Proceedings of The Institute of Acoustics

EXPERIENCES IN IMPLEMENTING THE REVISED CALCULATION OF ROAD TRAFFIC NOISE

R C Hill (1) and K R Tompsett (2)

(1) Acoustical Investigation & Research Organisation Ltd, Hemel Hempstead
(2) WS Atkins Engineering Sciences, Epsom

INTRODUCTION

The Department of Transport have recently published a revised edition of the Technical memorandum "Calculation of Road Traffic Noise"[1]. The original edition [2] was published in 1975 and although the document has been in constant use since that date both as a general prediction method for traffic noise and as the specified method for determining eligibility under the Noise Insulation Regulations 1975 [3] there were known to be a number of points that had given rise to confusion and therefore needed clarification and some technical points that required amendment.

Essentially the general structure and layout of the method is unaltered and a number of the ambiguities and confusions that arose with the old method have been removed. However, in carrying out their revision, the authors have made minor amendments to virtually every part of the calculation procedure. This has presented a number of difficulties to individuals and organisations who use this prediction method on a regular basis as part of their normal work.

There have been changes made to the terminology (soft ground), revision of the constant term in equations (Basic Noise Level) and the addition of riders to deal with unacceptable end conditions etc in the relationships (change in mean traffic speed on gradients and the low flow correction). These changes can and do give rise to differences in the predicted noise levels but the changes are seldom significant in absolute noise level terms. It is, however, important to note that the new or revised portions of the new method cannot be calculated independently and applied to an "old" noise level from the 1975 method but the whole calculation must be reworked afresh.

There are also two major changes. One is a significant revision of the retained cut correction which was considered to be an over simplification of a complex problem. It has been extended to encompass a wide range of situations and the calculation procedure is now complex and probably incomprehensible to many of the people who will be required to use this calculation procedure. The last item is the inclusion of the surface correction which, although simple enough in its implementation, is going to present many other problems of a perhaps more political nature.

As soon as the new edition is published it becomes the best available information on the prediction of road traffic noise and all on-going projects have to be re-evaluated. Changes of this sort take time to incorporate into the normal working procedures and to give users familiarity with the revisions. Problems have arisen from the very short implementation period. In the event the delay in implementing the Amendments to the Noise Insulation Regulations has helped but the Government should consider the implications and timescale of such changes. It is not just newly started schemes that will be

affected but there is also an immediate backlog of all the schemes at the various stages in the roads programme. Schemes that are about to be published or to go to Public Inquiry right up to projects where the NIR appeals period is almost completed will all have to be re-evaluated. Also, where this method is intensively used it is inevitable that computers will be used to assist with the calculations and therefore the changes to the method will involve significant alterations to a considerable quantity of software. This paper describes some of the authors' experiences in implementing the changes and discusses some of the problems encountered.

USE OF COMPUTERS

The revisions have added significantly to the complexity of the method as a whole. For anyone who has a number of calculations to perform it can hardly be viable to use the charts provided. This seems to have been accepted by the authors as the artwork of some of the new charts militate against their use by employing 0.4 dB(A) wide lines. Whether the added complexity can be justified by a measurable improvement in prediction accuracy is a question that remains to be answered. The 1975 edition was followed by an article in the technical press [4] giving considerable technical detail about the development of the prediction procedure and quantifying the prediction accuracy. It is hoped that similar supporting information will follow the publication of the revised edition.

Both the authors of this paper make extensive use of Calculation of Road Traffic Noise and have developed suites of computer programs to assist with the calculation of noise levels. The approaches adopted are significantly different and it is therefore appropriate to briefly describe them both.

WS Atkins have developed a system known as ROPLAN in which a digitizing tablet is used to create a three dimensional computer model of the road structure, the surrounding buildings and other topographical features. Details of the traffic flow parameters for the various road links and details of the required calculation points are also supplied to the program. From this data the computer then calculates the contribution from each road segment, applies the appropriate corrections for the propagation path and other relevant factors and presents the overall noise level for each of the required points. Separate models can be constructed for different conditions or proposals so that changes in noise level can be determined.

The AIRO approach has been to develop a program which is interactive and prompts the user for appropriate input information, performs the noise calculations for each segment and prints a detailed calculation sheet that records all the input data as well as the resulting noise levels. An important difference is that the segmentation is performed manually by the user for each calculation rather than globally carried out at the digitization stage of the ROPLAN method.

