inter.noise 2000
The 29th International Congress and Exhibition on Noise Control Engineering
27-30 August 2000, Nice, FRANCE

I-INCE Classification: 3.1

ACOUSTIC PERFORMANCE OF TRAFFIC NOISE BARRIERS WITH VERTICAL LOUVRES

G. Watts

TRL, Old Wokingham Road, RG45 6AU, Crowthorne, Berkshire, United Kingdom

Tel.: +44 13 4477 0414 / Fax: +44 13 4477 0918 / Email: grwatts@trl.co.uk

Keywords:
BARRIER, LOUVRE, TRANSMISSION, SCREENING

ABSTRACT
Louvred barriers allow the driver to see beyond the barrier and improve the natural lighting of the road. This can assist in reducing boredom and maintaining vigilance. However because of sound leakage through the gaps this may lead to unacceptable increase in noise levels for residents in the shelter of the barrier. Using a Boundary Element Method (BEM) the acoustic performance of various designs were examined with a view to identifying designs that reduce sound leakage while maintaining view. A wide range of performances was predicted depending on the amount of absorptive material applied and angles of the louvres.

1 - INTRODUCTION
A vertically louvred design has been used on a Belgian highway [1]. Drivers on the nearside carriageway have a view through the barrier at angles to the direction of travel of between 6 to 30 degrees. This may well improve on the optical performance of transparent screens since at these small angles the support posts reduce or block the view and transmitted light may be lower due to specular reflections. This and other designs were examined using a Boundary Element Method (BEM) [2] with the aim of identify acoustically efficient designs. A program used to carry out 2-D boundary element calculations for road cross-sections was modified so that the two dimensions available in the program included the barrier in plan instead of cross-section. This allowed the examination of vertical louvres in the barrier. The model was validated by performing scale model tests on selected designs. The point source in the numerical model was placed in exactly the same position as for scale model tests. The number and dimensions of all louvres were identical. The insertion losses at the third−octave band frequency from 100 Hz to 5 kHz were compared.

2 - SCALE MODEL TESTING
Scale model testing was carried out in an anechoic chamber with reflective floor at the University of Bradford. The scale of the models was 1:20 so that the scaled frequencies ranged from 2 kHz to 100 kHz corresponding to the range of interest (100 Hz to 5 kHz). The atmosphere in the chamber was dehumidified so that relative humidity was below 3%. An automatic microphone positioning system was employed which was capable of positioning with a tolerance of ± 1 mm. The BEM model assumes an omni-directional point source, which is in the same plane as the receivers. This was achieved in practice by the use of air-jet whistle flush with the floor.
The tests were made in four stages i.e. free-field, with a solid plane barrier, with reflective louvres and with louvres with absorptive edges. All barriers used in the experiment were as high as practicable i.e. 12 m high in full scale (note that further dimensions will be given in full scale to assist clarity). As a result sound transmission though the barrier gaps dominated insertion loss measurements facilitating comparison with the predictions from the BEM model which being 2-D in the horizontal plane assumes infinitely tall barriers. The panels were 10 cm thick and 4 m wide and the centres of the panels were spaced at 3.55 m intervals. Tests were made with the louvres set at 8.9 degrees to the barrier axis. The tests were then repeated with the angle set at 12 degrees where the gap size was over 40% larger enabling the BEM to be tested under significantly different acoustic conditions. All measurements were made on

the acoustically hard floor along lines parallel to the centreline of the barrier. The distances from these lines to the centre line of the barrier were 5, 10, 20 and 40 m. The microphone positions along the sampling lines were selected to cover a representative range of angles, θ, from the source to the barrier perpendicular as shown in Figure 1.

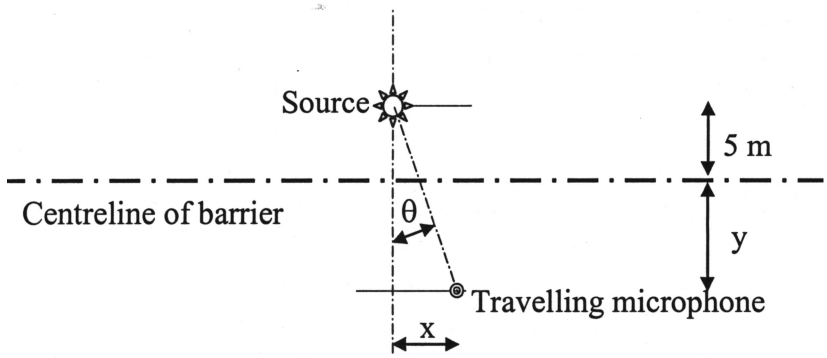

Figure 1: Experimental arrangement.

