ASSESSMENT OF NOISE FROM TRAFFIC ON A DUAL CARRIAGEWAY

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1. SUMMARY

It has long been recognised that noise from road traffic can cause serious and unacceptable environmental disturbance, henceforth there has been almost simultaneous growth in the awareness to road traffic noise as a nuisance. The Wilson Committee reported these facts in 1963. However little had been done about noise as a problem until the Land Compensation Act in 1973, mainly because there was no recognised method of assessing the impact of road traffic noise and also because there was no statutory means of providing mitigation measures or compensation.

The LCA was therefore a milestone in providing a legal framework and stipulating a method of assessment. The first quantitative method of traffic noise prediction was outlined in "New housing and road traffic noise". This was soon followed by a very much improved and extensive procedure "Calculation of Road Traffic Noise" (CRTN) which was published in 1975. The legal framework was contained in the Noise Insulation Regulations (NIR) published in 1975, which included the CRTN as the statutory method of predicting traffic noise.

Use of the CRTN procedure over a number of years has highlighted a few shortcomings within it. Subsequently, this procedure was revised in 1988 and this revision took into account various additional factors, such as, the effect of low volume of traffic and the road surface texture. However, there remains a case of when to apply separate source lines for dual carriageways.

This paper evaluates a situation that can affect a large number of nearby residents in an already sensitive area. It recommends that under certain conditions traffic noise should be calculated using two separate source lines, one for each carriageway, and the noise from each should then be combined to obtain the overall noise level. At present, this method is conditional upon firstly, the central reservation being greater than 5m in width or secondly, where the outer edges of the carriageways are vertically separated by more than 1m. Results of this evaluation shows that noise levels in certain areas are up to 3dB higher when calculated using two source lines.

2. INTRODUCTION

Growth in road traffic has long been identified as a source of demand for ring roads and bypasses. It was in 1905 that a Royal Commission on London's Traffic first suggested a ring road solution. Farsightedly, at a time when motor vehicles were a small (though increasing) proportion of all traffic, it proposed a ring at about 12 miles from the centre of London. The growth in road traffic really mushroomed in 1960's and 1970's and resulted in considerable demand for new roads to relieve the congestion in all urban centres. Public awareness to road traffic noise became widespread as new roads paved into the rural countryside. New ways to assess and quantify traffic noise were therefore required to plan roads and new housing. The first statutory quantitative method traffic noise prediction was outlined in "New housing and road traffic noise" in 1972 [Ref 1].

The main purpose of assessing traffic noise from new and improved road schemes in the UK is to establish whether a dwelling qualifies for an offer of sound insulation. The conditions for eligibility are contained in the NI Regulations [Ref 2]. These regulations also specify that CRTN is to be used for noise prediction. The revised CRTN [Ref 3] was published in 1988 and included additional corrections to those in 1975 version. However, there still remain one or two situations which it is considered are not adequately covered in the new CRTN.

This paper presents a case that traffic noise prediction according to the new CRTN is slightly under-estimated for certain circumstances when assessing dual carriageways. A more appropriate approach is put forward by way of an example. Since the method of split sources for dual carriageways is already included in the CRTN, this paper proposes that another condition is added to its terms of application.

3. THE PROCEDURE

The above mentioned growth in road traffic has resulted in proposals for widening of many of our trunk roads and motorways. The example in this paper is based on a situation experienced during a recent reassessment of a current road widening scheme. Hence the base data is taken from this real situation.

Prior to the improvement, the road was a dual two lane carriageway of 7.3m width and 4.5m central reserve, almost without a hard shoulder but a 3.5m soft verge. There was no noise barrier installed in this case.

The proposal was to improve the road to dual three lane 11m wide carriageway, 4m central reserve and a 3.3m hard shoulder with 1.5m soft verge. A 3m high noise barrier was designed to mitigate the noise impact at nearby dwellings. A case of further widening to dual four lane carriageways, thus an example of much wider spread of traffic, is also investigated, both with a 3m and a 4m high noise barrier. The noise level calculated using a single source line is compared with separate source line for each carriageway.

Initial calculations indicated that at properties where the far carriageway was visible over the top of the noise barrier, noise levels calculated using a single source line could be significantly lower than those predicted using two source lines. Further calculations were made covering a wider area as regards ground slopes and distances as detailed below.