It should be remembered that the calculation method must take account of every possible permutation and combination of effects. With a manual segmentation approach the engineer performing the calculations has to make decisions on how

to approach a particular problem as and when it arises. With the digitization approach the same full range of problems have to be addressed but in this case before they occur as the decision making process has to be programmed into the computer. This places an additional burden on the programmer and in the context of this paper has brought to light a number of interesting points.

METHOD AS A WHOLE

A number of amendments have been made to the original method which have dealt with some of its deficiencies and these are welcomed and will be referred to in detail below. In many cases the changes have only involved a simpler, clearer presentation of the original method. However, some of the changes have inadvertently introduced unnecessary new difficulties. Some of these difficulties may derive from an academic wish to be rigorous but result in a method which is not sufficiently practical about the limitations of real situations. This means that objectors in a Public Inquiry situation can score points by claiming that Highway Authorities have not stuck to the letter of the law, although the deviations may not make any practical difference to the answer. An example of this is the suggestion that where hourly flows are available, then the L10 (18-hour) value should be determined from these (para 13.2, p5). This would hardly be practical for a major highway improvement that could require noise level predictions for more than 3000 properties.

The 1975 edition established a simple sequential procedure that was easy to comprehend and to implement. The new edition includes much more interrelation between the variables (eg gradient correction related to % heavy vehicles and low traffic flow correction related to distance). The recursive nature of some of the amendments causes problems in implementation, not so much for the software itself but rather for the human comprehension of what is happening. It may be theoretically appropriate to consider the gradient and low flow terms as source characteristics but, in practice, they have to be implemented as segment related functions and accordingly align with the propagation terms. All things (well, almost all things) are possible with software but the time taken to produce the program and the machine time taken to run it have to be taken into account as well.

In a prediction method such as this it is inevitable that step functions will occur in the procedure as particular variables come into play. However, it is desirable to keep these to the minimum but the amendments have introduced more step functions into the method. It is particularly unfortunate that the threshold for the changes in the surface correction occur at 75 km/hour while the speed correction for gradients can be in excess of 5 km/hour for as little as a 5% gradient. With new highways it is usually only on the slip roads where large gradients occur and the design speed would probably be 80 km/hour which means that the speed used for the calculations may arbitrarily fall either side of the 75 km/hour threshold.

Another problem, which is emphasized in the new method, is the need to divide the road into a number of separate segments in such a way that, within any one segment, the noise level variation is less then 2 dB(A) (para 11), that varying the ground type within a segment does not introduce a variation of

more than 2 dB(A) (para 20.3) and that non-parallel barriers are subdivided so that the variation in the potential barrier correction between segments is less than 2 dB(A) (para 22.2). In practice, this is unlikely to be an onerous requirement, but unfortunately there appears to be no simple analytical way of deciding whether subdivision is necessary. Procedures can be devised on a trial and error basis, but these increase the amount of computation, perhaps unnecessarily. It will take time for the various procedures to be tested and evaluated and to gain experience. Meanwhile this may remain very much a black art, although programs such as ROPLAN can be programmed to test, and improve if necessary, the accuracy of the sub-division.

The rules about the rounding of the noise levels have been retained from the earlier edition (footnote to para 7). This is a sensible condition to impose as it helps repeatability and controls the accumulation of rounding errors. It has always, however, seemed pedantic to specify the direction of rounding for exact values of 0.05 dB(A) based on the sign of the answer. The problem with the new edition is that the rules for application have become blurred. The wording states that "each step (involving a separate chart or formula) shall be rounded". However with the retained cut correction there are 3 charts involved which are accumulated in one final equation. Clearly the results from Charts 13 to 15 are not intended to be individually rounded as the limits of applicability are expressed to two decimal places. The rounding should only be applied to the equation in paragraph 36.1.3. This exception should have been made clear or the rule of application amended. Paragraph 21.1 does give detailed advice on rounding in respect of the path difference calculations which is a welcome addition to the document. Problems have arisen in the past with the 1975 edition when people have rounded the distances in the path difference calculation to one decimal place!

Another thing to watch is that some of the formulae (particularly for the new charts) rapidly go haywire beyond their range of validity, so woe betide anyone who omits rigorous range checking. Even the authors of the revised edition make this mistake as can be seen from detailed examination of the ground absorption correction in Annex 2.