The x and y co-ordinates of the sampling positions relative to the point where the perpendicular from source to barrier meets the barrier are given in Table 1.

Distance from centre line y (m)	Horizontal angle, θ							
	0	10	20	30	40	50	60	70
5.0	0.0	1.76	3.64	5.77	8.39	11.92	17.32	27.48
10.0	0.0	2.65	5.46	8.66	12.59	17.88	25.98	-
20.0	0.0	4.41	9.10	14.43	20.98	29.79	-	-
40.0	0.0	7.94	16.38	25.98	-	-	-	-

Table 1: Displacements on the x-axis (in metres) both positive and negative for the range of horizontal angles, θ.

Figure 1 defines these co-ordinates. It can be seen that the range of angles reduces as the receiver moves away from the barrier. This is a result of the need to keep the receivers well within the shadow zone of the barrier so that barrier end effects are not likely to significantly affect results. The source was positioned 5 m from the centreline of the barrier. There were 23 louvres in each barrier tested each louvre being 4 m long. The source was placed exactly opposite the inner edge of the 12th louvre. With louvres set at 8.9 degrees the length of the barrier was 80.5 m and when set at 12 degrees the barriers was slightly less at 80.4 m. The plane barrier was 81.4 m long and was constructed from the same gauge aluminum sheeting as were the louvred barriers. Measurements were carried out with and without a 0.5 m wide absorptive strip applied in the louvre gaps. Figure 2 shows the arrangement of the strips on the receiver side of each louvre edge. Using excess attenuation measurements it was shown that the absorber could be represented in the BEM model with an effective flow resistivity of 4889 kPa s m^{-2}, a porosity of 0.9 and tortuosity set at 1.5. This represented a good sound absorptive material with an average sound absorption coefficient of 0.94.

Two sets of measurements were carried out and averaged to determine the third-octave sound pressure levels behind the barriers. Measurements were also completed without barriers so that the insertion loss could be calculated. Figure 3 illustrate the agreement for the 12 degree louvres with absorptive treatment for receivers at 5 and 10 m from the barrier. It was concluded that generally there was good agreement between the measured results obtained in the scale model facility and those predicted by the BEM approach. This gave confidence in the predictions that have been made for other designs of louvres.

3 - BEM PREDICTIONS

The BEM program was used to make predictions of the vehicle noise spectrum behind 60 m long louvred

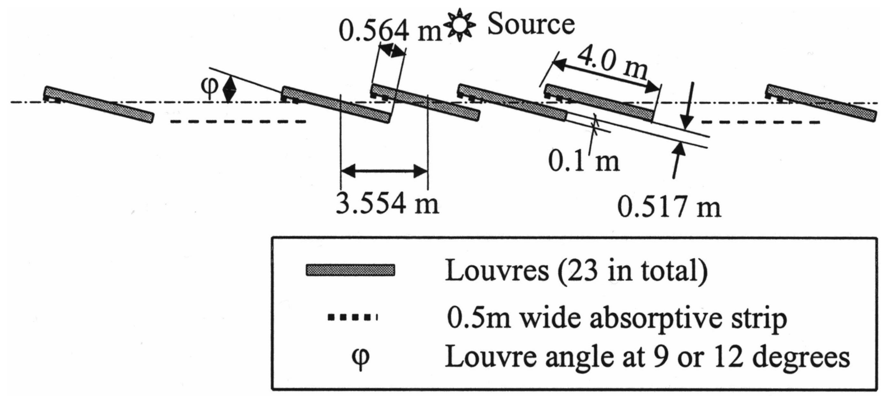

Figure 2: Arrangement of louvres.