4. THE METHOD

The noise calculation method outlined in the CRTN must be used to determine eligibility of a residential property to an offer of sound insulation. CRTN states that where the central reserve is less than 5m wide, then "the flow of traffic in both directions shall be aggregated to obtain the total flow". All the traffic should then be considered as a single noise source line located 3.5m in from the edge of the nearest carriageway and 0.5m above the road surface. Alternatively, for central reserve wider than 5m "noise level produced by each carriageway shall be evaluated separately and combined". The source line for the nearside carriageway is located as stated above and that for the far carriageway should be located 3.5m in from its far edge, that is, about 24m from the nearside edge of the carriageway (for dual 3 lane and 5.5m wide central reserve).

Distance from the nearside road edge to the dwelling was 50m to 300m in 50m intervals and the intervening ground slopes as -20%, -10%, -5%, 0%, 5%, 10%, and 20%. Positive gradients represent rising ground away from the road. A cross section of the widened road with the ground slopes illustrated is given in Figure 1.

5. THE RESULTS

Summary of the noise calculations are tabulated in Figure 2, as follows;

Case 2a	Dual 2 lane road with all traffic considered on the nearside carriageway,
Case 2b	Dual 2 lane road with traffic separated onto each carriageway,
Case 2c	Dual 3 lane road with a 3m noise barrier and all traffic considered on the nearside carriageway, strictly in accordance with CRTN,
Case 2d	Dual 3 lane road with a 3m noise barrier and traffic separated onto each c/w,
Case 2e	Dual 4 lane road with a 3m noise barrier and traffic separated onto each c/w,
Case 2f	Dual 4 lane road with a 4m noise barrier and traffic separated onto each c/w.

The results are for a receiver height of 5m, representing the first floor level of a typical dwelling.

6. DISCUSSION

Results shown in Figure 2 illustrate a number of interesting points as regards the way in which sound propagates, details of the prediction method and the effect of a noise barrier.

1. For a particular ground slope, as expected the noise level decreases as the distance between the road edge and the dwelling (the receiver) increases.

2. For case 2a, road without a noise barrier, note that at a particular distance as the ground slope progresses from -20% to +20% there is an increase in the noise level. This can be explained by the lack of ground absorption effect as the sound propagation height becomes greater for rising ground slopes compared to the downward slopes. Also the edge of the road tends to act as a barrier at downward slopes.

3. For the prevailing situation, that is without the noise barrier, the predicted noise level at a particular distance is slightly lower when the road is modelled as two separate source lines. In this case the traffic flow has been divided into two, one half on each carriageway. This result is expected because by moving half of the traffic further away from the receiver the noise level decreases as per the inverse square law. This decrease is most pronounced especially at closer receiver distances.

4. In the relevant year, 15 years after opening, the traffic flow increases by over 75% because of road improvement and natural growth. Consequently, a 3m noise barrier was designed to mitigate the noise impact. Therefore, comparing case 2c with 2a, the noise levels follow

a similar pattern but are generally lower because the noise barrier is indeed effective. The benefit is more pronounced for negative ground slopes and closer receiver locations, because the path difference (direct distance the sound would travel through the barrier compared with that around it) is greatest. Notice the increase in levels at steeper positive slopes and increasing receiver distance. This is due to the barrier being less effective and higher traffic flows.

The following points refer to flow of traffic on a road having a noise barrier and is a comparison between a single source line, in accordance with the CRTN, and two separate source lines.

5. It was mentioned above that when considering a road without a noise barrier, noise levels predicted using two source lines were lower than those from single source. With a noise barrier, however, results given by cases 2c and 2d show that noise levels can be significantly higher especially for steeper positive slopes and greater distances. These areas are where the path difference with a 3m barrier are least improved.

6. The prevailing and relevant situations in accordance with the CRTN and the NI Regulations are cases 2a and 2c, respectively. In terms of eligibility for sound insulation, only those properties that lie on a steep uphill ground and located considerable distance from the road qualify, as long as these were within 300m of the new road and the noise level was above the qualifying level. In this example, only three locations are eligible, ie, more than 200m away at 20% slope.

7. If the noise is predicted using two source lines, case 2d, these levels can be significantly higher than the single source case in 2c. In this example, all locations on 0% to 20% slope and 50m to 300m would qualify for offers of sound insulation. This area is a tremendous increase on that found if calculations are done in accordance with the CRTN. This area is greater still if like is compared with like, that is, comparing case 2b with 2d both predicted using two source lines.

8. Further widening to dual 4 lanes with a noise barrier, however, does not increase noise levels much higher, as shown by comparing case 2d with 2e, both calculated using two source lines. The differences are marginal. By considering a single source line, however, it was found that noise levels do not change whether the road is a 3 lane or 4 lane dual, because the position of the source line remains unaltered (result not shown).

