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THE CALCULATION OF TRAIN NOISE

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1. INTRODUCTION

In the UK, a major research project has been undertaken by Ashdown Environmental Limited (AEL) to develop a noise program for the calculation of noise from new railway lines. The model has been validated in France where an extensive series of noise level measurements were taken on the TGV-A. The model has also been evaluated on trains travelling at reduced speeds in the urban environment. In this paper the essential components of the calculation procedure developed by AEL and its evaluation are presented.

In the U.K., two noise parameters have been identified to describe the noise impacts of new railway lines. These are the maximum level (L_{Amax}) of individual train passbys outside noise sensitive receivers and the 24 hour equivalent continuous noise level ($L_{Aeq,24hour}$). A description of the various noise criteria developed by AEL is given elsewhere [1].

2. EFFECTS OF TRAIN SPEED

The field survey was not specifically designed to develop a speed-noise relationship as the control of train speed was outside the scope of the validation exercise. The field data indicated (see Figures 1 & 2) that the measured speed dependencies did not differ significantly from previous theoretically and empirically derived speed coefficients. The field data was normalised to a speed of 300 kph.

3. CALCULATION OF TRAIN NOISE OVER FLAT GROUND

The propagation of noise over flat ground, and in the absence of any physical obstructions, is dependent on geometric spreading, air attenuation and ground absorption. A separate relationship has been developed for SEL and L_{Amax}.

The results of this analysis indicated that SEL and L_{Amax} noise levels were dependent on the following relationships:

$$SEL \propto 10 \log \left(\frac{\text{Distance (m)}}{25\ \text{(m)}}\right)$$

$$L_{Amax} \propto 14.5 \log \left(\frac{\text{Distance (m)}}{25\ \text{(m)}}\right)$$

The results of the analyses indicated that the fitted models provided a reliable indicator of train noise propagation over flat ground with no obstructions under positive wind conditions and at distances of up to 800 m from the railway.

The accuracy of the calculation procedure for the SEL measure is shown in Figure 4. The fitted linear model has a slope of 0.90, a correlation coefficient of 0.95 (R^2 = 90%) and a standard error of 2.3 dB(A).

The corresponding analysis for L_{Amax} is shown in Figure 5. This fitted line has a slope of 0.96, (R^2 = 92%) with a standard error of 2.3 dB(A). The analyses were based on 171 measured noise levels and indicated that the propagation of train noise can be accurately predicted for relatively straight forward situations.

4. EFFECTS OF SCREENING

Reflective and Absorptive Barriers

Measurements were taken behind a number of purpose built concrete barriers at various distances and for different situations. These included barriers located adjacent to track at grade, on embankments and viaducts. It was thus possible to examine the dependence of reflective barrier attenuation over a relatively large range of path level differences covering both the shadow and illuminated zones.

The relationship between barrier attenuation and path level difference was examined and the best-fit curve shown in Figure 3 was derived. The net effect is that barriers which have an absorptive facing or are naturally absorptive, such as cuttings and bunds, provide greater attenuation than the so-called reflective barriers at any given path level difference.

Reflective Barrier Attenuation

The model for reflective barrier attenuation was assessed by examining the relationship between measured and calculated SEL and L_{Amax} noise levels, is shown in Figures 6 and 7 respectively.

Absorptive Barrier Attenuation

The corresponding relationships between measured and calculated levels for the field data obtained behind cuttings and bunds are shown in Figures 8 and 9, for SEL and L_{Amax} respectively.

5. OTHER EFFECTS

The effects of a number of other parameters on train noise levels were also examined. The results indicated for example that the effects of ballasted track on concrete viaducts with and without noise barriers led to a slight enhancement in train noise levels of 1 dB(A). The results also showed the effects of facades on SEL and L_{Amax} noise levels were an enhancement of 1.5 and 2.5 dB(A) respectively.

6. SUMMARY OF METHODOLOGY

The overall accuracy of the calculation procedure has been assessed and is shown in Figures 10 and 11 for SEL and L_{Amax} respectively. The SEL regression of the calculated levels against those measured for all 665 observations has a slope of 0.89, a correlation coefficient of 0.94 and standard error of 2.6 dB(A). The same regression for the L_{Amax} gives a correlation of 0.94 and standard error of 3.1 dB(A)

7. CONCLUSIONS

The major components of a procedure for the calculation of train noise were presented in parts 2 to 5 and their evaluation outlined in Part 6 of this paper.

These results indicate that train noise levels can be reliably predicted at distances of up to 800 m. The residual errors shown in Figures 12 and 13 are attributable to a number of sources. It is well known that meteorological effects have an increasingly significant influence on the propagation of noise with increasing distance. Other factors, such as trackside were also found to be significant together with large variations in source terms. Although it is anticipated that the further research currently being undertaken will improve the correlation between calculated and measured noise levels, the procedures presented in this report provide a sufficiently robust methodology for planning purposes and the evaluation of mitigation options for new developments.

