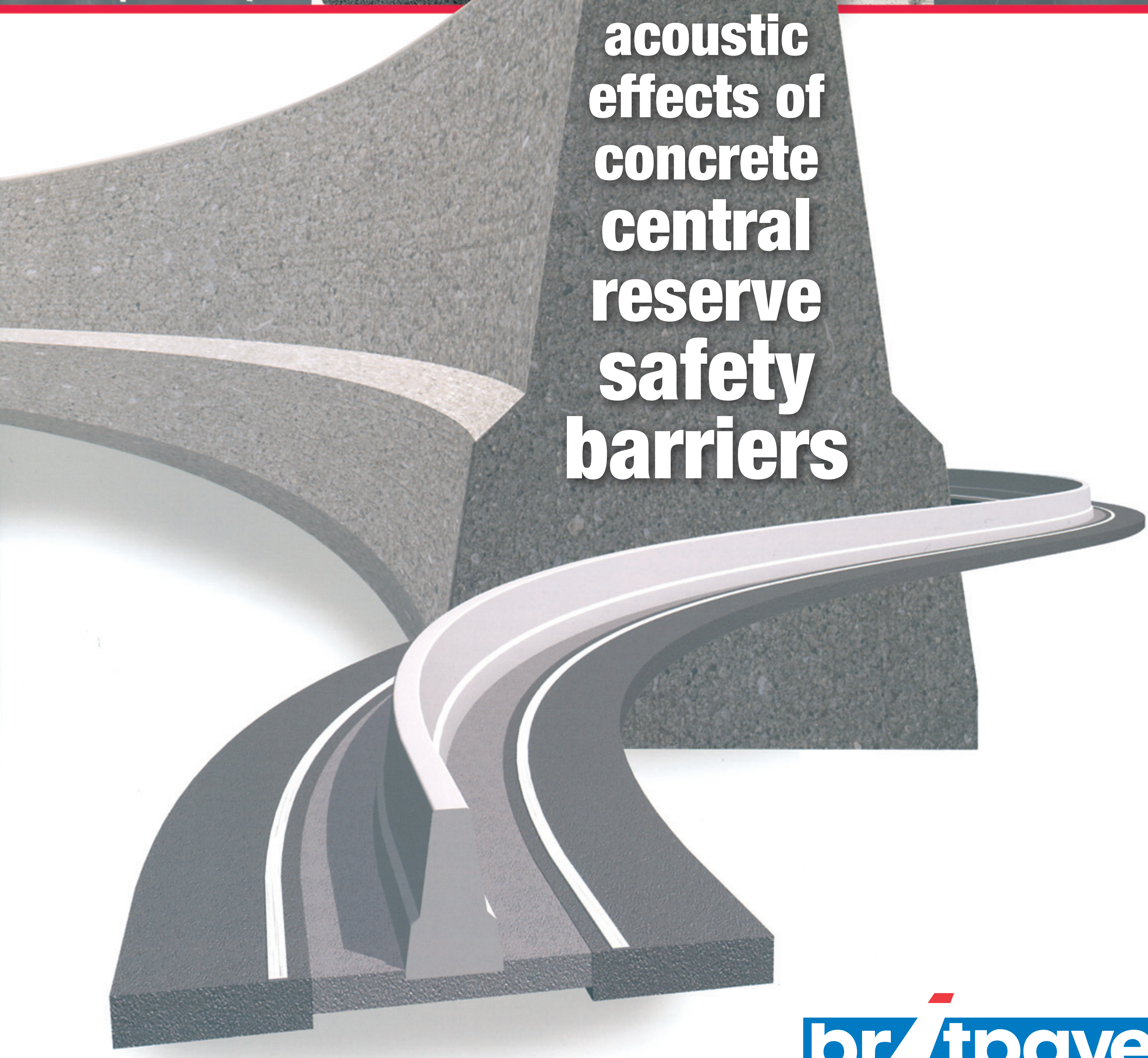
Barrier**Acoustic**Study:




The acoustic effects of concrete central reserve safety barriers



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The British In-situ Concrete Paving Association

EXECUTIVE SUMMARY

This study examines the effect of concrete safety barriers constructed in the central reserve of dual carriageways or motorways on the noise levels alongside the road. It has been suggested that there is the potential for these structures to reflect traffic noise back to the nearside. Arup was commissioned to compare noise alongside a motorway with and without a concrete safety barrier. This report describes the development of a study methodology and the results of the empirical and theoretical testing carried out. The results of the study demonstrate that differences in roadside noise levels alongside concrete and steel rail safety barriers are negligible at a range of receiver heights.