9. As shown by the above conclusions, there is a significant increase in the noise levels if predicted by considering two source lines (this method was used in response to a situation where the far carriageway is visible over the top of the barrier), compared with results for a single source line, in accordance with CRTN. This increase in the noise impact, however, can be mitigated by increasing the height of the noise barrier. Case 2f shows the results for a dual 4 lane carriageway modelled as two source lines with a 4m high barrier. The noise levels are lower for negative slopes but otherwise still slightly higher than those for case 2c, that is, as per CRTN. There are still a few locations even with a 4m barrier where dwellings would qualify for sound insulation. Consequently, because the predicted noise levels are under estimated by the CRTN method, it requires a taller noise barrier to mitigate the actual noise levels.

10. The above comments have not been substantiated by noise measurements. Nevertheless, the

results are based on the noise calculation procedure given in CRTN.

7. CONCLUSIONS

1. For a dual carriageway without a noise barrier, noise predicted using two source lines, as expected, gave slightly lower levels compared with those obtained using a single source line.

2. A noise barrier is extremely effective in mitigating the impact of traffic noise, particularly so for properties closer to the road and those lying on downward slopes.

3. For properties lying on rising ground from the road the noise barrier is not as effective.

4. For a dual carriageway with a noise barrier, noise levels predicted in accordance to CRTN would be the same whether the road comprises 2 lanes, 4 lanes or 6 lanes. Therefore in view of the increase in the spread of traffic the CRTN procedure does not seem correct.

5. For a dual carriageway having a central reserve of less than 5m wide and with a noise barrier, noise levels calculated using the CRTN method (single source line) are significantly lower than those obtained by using two source lines. This under-estimate is particularly low for properties lying on steep uphill ground from where the far carriageway is visible over the top of the barrier. Differences of more than 3dB can result in certain circumstances. This sort of situation should be considered extremely carefully when establishing eligibility for sound insulation under the NI Regulations. The method of two source lines would be more realistic in these situations.

8. RECOMMENDATIONS

A comprehensive method for predicting road traffic noise is given in the CRTN memorandum. The effect of such factors as the traffic flow, speed, percentage of heavy vehicles, road gradient, etc are taken into account. Additional corrections are included, for example, low traffic flow, angle of view, barrier correction and sound reflections within a retained cut. Some of these corrections are only applied under certain circumstances. Likewise, it is considered that for the situation where the intervening ground slope allows a view, from a dwelling, of the far carriageway over a noise barrier the prediction of traffic noise should ideally be assessed by using two separate source lines, regardless of the width of the central reserve. Terms of its application, such as certain ground slope and/or receiver distance could easily be set.

Perhaps now that the European Cummunity is becoming more integrated, the CRTN method could be improved in areas where the procedures employed in other member countries are justifiably better, not necessarily more complex as was described by Favre [Ref 4].

9. REFFERENCES

1. "New housing and road traffic noise; a design guide for architects", Design Bulletin 26, Department of the Environment, HMSO, 1972.
2. "Noise Insulation (Amendment) Regulations", HMSO, 1988.

3. "Calculation of Road Traffic Noise", Department of Transport, Welsh Office, HMSO, 1988.
4. "Urban Road Traffic Noise: Characteristics and Computation Methods", Favre B M, p211-218, Proc IOA Spring Conference 1984, Institute of Acoustics.

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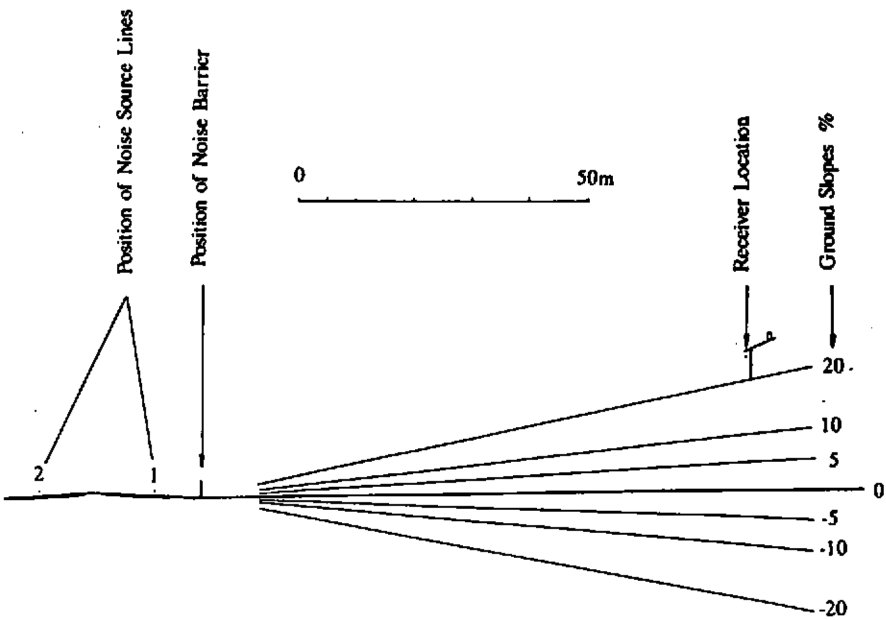