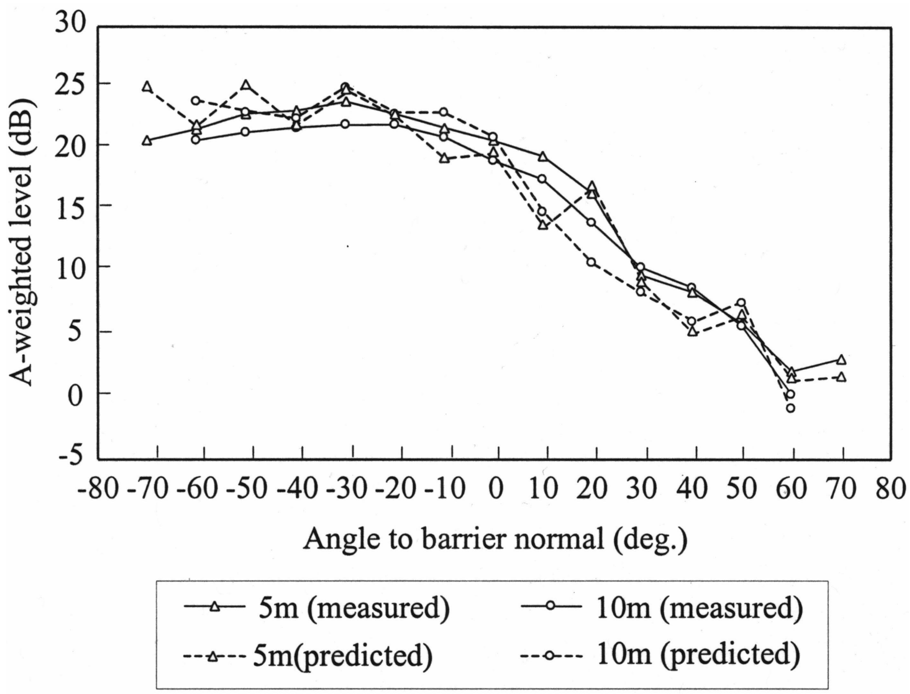

Figure 3: Predicted and measured levels for louvres set at 12 degrees and with absorptive strips.

barriers in order to investigate the effects on screening performance of louvre design. A barrier with louvres at 8.9 degrees and a 0.5 m wide absorptive strip on the receiver sides of each louvres was used as the reference barrier. The spacing of the louvres was kept constant at 3.55 m centres for most of the designs. The amount and disposition of the absorptive material was altered and the angles of the louvres (and hence the gap width and overlap of the louvres) was also changed. Figures 4 illustrate the designs that were tested.
These designs were generated by:

- Varying the angles of the of the louvres i.e. to angles of 6, 9, 12, 15 and 30 degrees with a single 0.5 m wide absorptive strip on the receiver sides of the louvres.

- Altering the spacing so gap size and degree of overlap was both greater and smaller than the reference barrier.

- Applying absorptive material in different degrees to both the receiver and source side of the barrier. The louvre angle was 8.9 degrees with gap width and overlap as for the reference design. In most cases the absorptive coefficient of the material averaged 0.94 but in a small number of cases the average absorption coefficient was lowered to 0.82 by adjusting the flow resistivity of the material. This material is described as mildly absorptive.

Predictions were made at receivers placed at angles from ±85 degrees from the normal to the barrier at the four receiver distances (i.e. 5, 10, 20 and 40 m from the barrier. In order to estimate the effects of louvred barriers on road traffic noise it was necessary to calculate the sound field behind the barrier options produced by moving point sources representing individual vehicles. The problem of a moving source and stationary receivers is a comparable to the inverse problem of a stationary source and moving receiver.

To check and, if necessary, to adjust for the contribution diffracted around the ends of the barrier the average level was calculated for a barrier without louvres. This contribution was then subtracted to obtain the corrected value. As expected this was found to be a small correction of less than 1 dB(A). Averages were calculated over the four receiver distances of 5, 10, 20 and 40 m from the barrier and are given in Figure 4. Posted values in this figure refer to the reductions in average levels for designs (a to s) compared with the reference barrier b).

4 - RESULTS AND CONCLUSIONS

As expected the greater the amount of absorptive material located in or near the gaps the smaller the increase in levels behind the barrier due to the louvres. Fully treating the louvres reduced average noise levels by nearly 6 dB(A) compared with the reference barrier. Relatively small areas of treatment can be used to advantage if both sides of the gaps and the tips of the louvres are treated. This has been shown to be as effective or more effective than treating the whole of one side of the barrier. However, if there is a requirement to reduce reflected noise where barriers are erected on both sides of the road then it may be necessary to treat the whole of the source side of the barrier with absorptive material. A fully reflective louvre produced a 1.3 dB(A) lowering of performance.

A narrow gap obviously reduces leakage but this has to be weighed against the decrease in visibility through the barrier. With a barrier similar to the reference barrier with the louvres set at 6 degrees the gap width is reduced by a factor of 0.6 but this only improves the performance by 0.8 dB(A). Conversely a wider gap reduced performance. For example when the louvres were set at 30 degrees the gap width was increased by a factor of 3.7 and the performance fell by 4.5 dB compared to the reference barrier.

In order to predict the effects on noise levels behind barriers of finite height it was necessary to take account of the component diffracted over the top of the barrier and combine with the transmitted component. A sound intensity approach based on previous work has been developed for this purpose [3]. The results of this approach show that the introduction of partly absorptive louvres (reference design) into a 3 m solid barrier would produce an average noise increase behind the barrier of over 8 dB(A). However, introducing fully absorptive louvres would increase levels by only 2.9 dB(A).

ACKNOWLEDGEMENTS

This study was commissioned by Mr Kinsey of the Traffic Safety and Environment Division of the Highways Agency. Professor Hothersall and Dr Horoshenkov of the University of Bradford assisted by carrying out scale model measurements and Dr Chandler-Wilde of Brunel University by making changes to the BEM program.

