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ASSESSING NOISE OF WIDE MOTORWAYS

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1 INTRODUCTION TO MOTORWAY WIDENING

The growth in traffic in recent years has lead to a situation where many of Great Britain's major motorways are badly congested. The growth in traffic is projected to continue and many more sections of motorway will reach full capacity in the next few years. One solution to this problem would be to build additional motorways, however the time from route proposal to opening of a new motorway can often exceed fifteen years and this is too long a timescale to provide early relief of congestion on the motorway system. The alternative approach of increasing the capacity of the existing road network has been adopted as this can bring more timely relief. At present the Department of Transport is proceeding with widening studies on some 650 miles of motorway.

The majority of the congested motorways in Great Britain are dual carriageways with 3 lanes in each direction (D3). The current widening studies assess the forecast traffic demand and this often indicates the long term need for four, five or even six lanes in each direction. There are several techniques which can be employed to effect the widening and each has its own particular noise impact on surrounding population.

In its simplest form, widening can be achieved by using the existing hard shoulders as running lanes and constructing new hard shoulders: this is known as symmetric widening. Another solution which also involves relatively little land take is asymmetric widening: here two new lanes are constructed adjacent to one of the existing hard shoulders and the central reserve is repositioned. Both symmetric and asymmetric widening can result in major traffic delays during construction and therefore a technique known as parallel widening has often emerged as the economically desirable solution. Here a completely new, wide carriageway is first constructed alongside the existing motorway. Traffic is then diverted onto this new carriageway and the carriageway next to it is widened. Apart from the economic advantages of parallel widening, it also offers potential acoustic benefits, since the land occupied by the redundant carriageway can be used for mounding to mitigate noise. The scope for this, however, may in some instances be limited by the retention of at least two of the redundant lanes for emergency and maintenance use.

A final method of widening is achieved by providing collector/distributor or link roads along both sides of the existing motorway. The motorway itself is left unaltered but in some cases some of the junctions could be removed. This method of widening brings traffic closer to properties on both sides of a motorway and therefore increased noise levels will result at all nearby properties unless even more land is acquired for screening. Where greater capacity is required than can be provided by a D4 motorway, the use of link roads is emerging as the favoured solution. All of the above methods of widening are shown in Figure 1.

2 CALCULATION OF MOTORWAY TRAFFIC NOISE

The noise impact of the traffic using a widened motorway must be assessed as part of the environmental assessment required during the planning process. There is also a legal requirement to identify those residential properties which qualify for noise insulation under the Noise Insulation Regulations (Reference 1). Qualification for insulation under these regulations depends upon very small changes in noise level and thus it is essential that future noise levels can be accurately calculated.

Since 1975 traffic noise calculations have been carried out according to the method given in the Department of Transport's memorandum "The Calculation of Road Traffic Noise" (CRTN) (Reference 2). This method, which was revised in 1988, has generally been found to work well. The research on which it was based was, however, carried out mainly on single carriageways with some D2 routes also being studied. Very limited checks were made on D3 roads for the 1988 revision of CRTN but it is understood that no official validation has been carried out on D4 or wider roads.

Traffic comprises a large number of discrete moving noise sources which may conveniently be modelled as one or more line sources. For most situations the CRTN method uses a single line source located at 3.5 metres from the edge of the nearside carriageway. For single carriageway roads this source location is close to the centre of the road and is clearly a reasonable model. It has also proved to be a good model for D2 roads since overall noise levels will be most strongly influenced by traffic on the nearside carriageway. It is clear, however, that as the width of the road increases the potential error in this calculation method also increases. This is acknowledged in the CRTN method, which allows for two sources to be used in cases where the carriageways are separated by more than 5 metres. These sources are located at 3.5 metres from the edge of each nearside lane (see Figure 2). It is worth noting that the standard central reserve width has, until recently, been 4.0 metres and therefore CRTN requires that the single source method should have been used for the vast majority of noise calculations.

3 ASSESSMENT OF CRTN SOURCE MODELS

The CRTN method was not developed for wide roads such as D4 motorways. Its validity has, therefore, been checked using a more detailed model as a control datum. This was done for D4 and also D3 motorways. For the control model, traffic volumes and heavy goods vehicle percentages were measured on individual lanes of a D3 motorway. These data were used to calculate individual lane noise levels at various receiver locations. From this the overall motorway noise was derived. For the D4 model it was assumed that similar flow conditions would occur in lanes 2 and 3.

A further source model was also studied which treated the two carriageways as separate roads and used the CRTN single source method for each carriageway. This gave two sources each 3.5 metres in from the nearest edge of the carriageways. These models are also shown in Figure 2.

A range of propagation distances was first studied, but as expected the variation in results was greatest at the shortest propagation distance. Since it is at those properties closest to a motorway that noise is most critical, only the results of propagation over a distance of 50m are presented here. The results of calculations for D3 and D4 motorways are given in Table 1.