Figure 1. Cross-section of new dual c/w and ground slopes

	Receiver Distance (m)	Intervening ground slopes -20%	-10%	-5%	0%	+5%	+10%	+20%
Fig 2a	50	75.3	76.9	77.1	77.2	77.3	77.4	77.6
	100	71.1	72.5	72.6	72.8	72.9	73.0	73.2
Dual 2 lane c/w	150	68.6	69.8	70.0	70.1	70.3	70.4	70.6
single source line	200	67.0	67.9	68.0	68.2	68.3	68.4	68.6
	250	65.8	66.3	66.5	66.6	66.8	66.9	67.1
	300	64.8	65.0	65.2	65.4	65.5	65.6	65.8
Fig 2b	50	-1.5	-0.7	-0.5	-0.4	-0.4	-0.3	-0.3
	100	-1.7	-0.6	0.0	+0.1	+0.1	+0.2	+0.2
Dual 2 lane c/w	150	-1.6	-0.5	-0.6	-0.4	-0.4	-0.3	-0.1
two source lines	200	-1.6	-0.5	-0.4	-0.3	-0.2	-0.1	0.0
	250	-1.6	-0.4	-0.4	-0.3	-0.2	-0.1	0.0
	300	-1.6	-0.3	-0.4	-0.3	-0.1	0.0	+0.1
Fig 2c	50	68.8	70.4	71.3	72.2	73.2	74.3	77.5
	100	65.2	66.8	67.7	68.6	69.6	70.7	73.3
Dual 3 lane c/w with	150	63.3	64.8	65.7	66.6	67.6	68.7	71.2
3m noise barrier	200	61.8	63.4	64.3	65.2	66.2	67.3	69.8
single source line	250	60.8	62.3	63.2	64.1	65.1	66.2	68.7
	300	59.9	61.4	62.3	63.2	64.2	65.3	67.8
Fig 2d	50	-0.4	+0.1	+0.5	+1.3	+2.0	+2.9	+1.0
	100	-0.4	+0.1	+0.5	+1.3	+2.7	+3.3	+1.7
Dual 3 lane c/w with	150	-0.5	+0.1	+0.5	+1.3	+2.6	+3.3	+1.8
3m noise barrier	200	-0.4	+0.1	+0.5	+1.3	+2.4	+3.2	+1.6
two source lines	250	-0.4	0.0	+0.5	+1.2	+2.3	+3.2	+1.5
	300	-0.4	0.0	+0.4	+1.1	+2.1	+3.0	+1.3
Fig 2e	50	-0.6	0.0	+0.5	+1.7	+2.4	+2.6	+1.7
	100	-0.6	0.0	+0.5	+1.5	+2.6	+3.2	+1.6
Dual 4 lane c/w with	150	-0.7	0.0	+0.5	+1.5	+2.8	+3.2	+1.7
3m noise barrier	200	-0.6	0.0	+0.7	+1.6	+3.0	+3.1	+1.6
two source lines	250	-0.7	+0.1	+0.7	+1.6	+2.5	+2.0	+0.7
	300	-0.7	+0.1	+0.6	+1.6	+2.3	+1.8	+0.6
Fig 2f	50	-2.2	-1.8	-1.5	-0.8	+0.3	+0.8	-0.5
	100	-2.0	-1.5	-1.1	-0.4	+0.6	+1.6	+0.8
Dual 4 lane c/w with	150	-2.1	-1.4	-1.0	-0.3	+0.7	+1.9	+0.9
4m noise barrier	200	-1.9	-1.4	-0.9	-0.2	+0.8	+2.1	+0.8
two source lines	250	-2.0	-1.3	-0.8	-0.1	+0.9	+1.4	-0.2
	300	-2.0	-1.3	-0.9	-0.1	+0.9	+1.2	-0.3

Note: Levels are in L10 (18 hr), differences are with respect to cases adhering to CRTN.

Figure 2. Calculation of traffic noise levels by single and two source lines