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CALCULATING RAILWAY NOISE

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1. INTRODUCTION

In the absence of an accepted methodology, Ashdown Environmental Ltd. developed a train noise calculation procedure in 1989/90[1] for the Airborne Noise Assessment of the proposed high speed rail link between London and the Channel Tunnel.

AEL's computer implementation of the procedure developed for the CTRL, Train Noise Prediction Model (TNPM), has been derived from and tested with over 2000 measurements undertaken on high speed and slower mixed rail traffic, yielding an overall accuracy of ±2.6 and ±3.1 dB(A) for L_{Aeq} and $L_{Amax,F}$ predictions respectively. This level of accuracy is similar to that of Calculation of Road Traffic Noise (CRTN), which has an accuracy of ±2.8 dB for L_{A10}. TNPM has been used extensively for noise predictions, for both railways in the UK and overseas, and have been rigorously tested by bodies such as the Environmental Protection Department in Hong Kong. However, its most extensive use has been for route optioneering, mitigation appraisal and assessment of the published route of the CTRL, as reported in the Environmental Statement.

The Noise Insulation Regulations for Railways (NIRR) are expected to be confirmed by Parliament in the near future. These will be accompanied by a calculation procedure, Calculation of Railway Noise (CRN) which is likely to obtain the same status that CRTN has already achieved.

CRN is still very much in its infancy and will have been used, in its draft form, by only a small cross section of interested parties. As a result, the rigorous testing or validating of the calculation procedure will, as yet, not be evident.

This paper presents the results of a comparison between the two methodologies, highlighting areas of difference between the two procedures.

2. SCOPE OF STUDY

The structure between the two calculation procedures is basically the same, adopting a 'building block' approach. It is beyond the scope of this paper to compare the actual elements or algorithms of each methodology, but more to concentrate on the areas of major difference. TNPM and CRN have therefore been applied to the same receptors to enable a direct comparison of results. CRN only allows the prediction of L_{Aeq}, whereas TNPM computes both L_{Aeq} and L_{Amax} and so this study is restricted to the evaluation of L_{Aeq}.

The statistical analysis which is applied in this paper concentrates on the difference in noise level from a TNPM prediction compared to a level at the same receptor calculated using the CRN procedure. More detailed analysis has been conducted by separating out the predicted levels at receptors which are totally influenced by one particular propagation parameter, and thus enabling the largest discrepancies to be pinpointed to specific propagation conditions. Receptors which are influenced by more than one propagation condition have not been used in the detailed analysis but contribute to the overall comparative statistics.

The train noise source terms used by AEL in TNPM, were, in the main, supplied by BRR and differ in detail to those listed in the appendix of CRN. In addition, there is no source term for a Eurostar train (which will use the CTRL) supplied in the draft of CRN. This study has conducted CRN predictions using the CRN source terms and the BRR source terms for the Eurostar, thus examining the difference in the overall methodology. It is also proposed either to calculate the noise levels using TNPM source terms with the CRN methodology or using the CRN source terms with the TNPM methodology. This will enable the dependency and likely differences of the source terms to be quantified in a real situation. This process will also provide a better comparison of how the different methodologies arrive at overall levels using the same starting block (i.e. the source terms).

All other input information such as speed profiles, engineering detail and railway traffic flows has been used in both the TNPM and CRN predictions, so it is just the source terms and prediction methods which differ.

The propagation parameters which have been considered in the detailed statistical analysis include the following:

1. Open flat ground
2. Track on Embankment
3. Track in Cutting
4. Track on viaduct
5. Restricted angle of view
6. Track screened by a lineside Reflective Barrier
7. Track screened by a lineside Absorptive Barrier

Simple linear regression analyses have been conducted where a significant difference has been identified and the resulting statistics presented and discussed.

3. RESULTS

Figure 1 presents a scatter plot and linear regression of the "CRN Predicted" and "TNPM Predicted" absolute train noise levels. This shows that, at the 2971 receptor locations at which noise levels were calculated, CRN predicts noise levels which are lower than TNPM, with a mean difference of 0.9 dB and a standard deviation of 1.9 dB.

From the analysis of the individual propagation parameters, the following parameters are likely to give rise to the greatest differences between noise levels calculated using TNPM and CRN;

Open, flat ground;

Barriers.

Angle of view also appears to give rise to a significant difference, although the sample at which this was a dominant feature is small. This has therefore not been considered in detail, yet.

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Open Flat Ground

In the open flat ground situation, which is a relatively small data set, CRN predicts levels some 0.8 dB higher than TNPM. This is contrary to the difference for all situations, in which TNPM predicts higher levels.

As this would appear to be the simplest situation, it is perhaps worth noting that CRN adopts a facade correction of 2.5 dB (which is the same as CRTN), whereas TNPM adopts a facade correction of 1.5 dB. There is evidence to support both corrections (and, indeed, others!) but if TNPM adopted a facade correction of 2.5 dB, the overall difference in the calculations from the two methodologies for open flat ground situations would be 0.2 dB, which is clearly very good. However, this would have implications on the overall prediction differences, and this is discussed later.