In the case of unscreened propagation for a D3 motorway over soft ground the single source model overpredicts noise by 0.7dB when compared with the control model. For the D4 motorway this overprediction increases to 1.1dB. In both cases each of the two source models show much closer agreement with the control model, with the closest agreement being given by the CRTN two source method.

Screen fencing is commonly used to mitigate traffic noise. For motorways these are typically 3 metres high and located close to the hard shoulder to optimise performance. Table 1 also shows the results of using a 3 metre fence at 1.5 metres from the hard shoulder. The single source method significantly underpredicts noise for both D3 and D4 motorways since the model places most of the noise energy sources closer to the barrier than they would be on the motorway. Again both two source models gave closer agreement with the control model, with the CRTN two source model giving the best agreement.

4 CENTRAL RESERVE NOISE BARRIERS

Traditionally noise screening, either in the form of fences or bunds, has only been used at the outside edges of roads. However, with the very high volumes of traffic now expected to use the motorway system, it is becoming increasingly impractical to achieve satisfactory screening. With anticipated traffic flows of 150,000 vehicles per day or even more, barriers higher than 6m are often found necessary to reduce noise at housing to below the noise insulation threshold of 68dBL_{A10}18hr. Apart from the high cost of such structures, they are likely to prove unacceptable to both road users and local residents. Studies have been carried out on a wide range of techniques to enhance the performance of screens without increasing their height, however, none has yet enjoyed widespread use.

A limiting factor on the performance of any screen at the side of a D4 motorway is that at least half of the traffic is 25 to 40 metres from the screen. A possible solution to this is to introduce screening in the central reserve to provide more effective screening of the far carriageway. A traditional wood or masonry screen would be of little benefit in this case. The sound energy reflected from the nearside carriageway would negate any benefit provided by screening of the far side carriageway. It is concluded that any central reserve barrier would need to be faced with sound absorbing material in order to optimise its performance. At each location careful appraisal needs to be made of screening methods to find the most appropriate solution, but in some instances there may be no alternative to a central reserve barrier.

The benefits which could be gained by using a 3 metre high central reserve barrier on both D3 and D4 motorways are presented in Table 2. The exact geometries for the models studied are shown in Figure 3.

When used as the only form of screening, a central reserve barrier can provide only modest reductions in noise and would not be used in a practical situation. The single source model significantly overpredicts noise in this case since none of the traffic in the model benefits from screening. The two source models both show good agreement with the control models. In practice a central reserve barrier would only be used to enhance the performance of side barriers. In these cases the single source model overpredicts noise from both D3 and D4 motorways. The CRTN two source method shows good agreement with the control model but the two road model significantly underpredicts. This is because both sources are unrealistically close to the barriers.

It should be noted that the benefit provided by a central reserve screen will be gained on both sides of the motorway. Thus, this treatment is considered to be particularly suitable in situations where there are noise sensitive properties very close to both sides of a motorway.

5 DISCUSSION AND CONCLUSIONS

From the above study it can be seen that using the CRTN single source method for wide roads can lead to overprediction of noise in unscreened sections and underprediction of noise where screening is present. The potential errors are minimised by using the CRTN two source method, regardless of whether the central reserve is more than 5 metres wide. It is considered that this method should be adopted for the calculation of noise from all wide roads, since an underprediction of less than 1dB can result in disqualifying householders from noise insulation to which they are otherwise entitled.

The decision to widen existing motorways, rather than to provide additional routes, is creating a motorway system carrying very high volumes of traffic with concomitantly high noise levels. In some instances, the traditional solution of providing side screens can no longer be relied upon to achieve satisfactory reductions in noise levels. The use of sound absorbent screens in the central reserve is proposed to enhance the performance of the side screens. Such measures are likely to be particularly effective where communities are close to both sides of the motorway.

REFERENCES

1 Statutory Instruments No. 1763, Building and Buildings, The Noise Insulation Regulations 1975 (Amended 1988)

2 Calculation of Road Traffic Noise, Department of Transport, Welsh Office, HMSO 1988

	Control	Single Source	Two Sources, Split Carriageway	Two Sources, Independent Roads
D3, no barriers	73.9	74.6 (0.7)	73.8 (-0.1)	73.9 (0)
D3, side barrier	67.9	66.4 (-1.5)	67.8 (-0.1)	67.6 (-0.3)
D4, no barriers	74.9	76.0 (1.1)	75.0 (0.1)	75.2 (0.3)
D4, side barrier	69.5	67.8 (-1.7)	69.3 (-0.2)	69.1 (-0.4)

TABLE 1: Noise levels for motorways with and without 3m side barrier (dBL_{A10}18hr)
Figures in brackets are the differences relative to the control