This report has been prepared for Britpave by

Ove Arup & Partners International Ltd
Parkin House, 8 St Thomas Street
Winchester, Hampshire SO23 9HE

Tel +44(0)1962 829900
Fax +44(0)1962 867270
www.arup.com

Published by

Britpave
Riverside House, 4 Meadows Business Park,
Station Approach, Blackwater, Camberley, Surrey GU17 9AB

Tel 01276 33160
Fax 01276 33170
www.britpave.org.uk

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1 INTRODUCTION

The purpose of this study is to investigate the effect of concrete safety barriers constructed in the central reserve of dual carriageways or motorways on the noise levels alongside the road. Concrete safety barriers are increasingly used on the highway network on roads with high traffic flows as studies have indicated that there are maintenance benefits relative to traditional steel rail barriers. The Highways Agency Interim Advice Note 60/05 [1] requires “Rigid Concrete Safety Barrier with a Containment Performance Class H2 and a Working Width Class W2” for all new installations in motorway central reserves. TD 19/06 (August 2006) also requires rigid safety barriers [2].

However, it has been noted that there is the potential for these structures to reflect traffic noise back to the nearside, an effect which would not occur to the same extent with the open, steel rail design. Conversely, a concrete barrier could provide screening from traffic noise on the opposite carriageway.

Arup was commissioned to compare noise alongside a motorway with and without a concrete safety barrier in the central reserve. The following report describes the development of a study methodology and the results of the empirical and theoretical testing carried out.

2 METHODOLOGY

2.1 Experimental design

2.1.1 Empirical study

It was decided that the acoustic effects of the barriers should be tested directly by investigating adjacent roadside sites with and without concrete central reserve barriers where the relative noise levels could be compared under equivalent conditions. This approach would rely on a suitable site being found with:

- An interface between a concrete and steel rail safety barrier;
- A steady traffic flow;
- An even gradient;
- Equivalent acoustic conditions either side of the barrier interface at the measurement position (e.g. no significant reflecting surfaces);
- Consistent road surface conditions either side of the interface.

Measurements of traffic noise would then be taken simultaneously either side of the concrete/steel interface. The separation of the measurement positions would be set sufficiently far apart such that either position would not be affected by the adjacent barrier type. Specifically, the position alongside the steel barrier would not be affected by reflected sound from the concrete barrier, and the position alongside the concrete barrier would receive reflected sound as if the barrier were of infinite length. Using the methodology described in the *Calculation of road traffic noise* (CRTN) [3] it was determined that if the adjacent road segment were at a distance such that the angle of view from the measurement position were approximately 20°, the noise contribution would be some 10 dB lower than the road segment immediately alongside the measurement position.

Assuming that the measurement positions would be close to the road edge, the positions would have to be approximately 40 m from the steel/concrete interface to avoid the influence of noise from the adjacent road segment (see Figure 1, positions A and B).

If possible, measurements would also be taken at different heights (A' and B' shown in Figure 1) as this might show effects related to the screening angle of the concrete barriers (i.e. lower receiver heights would be screened from the opposite carriageway more effectively than higher receivers).

Measurements would be taken over a suitable measurement period and the traffic noise levels from adjacent segments compared. Assuming all other conditions to be equivalent, any difference in the measured noise levels at the two positions could be attributed to the different central reserve barrier types. The measurements would be carried out a number of times to ensure that the results would be repeatable.

