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THE COMBINED EFFECTS OF POROUS ASPHALT SURFACING AND BARRIERS ON TRAFFIC NOISE

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1. INTRODUCTION

There is considerable interest in the use of porous asphalt (PA) surfacing since physical and subjective measures of noise under similar traffic conditions have indicated a significant advantage over conventional non-porous surfaces such as hot rolled asphalt (HRA) used widely for motorway surfacing in the UK [1]. However, it was not known whether the benefit of the PA surface was affected by the presence of roadside barriers.

Noise predictions have been made using the Boundary Element Method (BEM) approach [2] after suitable modification to take account of propagation effects over a porous layer such as PA. This model had been successfully employed in previous studies to determine the effectiveness of various barrier profiles in reducing noise levels in the shadow zone of the barrier [3].

The objective was to determine to what extent the noise reducing benefits of PA (advantage) could be added to the screening effects of noise barriers in order to obtain the overall reduction in noise levels.

The assumptions in the model were that a good quality PA was laid on both carriageways of a dual 3 lane motorway and the barriers were erected along the edges of the motorway. In all cases the road was assumed to be straight and flat and the surrounding area was grassland.

2. DESCRIPTION OF THE MODEL

The BEM model calculates the sound pressure wave field at a particular frequency by solving a reformulation of the Helmholtz wave equation in terms of an integral equation. For this purpose barrier and ground surfaces are divided into boundary elements of length no greater than L/5 (where L is the wavelength).

The effects of ground cover and absorptive surface treatment of the barrier can be included in the definition of the elements. For an accurate treatment of the effects of sound propagation over porous layers the Attenborough model [4] was incorporated. Layer depth, flow resistivity, porosity and the tortuosity of the connecting voids are needed. Values of these parameters for a good quality practical porous road surface were used in all modelling work [5]. To enable efficient computational methods to be used a numerical approximation to the equations used in the Attenborough model was developed [6].

3. METHOD

Calculations were carried out using the BEM for the source and receiver configurations employed in previous experimental investigations [3]. The road modelled was based on a typical motorway cross-section (dual 3 lanes with hard shoulders). Figure 1(a) shows the cross-section with a car source in the nearside (left hand) lane positioned 8m from the line of the nearside edge of the highway. Barriers were placed in various configurations at the edges of the motorway (Figures 1(a), (b) and (c)). Separate runs were carried out with the vehicle source in the nearside and farside lanes. For some of these configurations similar runs were carried out with a lorry source. Receivers were placed 1.5m above ground level (approximately ear height for a standing adult) and 4.5m (upper floor level in a typical dwelling) at 20, 40 and 80m from the road edge.

The cross-sections of a car and a lorry were selected to represent typical dimensions (see Figures 2(a) and (b)). Noise sources were placed on each side near the road surface. Absorptive materials on the underside and the non-vertical sides of the vehicle shapes were included to prevent large numbers of significant multiple reflections between road, barriers and vehicle sides which although theoretically possible do not appear to occur in practice.

The source strengths for each vehicle type assumed in the model were chosen to ensure an accurate match with measurements collected alongside new sections of HRA and PA on the M1 near Wakefield. The specification of the PA was comparable with that used in the model. The measurement point was 5m from the centre line of passing vehicles and 1.5m above the carriageway. The spectra of approximately 50 vehicles in each category (light and heavy) chosen at random were captured at the maximum A-weighted level and the pass-by speed recorded. Regression of levels in each third octave band against speed enabled an average spectra to be calculated at the mean speed for each vehicle type (110km/h and 95km/h for light and heavy vehicles respectively). Figures 3(a) and (b) show the source spectra used in the model for cars and lorries running on HRA and PA surfaces. Due to the reduction in air pumping on the PA surface (air is no longer compressed to the same extent between tyre and road) the levels in the source spectra between 1-3kHz for PA are considerably less than the corresponding levels in the HRA spectrum.

4. RESULTS

To gauge the effects that might be expected adjacent to a real road, the levels produced by vehicle sources in the nearside and farside lane were combined logarithmically to obtain the total noise level. This was calculated separately for HRA and PA surfaces and the difference in the A-weighted level calculated. The overall "advantage" of the PA surface when compared with the HRA surface was then found by averaging these differences over the six receiver positions behind the barrier located above the grassland surface. Table 1 lists these advantages for the car and lorry sources for each combination of barriers including the situation without barriers. Fewer runs were carried out with the lorry shape and taller barriers due to excessive computer CPU times. Nevertheless sufficient runs were carried out to establish the important trends.

5. CONCLUSIONS

When compared with the situation for unobstructed propagation, barriers located alongside the nearside edge of the road and tall parallel barriers reduce the advantage of PA over HRA. The decrease in average advantage for the car and lorry sources is greatest for the tallest barrier (4m high) on the nearside where the predicted reduction in advantage for traffic (consisting of cars and lorries) was in the range 1.6-3.2 dB(A). The reduction for a 2m high barrier was small and in the range 0 - 1.4dB. In the case of 4m parallel barriers the reduction in advantage was predicted to be in the range 1-1.9 dB.,

For the cases of barriers placed alongside the farside edge of the road and low reflective parallel barriers 2m in height a small improvement in advantage of less than 0.6dB(A) was predicted. In these cases the overall reduction in noise levels can be estimated from adding the separate effects of the barrier configurations and the PA surface.

The addition of absorptive materials to the barriers had only a small effect (less than 0.8 dB(A)) on the change in advantage for the cases examined.

