scholes et al [1] outdoors, where the insertion loss of a wooden barrier over grass-covered ground was studied. With ground effects subsequently removed from their data, a simple treatment such as that of Maekawa [2] seemed adequate; however, the actual recorded data showed a marked dependence of insertion loss with frequency, illustrating the presence of interference phenomena which Maekawa did not take into account.

A theoretical study by Isei et al [3] treated barrier insertion losses in the presence of asphalt and grass surfaces either side of the barrier. Assuming coherence in the source, interference effects in both the presence and absence of the barrier were seen to lead to maxima and minima in insertion loss at certain frequencies. The exact form of the curves was dependent upon the amplitude and phase of reflected waves from the ground, in turn dependent upon the flow resistivity σ of the ground surfaces.

In recent publications [4-6], the authors have described a modelling apparatus incorporating scaled ground surfaces of known flow resistivity at a 1:80 scale factor. In particular, grass (σ = 300 c.g.s. Rayls) and asphalt (assumed perfectly reflecting) were available. Studies of acoustic propagation over flat ground confirmed the presence of interference in the model at the correct frequencies [6].

We now wish to describe results from an investigation into insertion losses of barriers in the presence of either asphalt or grass-covered ground surfaces. The geometry used is shown in Fig. 1. In this investigation, only thin, upright reflecting barriers were studied; the treatment of other barrier designs is to be reported elsewhere [7].

To allow the proper interpretation of data to be accomplished, model results were obtained by undertaking three experiments. First, the spectrum for freefield propagation from source to receiver was recorded. A second spectrum was then obtained in the presence of the ground, to yield the excess attenuation of the ground surface in question. Finally, a spectrum was recorded with the barrier in place, a comparison with the second spectrum giving the barrier insertion loss.

RESULTS

The excess attenuation (E) and the barrier insertion loss (I) for the configuration of Fig. 1 was obtained for grass covered ground, and the results are presented in Fig. 2 (a) and (b) for receiver-barrier separations of 6.1 m and 12.2 m respectively. In both cases, the barrier insertion loss was a minimum at around 500 Hz. Conversely, the excess attenuation of the ground surface in each case was a maximum centred about a similar frequency. Fig. 3 shows results obtained in the presence of an asphalt surface, for a receiver-barrier separation of 12.2 m. It can be seen that the excess attenuation curve (E) did not contain the maxima observed in Fig. 2, and sound levels increased by up to 5 dB in comparison to those observed in the absence of ground. Conversely, the barrier insertion loss (I) exhibited marked variations with frequency, three distinct maxima being observed within the frequency range examined.

DISCUSSION

A comparison of Figs. 2 (b) and 3, where excess attenuation data and barrier insertion losses were determined for the same geometry but different ground types, illustrates the marked effect that a change in ground properties can produce.

Consider first the case of grass-covered ground, Fig. 2. The excess attenuation curves (E) for both geometries result from interference between a direct wave from source to receiver, and one involving a single reflection from the ground surface. This interference, which depends upon the phase change induced upon reflection, occurs destructively at around 500 Hz for both geometries. Note that such an effect has been observed in outdoor experiments [8], theory [9] and other modelling results [6]. If a barrier is now placed between source and receiver, this reflective path is removed. As this wave path was resulting in a decrease in sound levels by destructive interference, its removal will tend to reduce insertion losses over the frequency range at which it occurred originally. This effect is plainly visible in the model insertion loss data. Further modifications to the insertion loss data might result from interference on either side of the barrier following its placement; further modelling investigations [10] have shown this to be only a secondary effect for the geometries quoted.

The data for an asphalt ground, Fig. 3, differs from that of Fig. 2 (b) because of a change in the form of interference processes. The excess attenuation data for the asphalt ground surface (Fig. 3, curve E) varies little from zero, because interference processes only occur at higher frequencies than those examined. Hence only a small increase in sound level occurs over freefield propagation. Placement of the barrier, however, results in marked oscillations in insertion loss with frequency (curve I). This arises because interference is now occurring on either side of the barrier, when it is in position. A wave from the source can travel to the barrier top, and interfere with one reflecting from the ground. A similar phenomenon will occur on the receiver side. Note that this is not as marked in the grass case, because of a difference in the phase change induced on reflection from the ground.

CONCLUSIONS

A model study has demonstrated that barrier insertion loss is dependent markedly on ground properties. It has been demonstrated that interference processes are a predominant feature in expected data. For the geometry and frequency range studied, the principal effects occur prior to the barrier's insertion in the case of grass-covered ground, and following it for an asphalt ground.

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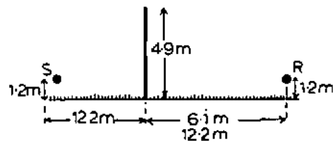

Fig. 1. The geometry investigated, with either asphalt or grass-covered ground. The dimensions shown are full-scale.

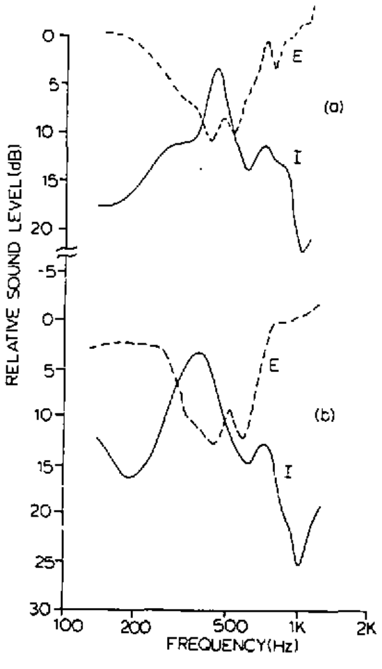

Fig. 2 Excess attenuation data (E) for grass-covered ground and corresponding barrier insertion loss data (I) as a function of frequency. (a) receiver 6.1 m from barrier, (b) 12.2 m from barrier.

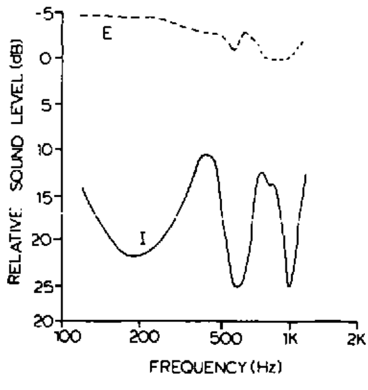

Fig. 3 Excess attenuation data (E) for asphalt ground and corresponding barrier insertion loss data (I) as a function of frequency.(a) receiver 6.1 m from barrier, (b) 12.2 m from barrier.