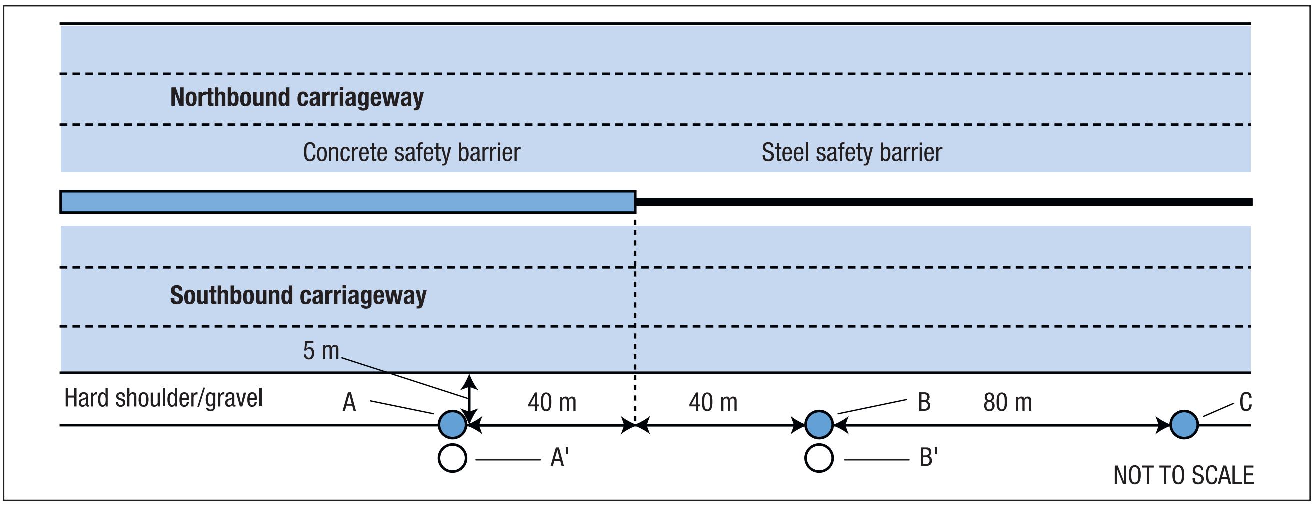
In order to verify that differences measured would be attributable to the different barrier types a control measurement would be taken at two locations alongside one of the barrier types (i.e. positions B and C shown in Figure 1). If the noise level difference were found to be repeatably smaller than that recorded at positions A and B, this would confirm that the difference would be due to the barrier types and not just random variations due to the measurement method.

2.1.2 Theoretical study

Although the measurement site results would be expected to directly demonstrate the noise effects of concrete safety barriers, the results could be further validated by modelling the situation. This would also allow consideration of different barrier and receiver heights, which could not be easily tested empirically. The effect of reflections from opposite façades, which includes other significant structures, is considered in CRTN. This is limited to reflecting surfaces at least 1.5 m above the road surface (paragraph 26.2, CRTN). The maximum correction would be 1.5 dB, corrected according to the angle of view from the receiver to the reflecting surface. In the case of concrete safety barriers lower than 1.5 m, no correction would be applied as the reflecting area is assumed to be insufficient to cause any significant reflection.

In order to predict reflection effects from concrete safety barriers, it was decided to use a general noise model capable of simulating the traffic noise line sources and the reflected component from a reflecting surface of any size.

Figure 1: Roadside measurement positions alongside concrete and steel safety barriers



2.2 Site selection

Concrete barriers have been used extensively on the M25 and a number of potential locations were proposed. Visits were initially made to areas around Junction 8 near Reigate and Junction 17 near Maple Cross. A suitable site was found slightly further north near Junction 18 north of Chorleywood on the southbound carriageway. The interface between the concrete and steel safety barrier was close to chainage 114.6 and in all respects the site met the required criteria set out in Section 2.1.1. Figure 2 shows the barrier interface between steel and concrete barrier in the central reserve at this location. Here the safety barrier height was estimated to be 0.6 m.