Barriers

The analysis shows that in any situation where there are barriers, whether purpose built or cuttings etc, TNPM tends to predict higher noise levels than CRN, about dB on average. In our experience, this is one of the most common situations encountered and therefore one of the most important.

Examination of Figure 2, which shows the absorbent barrier attenuation curves for the two models shows that CRN predicts more barrier attenuation, and consequently lower noise levels, than TNPM. This is also the case with reflective barriers.

It should be noted that TNPM was initially derived from measurements of TGV trains in France. With high speed trains, aerodynamic noise becomes increasingly important at speeds over about 350 km/hr. However, if the primary noise source, wheel/rail noise, is screened by a barrier, aerodynamic noise may assume more dominance as it may not be screened to the same extent. Thus at lower speeds of about 300 km/hr, the overall barrier performance may be reduced; this may be reflected in the differences between the TNPM and CRN attenuation rates.

4. DISCUSSION

It can be seen from the scatterplot for all data that at the relatively small number of predicted noise levels over 65 dB, CRN appears to predict slightly higher noise levels than TNPM. However, it may be that these noise levels are occurring in situations where the barrier effect is in the illuminated zone, where there is little difference between CRN and TNPM, or there is no barrier attenuation.

Conversely, it can also be seen that at levels below about 40 dB, noise levels predicted using TNPM become increasingly higher than those at the same receptor predicted using CRN.

However, the two models have been derived for different purposes. TNPM was primarily developed to undertake the noise assessment of a high speed rail link and, due to the assessment criteria adopted, it was necessary to undertake calculations at distances up to a kilometre from the railway. CRN was developed to determine eligibility for noise insulation, and was therefore only required to be accurate over a more limited range of distances and noise levels.

The two main differences between the models give rise to variations which act in opposite directions, and therefore tend to cancel each other out. However, if the facade correction in TNPM was adjusted to 2.5 dB, as mentioned earlier, the overall effect would be to increase the average difference between the noise levels to about 2 dB, with TNPM predicting the higher noise levels.

As the facade correction is based on limited, and sometimes conflicting, information, it is considered that further investigation of this aspect would be beneficial.

With regard to the barrier corrections, it may be that for domestic trains in the UK running at normal speeds, the barrier correction in CRN may be more appropriate. However, at the higher end of the speed range for which CRN is considered valid, and almost certainly for speeds above that, the barrier corrections adopted by TNPM may be more relevant. Indeed, for even higher speeds, some form of speed dependant source or barrier correction may be appropriate.

5. CONCLUSIONS

There is generally good agreement between noise levels predicted using TNPM and CRN, although, on average, TNPM tends to predict noise levels about 0.9 dB higher than those predicted by CRN.

It can be seen that, due to the prediction of higher noise levels by TNPM on average, it provides a more conservative tool for impact assessment over a wider range of noise levels and distances than CRN. TNPM also has the benefit of the prediction of L_{Amax}, which is a useful tool in impact assessment, but is not relevant to the current draft Noise Insulation Regulations for Railways.

CRN should, of course, be used for determination of eligibility for noise insulation.

Further work could usefully be undertaken on the facade correction and barrier correction aspects of the models.

6. ACKNOWLEDGEMENTS

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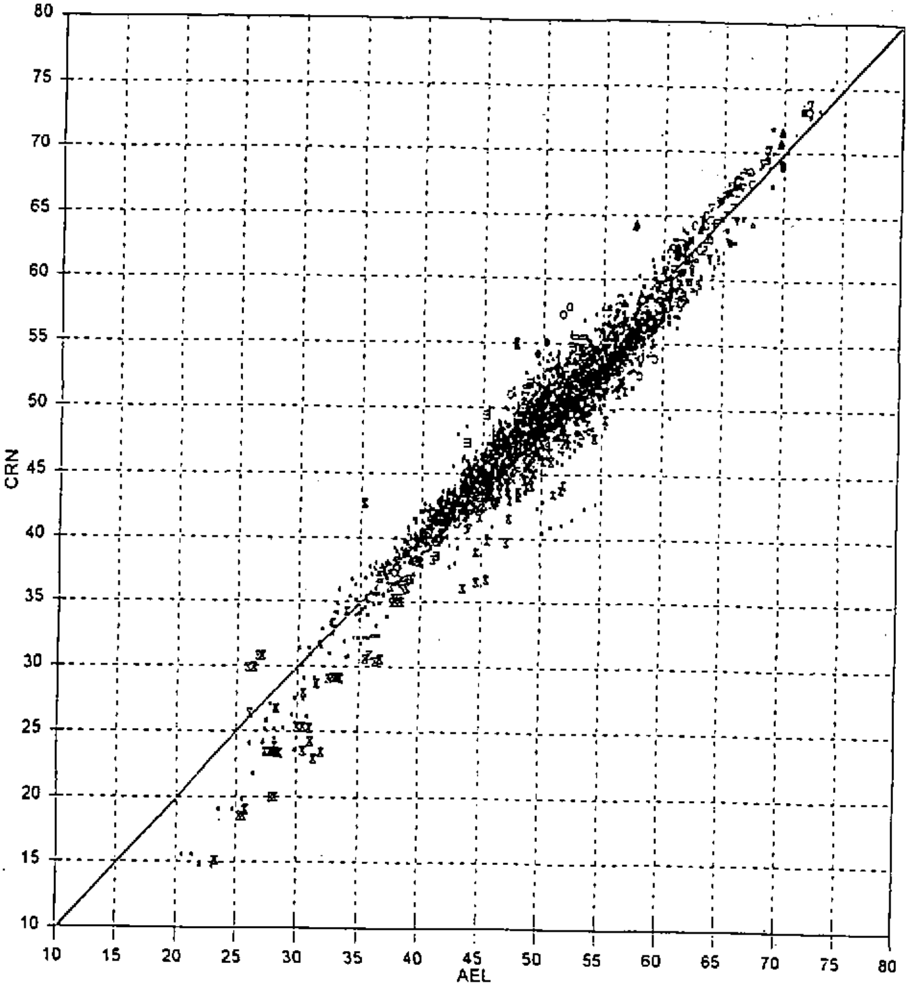
7. REFERENCE