MINOR CHANGES

Soft Ground

The soft ground correction in the 1988 edition (ground cover correction) is a considerable improvement over the old edition. The ground absorption is now presented independently of the distance correction arising from cylindrical spreading. This makes the substitution of a barrier effect for the ground absorption more logical for inexperienced users. Although the height parameter has been changed from effective receiver height to average height of propagation the function remains the same and the application of the correction is, on the whole, much clearer than before.

A new feature is the treatment of a mixture of hard and soft ground. The primary advice is divide the road into segments of uniform ground type but it is now accepted that this cannot always be done. For example where there is a strip of opposite ground type parallel with the road itself. The new method

allows the ratio of absorbent ground cover to be calculated and a factor applied to the soft ground correction. What is not made clear is why the step functions are introduced in paragraph 20.4 rather than allowing a continuum to be used. Perhaps it is assumed that people cannot accurately estimate the ratio of areas but this clearly would not apply to computerized methods. From the point of view of ROPLAN the new soft ground procedure is not at all helpfully designed. The last paragraph of 20.4 seems to be an unnecessarily complicated way of restricting the area of consideration to the region close to the receiver. It has been introduced because of the basic assumption in the method that all segments are infinitely long, and without it the area between the road and receiver is infinite, thus making a nonsense of the calculation. In practice road segments are not infinitely long and so the problem does not normally arise. When it does the method need only state that no area greater then 5d from the receiver point need be considered.

Gradient

The gradient correction is another area where the changes introduced are extremely welcome. There was always confusion with the old two curve chart exacerbated by the omission of part of the caption in the original print run. The new method makes clear the distinction between the estimated speed based on the class of road and the measured or calculated speed for a road with a gradient. Chart 5 provides for the change in mean traffic speed that would occur on a given gradient with a known traffic composition. From a presentation point of view it is unfortunate that the chart does not show the sign of the change and that it is necessary to look in the text to confirm that it is a reduction in speed.

Another point that will cause problems in this context is the new idea that the source line should be extended in elevation as well as plan as set out at the end of paragraph 18 and Annex 3. Presumably the reason for introducing this change is that otherwise on a gradient there will be different slant distances for each segment. The new procedure means that a short length of steep road off to one side would be very deep by the time it was extended, making the slant distance much greater than in reality. This introduction seems to be at odds with the general definition of d' as the shortest slant distance from the effective source position. Because this point is hardly prominent in the document and it requires the additional input of the distance along the source line to the segment to enable hg to be calculated (this value is not required for any other purpose) it seems highly likely that it will be ignored by most users. It also seems improbable that the original data used in the regression analysis took this form when the equations were derived so why change it at this stage. This appears to be a case of academic rigorousness prevailing over practicality.

Opposite Facade

Another ill-defined area is the reflection procedure for opposite barriers. The new method does include partial reflections from discontinuous opposite facades and the text has clarified that this correction applies to the facade behind the source line (refer to para 27 in connection with side roads). What is still not made clear is at what distance a reflecting surface can be

ignored, but in annex 2 a case is shown where it is ignored at a distance of 20 metres beyond the source line with a receiver to source line distance of 9.5 metres. Since reflections can make 1.5 dB(A) difference to the answer, it is important to be sure. This is another example of the step function referred to earlier.

MAJOR CHANGES

Surface Correction

This is one of the major new features of the revised edition but there is every appearance that it has been added as an afterthought. There is little guidance on its use, no worked examples and even the units of measurement of the texture depth have been omitted. From the point of view of a guidance document it is, to say the least, unsatisfactory.

The new prediction method provides two equations which relate noise level to surface texture depth, one for concrete and one for impervious macadam. The document contains no guidance on what texture depth to use unlike the traffic speed term where detailed guidance has been given. For a given texture depth concrete roads are significantly noisier than macadam but it has for a long time been Department of Transport policy that concrete and macadam roads produce the same noise levels for equivalent resistance to skidding. Examination of these equations show that 1.5 mm macadam would give the same noise level as 0.65 mm concrete. From other sources it appears that 2 mm of random textured surface (macadam) gives the same skid resistance characteristics as a transverse texture of only 0.8 mm (brushed concrete). These figures would, in noise terms, give a difference of only 0.1 dB(A) for the change of surface.