REFERENCES

1. **T C Ottmer and B Desborough**, Noise barriers, In *Acoustic barriers - the engineered solution to road rail noise pollution, Institute of Mechanical Engineers, London*, 1990

2. **G R Watts, S N Chandler-Wilde and P A Morgan**, The combined effects of porous asphalt surfacing and barriers on traffic noise, *Applied Acoustics*, Vol. 58, pp. 351-377, 1999

3. **G R Watts**, Sound transmission through timber noise barriers - effects on screening performance, In *6th International conference on sound and vibration, Copenhagen*, 1999

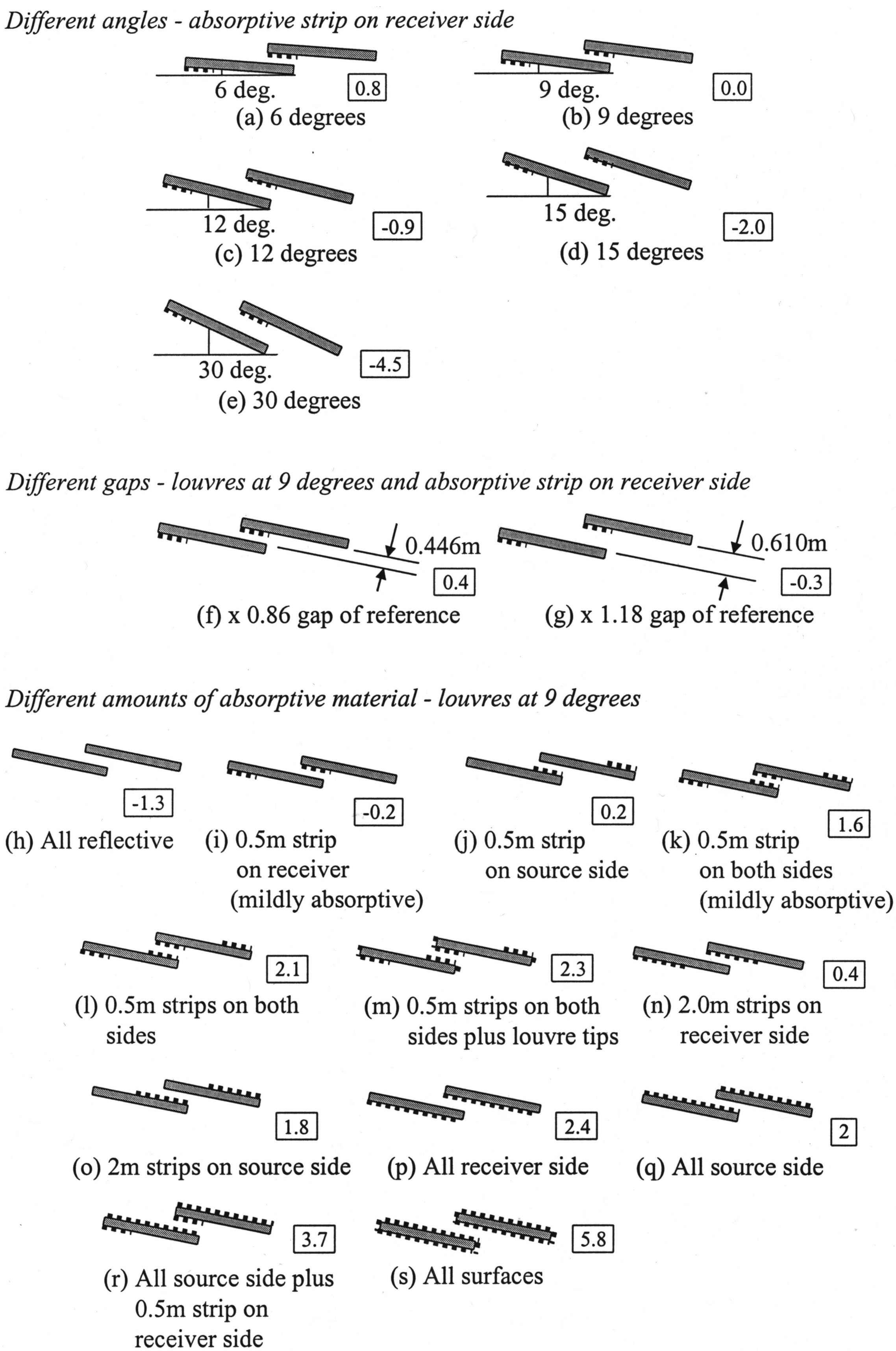

Figure 4: Louvre designs tested with average decrease in dB(A) level.