6. REFERENCES

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Table 1: Advantage of PA over HRA in terms of L_{Aeq} dB for roadside barrier configurations

Configuration	Barrier height	Barrier type	Advantage of PA over HRA (dB(A))	
			Car source	Lorry source
No barriers	---	---	8.85	6.89
Nearside barrier	2m	Reflective	7.42	6.89
		Absorptive	7.81	6.83
	4m	Reflective	5.67	5.27
		Absorptive	---	---
Farside barrier	2m	Reflective	9.26	7.40
		Absorptive	8.95	7.00
	4m	Reflective	9.27	7.33
		Absorptive	---	---
Parallel barriers	2m	Reflective	9.06	7.07
		Absorptive	8.29	6.81
	4m	Reflective	6.91	---
		Absorptive	---	---

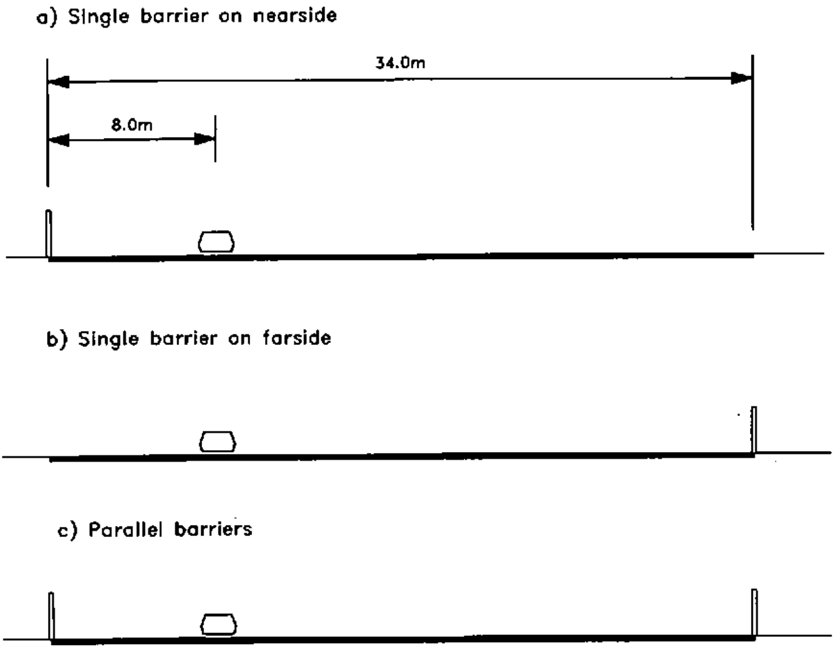

Figure 1: Barrier configurations

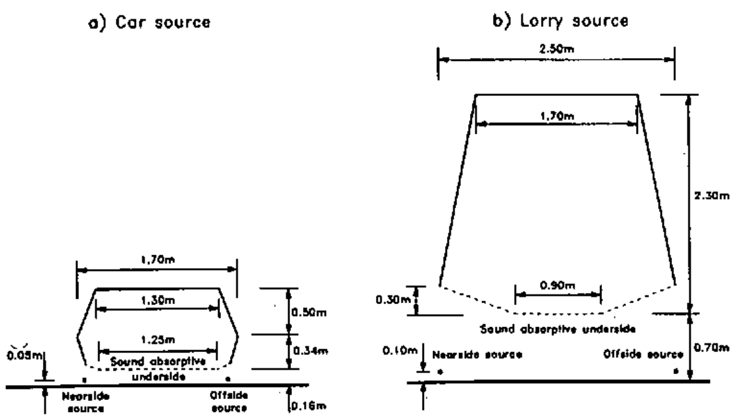

Figure 2: Cross-sections of sources

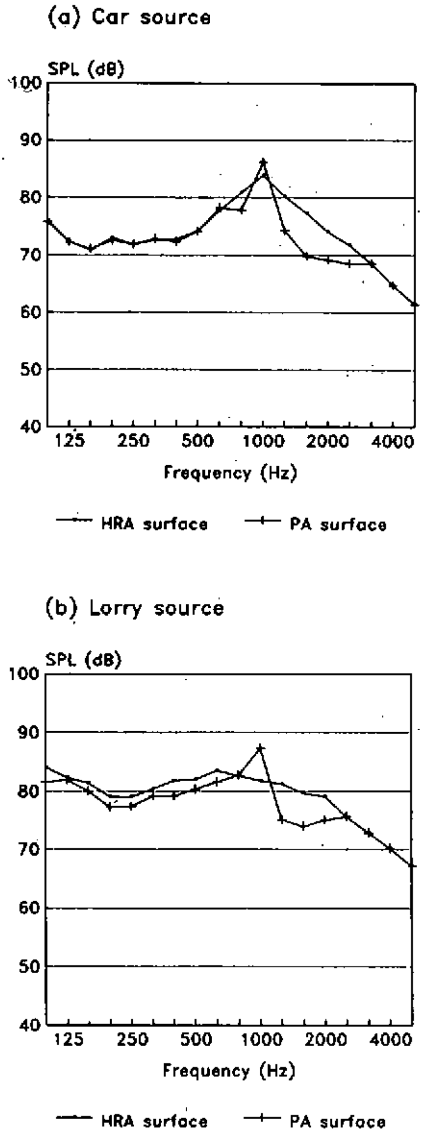

Figure 3: Source spectra for HRA and PA surfaces