1. Williams PR, Hood RA, Collins KM and Greer RJ. Validation of the AEL Methodology For the Calculation of Train Noise

All Data

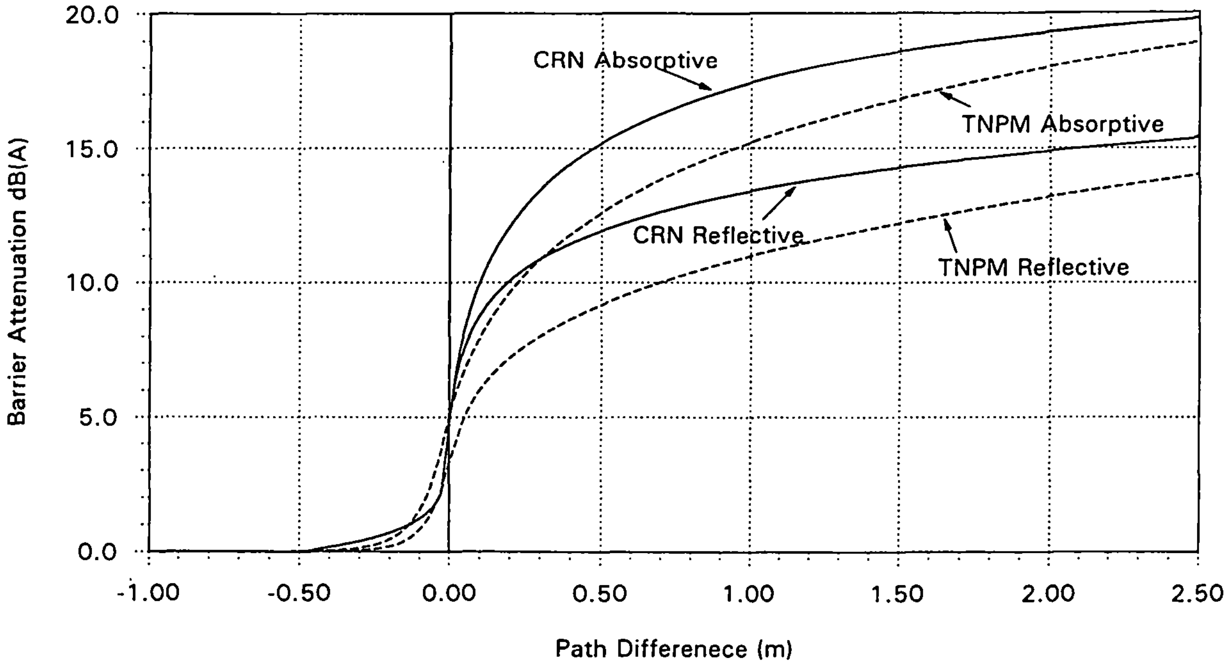


·	?	·	D	,	ABP	·	RBP	o	C	7	E	+	B
x	AOV	▲	F	•	RC	3	T	▼	V	∃	AB		

Figure 1

DOMINATED ATTENUATOR	
RBP	Reflective Barrier - Purpose Built
ABP	Absorbtive Barrier - Purpose Built
T	Tunnel
RC	Retained Cutting
C	Cutting
B	Bund
E	Embankment
V	Viaduct
F	Flat Ground
D	Distance
AOV	Angle of View
RB	Reflective Barrier - Other
AB	Absorbtive Barrier - Other

Figure 2



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CRN and TNPM Absorptive and Reflective Barrier Models as functions of Path Difference

TITLE: Comparison of Barrier Models CRN vs TNPM

FIGURE: 3

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