8. REFERENCES

1. Hood, R A. "Noise Impact Assessment of the CTRL" : Proceedings of the Institute of Acoustics, Volume 12(3) 1990

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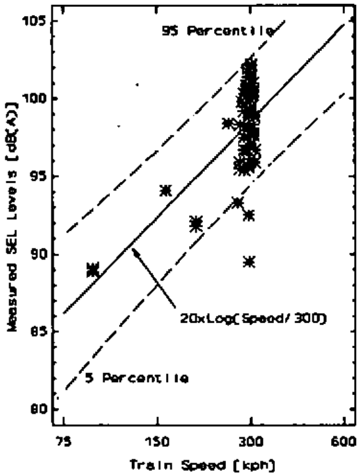

FIGURE 1: VARIATION OF SOURCE SEL LEVELS WITH TRAIN SPEED

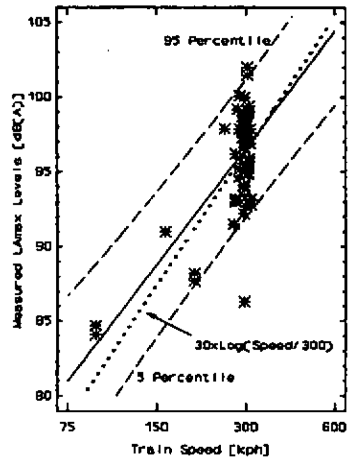

FIGURE 2: VARIATION OF SOURCE L_{Amax} LEVELS WITH TRAIN SPEED

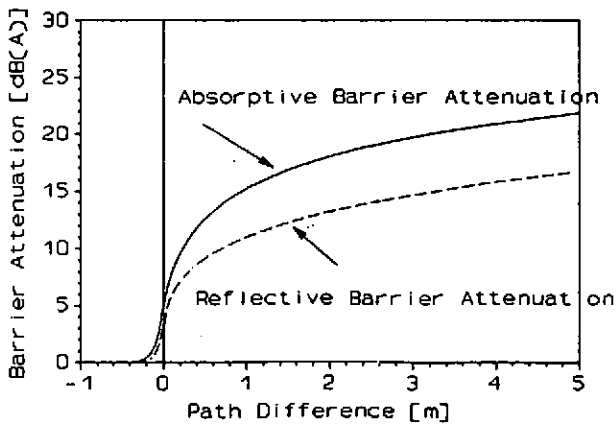

FIGURE 3: REFLECTIVE AND ABSORPTIVE BARRIER ATTENUATION

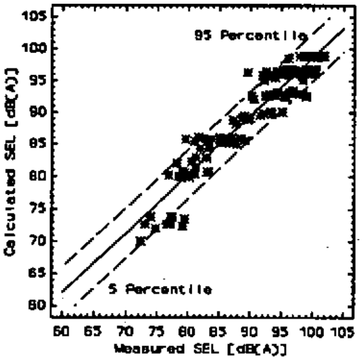

FIGURE 4: FLAT GROUND PROPAGATION - SEL

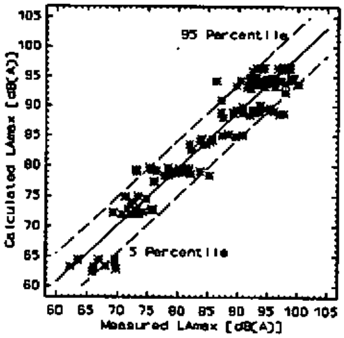

FIGURE 5: FLAT GROUND PROPAGATION - L_{Amax}

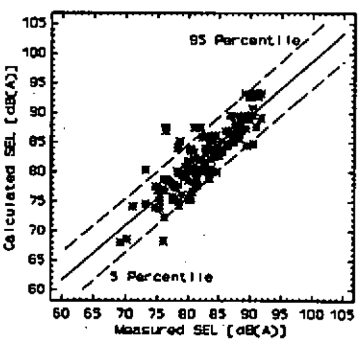

FIGURE 6: REFLECTIVE BARRIERS - SEL

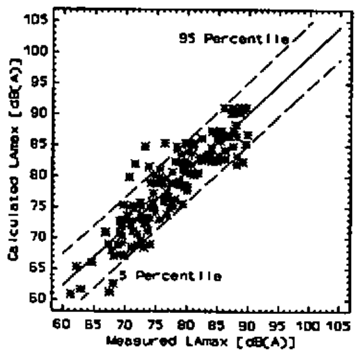

FIGURE 7: REFLECTIVE BARRIERS - L_{Amax}

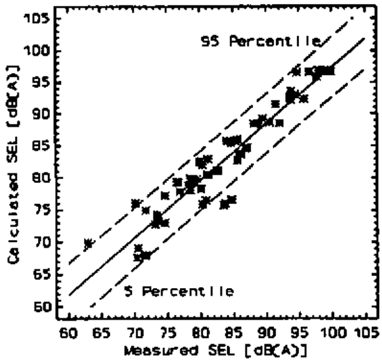

FIGURE 8: ABSORPTIVE BARRIERS - SEL

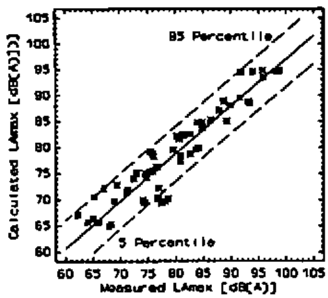

FIGURE 9: ABSORPTIVE BARRIERS - L_{Amax}

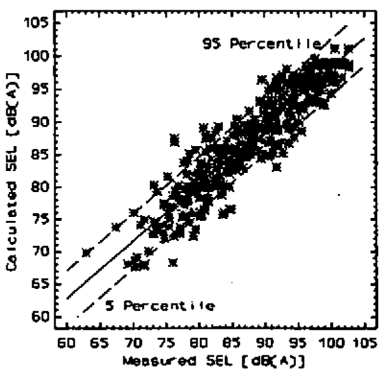

FIGURE 10: OVERALL EVALUATION - SEL

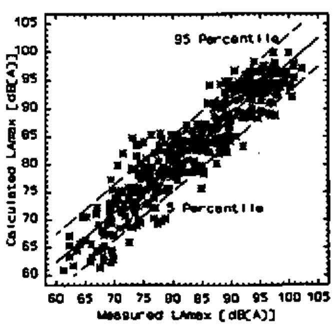

FIGURE 11: OVERALL EVALUATION - L_{Amax}