Figure 2: Measurement site on M25 north of Junction 18 showing concrete/steel safety barriers (view across southbound carriageway)

2.3 Measurement procedure

The survey was conducted according to the procedure developed in the experimental design (Section 2.1.1). Figure 1 shows the layout of the noise monitoring positions relative to the motorway and the concrete and steel safety barriers (not to scale). The measurements were taken over 10 minute periods, which were considered to be long enough to obtain a stable measurement representative of typical noise conditions for heavy free-flowing traffic according to the guidance given in paragraph 41.2 of CRTN. Measurements were taken at two positions simultaneously to compare traffic noise levels from the same vehicles passing the microphones. The first set of measurements was taken at locations A and B shown in Figure 1 (approximately 5 m from the edge of lane 1) to compare noise adjacent to the concrete and steel barriers. Measurements were then taken at locations B and C as a control test to determine the variation in noise levels at two positions alongside identical barriers. Finally, to examine the influence of receiver height on the results, the last set of measurements was taken at locations A' and B', which were 1 m higher up the embankment than locations A and B. This second receiver height was 2.2 m above the road surface. Each of the above pairs of measurements was carried out three times.

The weather was warm and fine with a light wind, which was negligible relative to the wind at the roadside from the passing traffic flow. The road surface was dry. Traffic was freely flowing throughout all measurements.

The following measurement instrumentation was used:

- Brüel & Kjær 2260 (Kit C) Type 1 precision integrating (SLM);
- Brüel & Kjær 2260 (Kit H) Type 1 precision integrating (SLM);
- Brüel & Kjær Type 1 4231 SPL Calibrator.

Immediately before and after each series of measurements was carried out, the sound level meter (SLM) calibration was checked using a sound pressure level calibrator. No significant variation was recorded during the survey period.

The sound level meters were mounted on tripods at approximately 1.2 m above local ground level. Windshields were fitted over the microphones at all times during the survey period to reduce any effect of wind-induced noise. The following parameters were recorded: L_{Aeq}, L_{Amax}, L_{Amin}, and percentiles L_{A10} and L_{A90}. The associated linear spectra were also recorded. It was anticipated that only the L_{A10} noise results would be used although the opportunity was taken to gather other metrics in case further analysis was required.

All noise measuring instrumentation owned and used by Arup Acoustics is checked for correct calibration to traceable national and international standards on an annual basis. Routine in-house spot checks are also carried out at regular intervals as part of Arup Acoustics Quality Assurance policy, to provide additional confidence in measured noise data.

2.4 Noise model

A simple noise model of a motorway with concrete and steel safety barriers was constructed using the SoundPlan modelling software. As mentioned, the CRTN method would not register the presence of a reflecting surface as low as the safety barrier. Instead a model was constructed using SoundPlan based on the ISO 9613 [4] environmental noise prediction methodology to represent propagation from line sources to a receiver position taking account of the various reflecting surfaces within the road corridor.

The model assumed separate line sources to represent the three traffic lanes on each side of the central reserve at the same source height as assumed by CRTN (0.5 m). The source noise levels were calibrated to give authentic levels at the roadside although the absolute levels were not critical to this study, only the difference between the level alongside concrete and steel safety barriers. A reflecting surface was assumed to represent the road surface and a vertical reflective structure to represent the safety barrier in the central reserve. Like the survey measurements, a receptor position was established 5 m from the nearside lane. Receptor heights of 1 m, 2 m and 4 m were assumed; the higher heights representing positions that would receive progressively less screening from the opposite carriageway. Two model scenarios were constructed to examine the effects of varying the concrete barrier height, i.e. 0.6 m and 1 m. The steel safety barrier was assumed to have a guard rail height of 0.15 m, the top edge being 0.5 m above the road surface.

3 RESULTS

3.1 Measurement survey

Tables 1 to 3 show the L_{A10} noise levels measured at various positions at the roadside. Table 1 compares noise levels simultaneously measured at positions A and B either side of the interface between the concrete and steel barriers. The results show that the measurements were highly repeatable with a very small variation in successive results. Most significantly, the difference between noise levels at the two positions was negligible, i.e. within 0.5 dB.

