ACOUSTICAL SCALE MODELLING OF HIGHWAY NOISE BARRIERS

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Introduction

The noise attenuation of scale-model roadside barriers was studied using a scale-model road configuration and an ultrasonic air-jet to recreate a line source of traffic. Scale-model materials were found that adequately represented outdoor ground surfaces. Scale-model noise barriers of three types were tested: vertical walls; earth berms; and earth berms crested by a wall. A-weighted Insertion Losses (ILAs) were obtained by applying an A-weighted traffic-noise spectrum before integrating over the 80–2500Hz full-scale third-octave bands.

Scale-Model Materials

Scale-model materials were selected by measuring the material's Excess Attenuation at scale-factors of 1:20, 25, 31.5, 40, and 50. A material is a good scale-model surface when the normal impedance of the scale-model surface at ultrasonic frequencies is equivalent to the normal impedance of the ground surface at full-scale frequencies. Theoretical Excess Attenuations were calculated using a sound-propagation model that describes the normal impedance using the Delany & Bazley [1] flow-resistivity model. An array of scale-factor versus effective flow-resistivity values was generated for each test material, and the residuals between the measured and theoretical curves were calculated for each cell of the array. An optimal scale-factor of 1:31.5 was selected, in conjunction with the selection of 3 model materials to simulate earth berms and soft ground(150–300 c.g.s.-rayl), and vertical walls or roadways(20000 c.g.s.-rayl). Roadways were simulated by varnished particle board, walls by dense polystyrene, and both earth berms and soft ground were simulated using extruded polystyrene. The impedance of berm surfaces was also altered using dense polystyrene and felt.

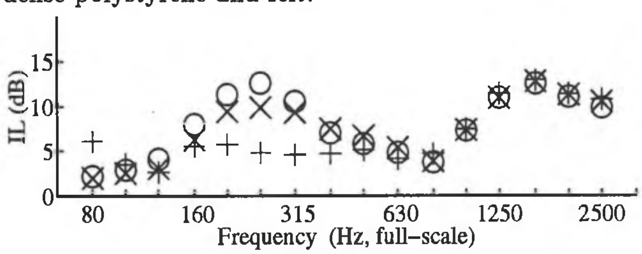

Figure 1: Measured third-octave Insertion Losses for wedge-shaped grass berms of 4m height with slopes of 1.5,2, and 3 to 1: (o) 1.5:1, IL=9.0, ILA=7.0; (x) 2:1, IL=8.5, ILA=7.2; (+) 3:1, IL=7.9, ILA=7.0

Insertion-Loss Results

The most significant factors affecting barrier IL were: earth-berm slope; relative earth-berm and berm-crest wall height; and earth berm surface impedance. Wall thickness did not significantly affect ILA, as long as the wall is thick enough to make sound transmission negligible. Walls were found to outperform earth berms by about 2dBA. Variations in the top profile of the earth berm, from a wedge to a flat-top of 1m or 2m width or a round top of 1m or 2m radius, produced at most an 0.8 dBA improvement in berm performance. Examining Fig.1, it is apparent that as earth-berm slope becomes shallower, the Insertion Loss is *reduced* in the vicinity of the 250Hz third-octave band. The application of the A-weighted traffic-noise spectrum suppressed many of the differences observed in the third-octave Insertion Losses, since its peak power was in the 1000Hz third-octave band. For all three earth-berm surface impedances, a shallower slope resulted in a decreased ILA, with the vertical wall being a limiting case for the grass-berm tests. In Fig.2, for earth berms with a crest wall, shallower slopes *improved* Insertion Losses so that they were as high as for a pure wall, or even up to 1dBA more effective, in the case of an earth berm of 3m height topped by a 1m crest wall. When a berm's height represented a smaller proportion of the total 4m barrier height, the affect on attenuation was reduced. The softening of an earth berm's surface produced substantial improvements in the ILA. However, when a wall was present the benefits of softer berm slopes were not as substantial; the beneficial effects of adding a wall or softening the earth berm's surfaces were not independent of one another.

[1] M.E. Delany and E.N. Bazley. "Acoustical Properties of Fibrous Absorbent Materials". *Applied Acoustics*, 3:105–116, 1970.

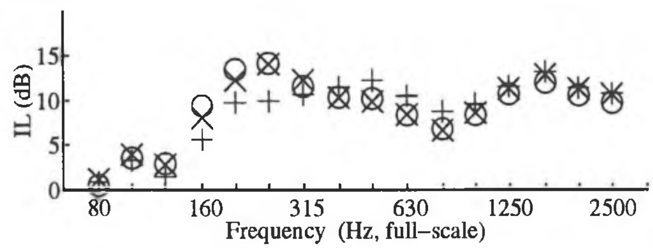

Figure 2: Measured third-octave Insertion Losses for flat-topped grass berms of 3m height and of 2m top width, and with slopes of 1.5:1, 2:1, and 3:1, topped by a 1m high crest wall that preserves a total barrier height of 4m: (o) 1.5:1,IL=10.1, ILA=8.9; (x) 2:1, IL=10.2, ILA=9.1; (+) 3:1, IL=9.9, ILA=10.2