	Control	Single Source	Two Sources, Split Carriageway	Two Sources, Independent Roads
D3, central reserve barrier only	72.1	74.6 (2.5)	72.1 (0)	72.0 (-0.1)
D3, central reserve and side barrier	65.7	66.4 (0.7)	65.6 (-0.1)	65.1 (-0.6)
D4, central reserve barrier only	73.3	76.0 (2.7)	73.5 (0.2)	73.3 (0)
D4, central reserve and side barrier	67.3	67.8 (0.5)	67.2 (-0.1)	66.5 (-0.8)

TABLE 2: Noise levels for motorways with 3m central reserve barrier, with and without 3m side barrier ($dBL_{A10}18hr$)
Figures in brackets are the differences relative to the control

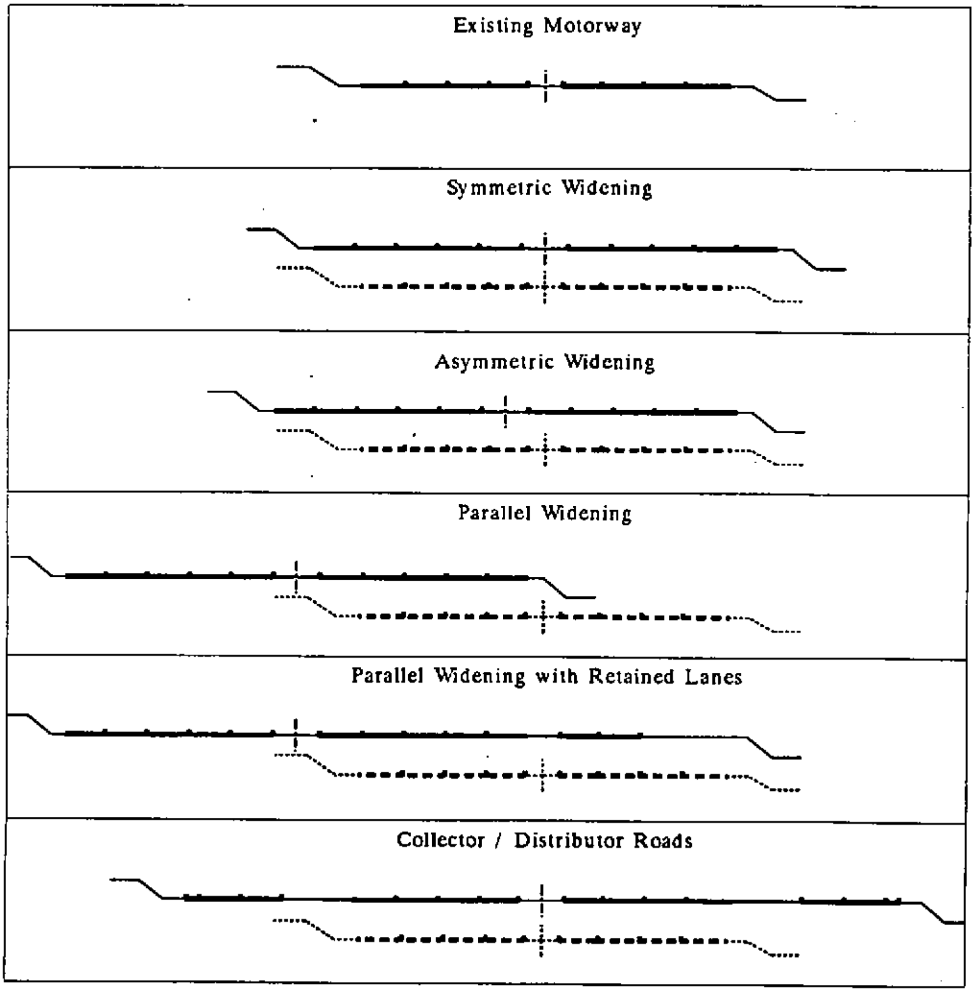

FIGURE 1 : Some Methods of Motorway Widening

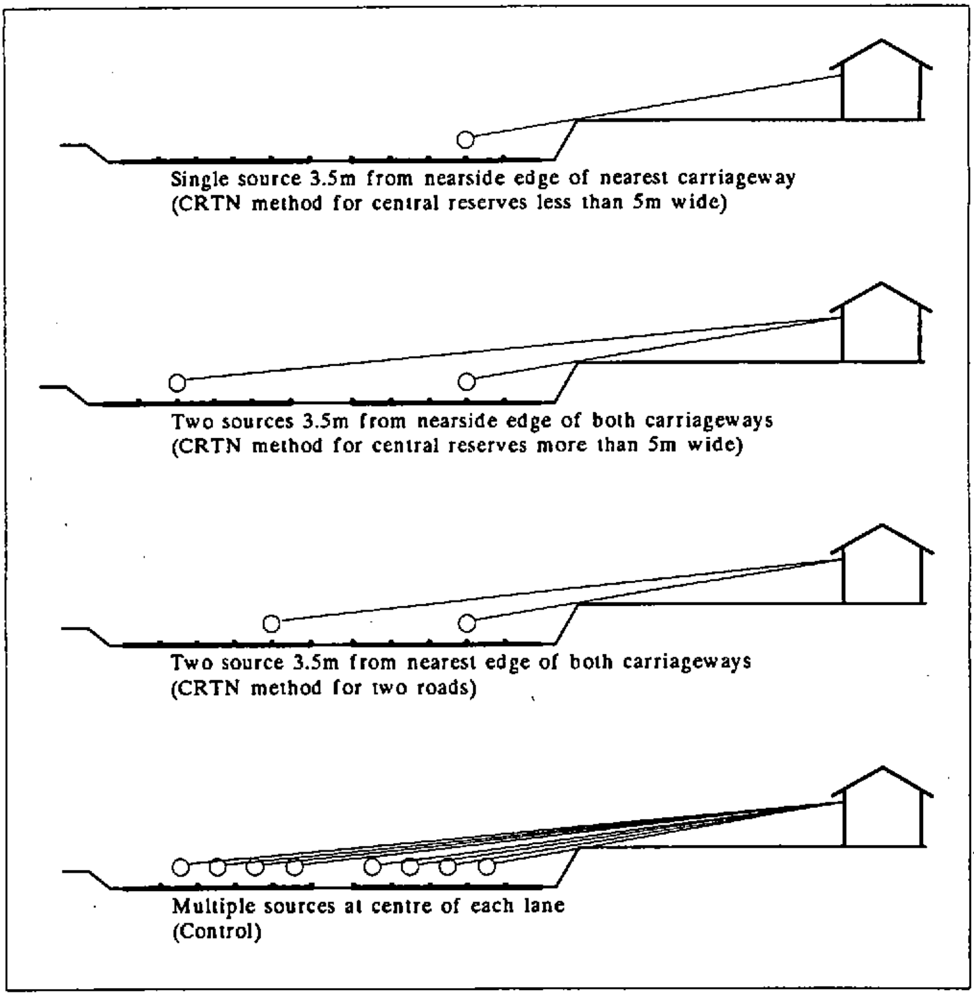

FIGURE 2 : Noise Source Locations

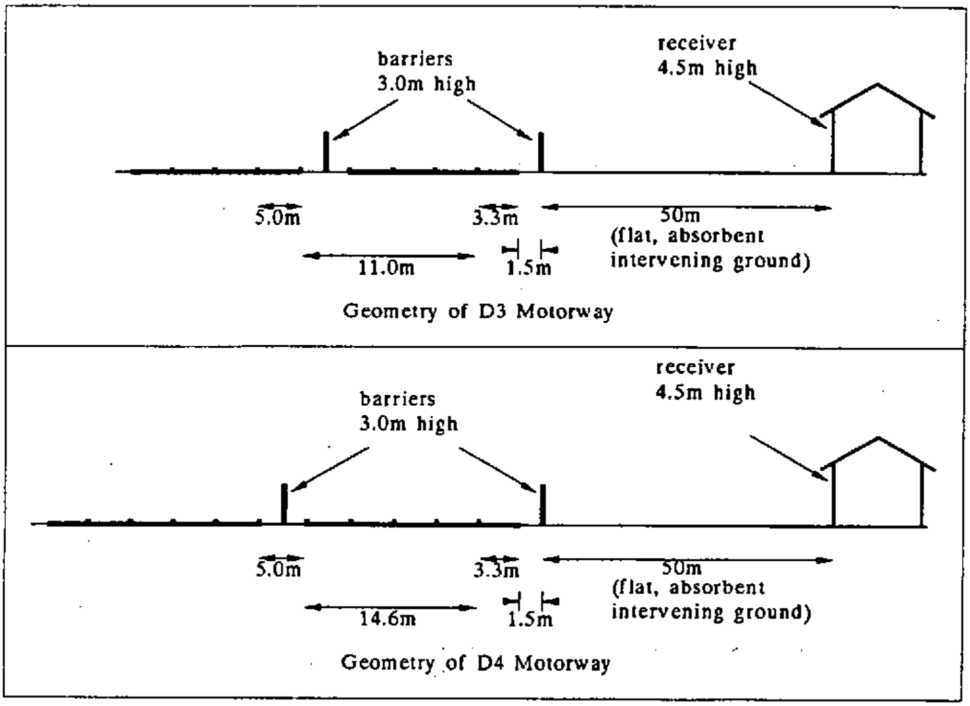

FIGURE 3 : Geometry used for the Calculations