The results of the measurements have been presented to a resolution of 0.1 dB to illustrate the measured differences precisely. However, it should be noted that these very small differences are not significant in assessment terms. The measurement procedure described in CRTN requires a resolution of only 0.5 dB. For prediction of traffic noise levels to assess qualification for noise insulation according to the *Noise insulation regulations* [5], noise levels would normally be calculated to the nearest 0.1 dB but then rounded to the nearest whole decibel.

Table 1: Noise levels measured during simultaneous measurements at positions A and B

Measurement	Noise level ($L_{A10,\,10\,min}$) dB		Difference
	Location A	Location B	(A – B)
1	89.6	90.0	– 0.4
2	89.8	89.6	0.2
3	89.6	89.8	– 0.2
Variation:	0.2	0.4	

The measurements at the control positions B and C are shown in Table 2. The purpose of these measurements, taken at the same 80 m separation but both alongside the steel barrier, was to test if the differences would be significantly smaller than those measured at positions A and B. Repeatably smaller differences at the control positions would indicate that greater differences at positions A and B could be attributed to the different safety barriers. However, the results show that this was not the case as the differences were of the same order. Therefore the concrete safety barrier was not affecting roadside noise levels at this receiver position.

Table 2: Noise levels measured during simultaneous measurements at positions B and C

Measurement	Noise level ($L_{A10,\,10\,min}$) dB		Difference
	Location B	Location C	(B – C)
4	90.0	90.2	– 0.2
5	89.6	90.0	– 0.4
6	89.6	89.8	– 0.2
Variation:	0.4	0.4	

The final set of results in Table 3 show the noise levels recorded at positions A' and B' which were located 1 m higher up the embankment. The table shows that, like those taken at the other locations, the differences were negligible showing that there was no significant difference in traffic noise levels at the greater receiver heights.

Table 3: Noise levels measured during simultaneous measurements at positions A' and B'

Measurement	Noise level ($L_{A10,\,10\,min}$) dB		Difference
	Location A'	Location B'	(A' – B')
7	88.6	88.4	0.2
8	88.4	88.4	0.0
9	88.2	88.0	0.2
Variation:	0.4	0.4	

3.2 Modelling

The results of the modelling exercise are shown in Table 4. The model was constructed with receiver positions equivalent to those used in the measurement survey (i.e. 5 m from lane 1) and calculations were carried out with 0.6 m and 1.0 m concrete barrier heights. Calculations were also conducted at a receiver position 10 m from lane 1. The comparison shown in Table 4 is made under identical conditions but assuming a steel central reserve safety barrier rather than the concrete structure. Noise level differences are presented for three different receiver heights.

The results show that for the 4 m receiver heights with the 1.0 m barrier the differences are slightly greater than the differences predicted for the lower receiver heights. However, the small differences are negligible and therefore comparable with those measured for the empirical study.

Table 4: Modelled differences in noise levels alongside concrete / steel safety barriers

Receiver height above road surface (m)	Difference in noise level (A – B) dB			
	(A = concrete barrier, B = steel barrier)			
	5 m from road edge		10 m from road edge	
	0.6 m barrier	1.0 m barrier	0.6 m barrier	1.0 m barrier
1	0.0	0.0	0.0	0.0
2	– 0.1	– 0.1	– 0.1	– 0.1
4	– 0.1	– 0.5	– 0.1	– 0.6

4 SUMMARY AND CONCLUSIONS

Empirical and theoretical studies have been conducted to determine if concrete central reserve safety barriers have any influence on roadside noise levels relative to conventional steel barriers. The mechanisms that could potentially give rise to differences were identified as reflection of noise from the nearside carriageway, or the screening of noise from the opposite carriageway.

However, the results of this study demonstrate that roadside differences in noise levels alongside concrete and steel safety barriers are negligible at a range of receiver heights.

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Britpave
Riverside House
4 Meadows Business Park
Station Approach
Blackwater
Camberley
Surrey GU17 9AB
Tel: 01276 33160
info@britpave.org.uk