The Department of Transport's standards for new highways require macadam roads to be laid with a texture depth of 1.5 mm while for concrete, a new road must have a texture depth of at least 0.65 mm on opening. New brushed concrete roads, however, will lose a fair amount of their texture in the first year after opening and they are therefore laid with a relatively rough surface to compensate. At the design stage it is not known what surface will be used as it is Department of Transport Policy to invite contractors to tender for both concrete and macadam surfaces and to accept the lower price. An added complication is deciding whether any form of resurfacing or retexturing will have been performed by the design year. In the case of concrete roads this can significantly increase the texture depth. All of this makes it difficult to decide on what design characteristics to assume in performing the noise evaluation on a road scheme and assessing the eligibility for noise insulation fifteen years after opening.

It would seem appropriate to adopt a moderately adverse condition but not necessarily an extreme one. As a suggestion both the noise evaluation and eligibility could be based on a well laid concrete road with a texture depth that would be typical of its characteristics over its expected life span. This is assumed to be of the order of 1 to 1.5 mm. It is accepted, however, that this will probably be a political rather than engineering decision in the end but it will have to be made and sooner rather than later.

Retained Cut

This correction is now much more complex than in the 1975 edition but the revision is very poorly presented. It is much easier for a person to understand something if they can see why it has a particular form. The method of presentation will defeat most casual users of the document and probably many acousticians. The ambiguity of the logic expression for the Δ_1 term is a case in point. The document does not make it clear that α is signed. Therefore if the receiver point is well below the road α is less than 1 and therefore $\Delta_1 = 1.0$.

The implementation of the method has raised a number of points such as how is the retained cut correction applied in multiple barrier situations? It is understood that the retained cut correction is calculated for the roadside/cutting barrier and that correction is then applied to the barrier attenuation (single or multiple) irrespective of which barrier is the one providing the major screening. However, does this extend as far as applying it to a soft ground correction when this is the more effective alternative to a barrier as described in paragraph Z2.37

Roads are often cambered but all the illustrations of retained cut corrections show flat roads. It is assumed that the reference point is the road surface height at the effective source position. What effect would the extension of the source line in elevation for a segment with a gradient have on the variables used in the retained cut calculation?

It is worth noting at this point that the term "dual barrier" is used to describe noise screens or barriers on both sides of the road. These are considered to be a special case of the retained cut.

Multiple Screening

The final innovation is the treatment of segments where more than one barrier is interposed between the source line and the reception point (not to be confused with dual barriers!). In this case instead of calculating the individual barrier performances and selecting the most effective one as in the 1975 edition the new method now combines the effects of the two most effective barriers. Although the equations are apparently complicated, as is the geometry when the barriers are not parellel to the road, the method is reasonably well presented and illustrated. The need to identify all possible permutations for the implementation in ROPLAN has, however, raised certain problems.

Firstly, the 1988 edition defines a procedure for fractional open area with a single row of houses, but not with multiple barriers. The problem is this: the most effective combination will depend not only on their combined attenuation, (taking the solid parts) but also on their combined fractional open area.

Secondly, barriers are seldom parallel to the road and at constant relative height (it is easy to see when barriers are parallel in plan, but very

difficult in elevation, yet the need for equivalent barriers is more important in elevation) and hence the multiple barrier problem is actually considerably more complex than Figure 6 suggests. A rigorous solution may well need to be recursive.

CONCLUSION

The revisions in the new edition of Calculation of Road Traffic Noise have dealt with a number of the shortcomings in the 1975 edition but the opportunity has also been taken to add some new features to the document. These have added to the complexity of the document and have in some cases introduced a new set of difficulties for the user.

Many of the enhancements are worthwhile in themselves and will certainly assist the experienced user of the method. Whether this will actually result in an increase in prediction accuracy is a question that still needs to be answered. However, the added complexity will make the document less accessible to the less experienced or casual user and may well lead to less reliable predictions being made. The presentation of information in a document of this nature is all important and it must be said that there is room for improvement in the new edition as there was in the old. It is to be hoped that the Department of Transport will not wait a further thirteen years before undertaking another revision. It would probably assist the layout of the document if they were to involve some of the people who have had many years experience in using the document on a day to day basis in any such revision.

REFERENCES

[1] Calculation of Road Traffic Noise
Department of Transport and Welsh Office, HMSO 1988

[2] Calculation of Road Traffic Noise
Department of the Environment and Welsh Office, HMSO 1975

[3] The Noise Insulation Regulations 1975, Statutory Instrument 1975 No.1763

[4] Delany M E, Harland D G, Hood R A and Scholes W E
The Prediction of Noise Levels L10 due to Road Traffic
Journal of Sound and Vibration (1976) 48(3) pp 305-325