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THE INFLUENCE OF FACADE REFLECTION EFFECTS ON MEASURED TRAIN NOISE LEVELS

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1. INTRODUCTION

In October 1993 the Department of Transport published the draft Noise Insulation Regulations for New Railways and Other Guided Systems [1] and the consultation technical memorandum Calculation of Railway Noise (CRN)) [2]. The draft CRN produced by the Transport Research Laboratory, outlines the procedure for calculating noise from moving railway vehicles and determines eligibility for insulation of residential properties under the Noise Insulation Regulations. The main purpose in producing the CRN document was to create a procedure similar in format to the Calculation of Road Traffic Noise (CRTN) [3].

According to CRN, the Sound Exposure Level (SEL) under free field conditions is obtained for each train type at a reference distance of 25 metres and corrected for train length and type of track support. The SEL value at the reception point is then obtained by taking into account propagation factors. The free field values are further modified to include facade effects and reflection from structures on the opposite side of the railway. The SEL values are then converted to Equivalent Continuous Sound Levels (L_{Aeq}) taking into account the total number of each train type and the appropriate time period.

In order to comply with the Noise insulation Regulations, it is essential to calculate the facade noise levels specified at one metre from the facade of a building and the draft calculation method recommends that a 1.5dB(A) facade correction value should be added to the free field SEL value. There is no published work to account for the 1.5dB(A) correction value but it is understood to have been derived from noise monitoring carried out of the "Train a Grande Vitesse" (TGV) on the high speed rail in France.

Following the publication of the draft document the Institute of Acoustics held a discussion workshop to formulate a response. One of the topics discussed was the facade correction value. This led clearly to a feeling that the figure of 1.5dB(A) is questionable and that a physical justification for the correction value was required [4].

2. FACADE CORRECTION VALUES

2.1 Traffic Noise

The facade correction value given in CRTN to be added to the L_{10} value is 2.5dB(A). This figure was originally derived from work carried out by Delaney et al. using theoretical and experimental evidence [5].

Research carried out by Chew and Lim investigated the variation in L_{10} for traffic noise, with buildings on one and both sides of the highway. It was found that at one metre in front of a building the L_{10} increased by 2.5dB(A) regardless of receiver height [6].

2.2 Railway Noise

The working paper on Noise Assessment Methodology by Ashdown Environmental Ltd (AEL) [7] includes a facade correction value of 2.5dB(A). This value has been theoretically derived taking into account the spectrum of high speed train noise. However, the calculation methodology given in AEL's "Train Noise Model 1992" [8] includes a correction value of 1.5dB(A). This calculation procedure is based on research and noise measurements taken of the TGV in France.

2.3 Planning Policy Guidance PPG 24

This document produced by the Department of the Environment recommends that "facade levels should be assumed to be 3dB(A) higher than levels measured away from any buildings, unless a more accurate figure is available" [9].

The work present in this paper aims to resolve the uncertainty associated with the facade correction factor to be applied in the calculation of railway noise.

3. THE FIELD STUDY

3.1 Methodology

Simultaneous measurements of train pass-by events were taken at both facade and free field positions. The SEL and L_{Amax} were recorded at both positions and the difference taken to be the reflection effect of the facade.

Measurements were carried out by using two integrating - averaging sound level meters complying with Type 1 of BS 6698 (B & K 2231 with event recording module). Both meters were located at a height of 1.4m above ground level. The meters were calibrated before and after each noise monitoring period by using an acoustic calibrator (B & K 4230).

Any relevant background noise which may have influenced the measurements was noted and the events discarded. Other information recorded included type of train, number of carriages, train pass-by time, direction and weather conditions. During the period of field measurements (10 May to 23 May 1994), recorded wind speeds were less than 5m/s. The wind direction varied from easterly to south-easterly.

A typical sample of a data sheet recorded during the monitoring process is illustrated in Table 1.

3.2 The Measurement Sites

A number of factors had to taken into consideration when deciding on a suitable site. The sites had to be situated away from significant background noise which may have influenced the measurements. The sites also had to include suitable adjacent land to carry out free field measurements and care had to be taken to ensure that there was no other noise reflective structures either side of the track or objects that might act as a significant barriers.

Five sites were chosen within the Maidstone, Kent area. Four sites on the Ashford to Tonbridge line and one on the Ashford to Maidstone East line. Both railway lines consist of continuously welded track with tread braked passenger trains using them. The five sites ranged from 24 metres to 124 metres from the nearest track. The intervening ground was mainly grass. Due to practical difficulties in measuring from the track to the reception point, distances were taken from the Ordinance Survey Maps. All facades faced the railway line and consisted of window and brick with the exception of Site 3 which was predominately brick with a small window.

Table 1: Sample of a data sheet

LOCATION		Site 5a	DATE	11 May 1994						
WEATHER		Dry, cloud cover 0 Wind slight breeze E								
Event records Minimum duration 4 seconds Threshold level 70dB(A)		Position 1 Measurement Location Facade 1m from facade Mic height 1.4m Dist from track 124m	Position 2 Measurement Location Freefield 9.9m from pos.1 Mic height 1.4m Dist from track 124m							
Instrumentation		Bruel & Kjaer	Bruel & Kjaer							
SLM		2231	2231							
Serial No.		1276981	1176469							
Microphone		4165	4165							
Serial No.		1260667	1317058							
Calibrator		4230	4230							
Serial No.		1275143	1275143							
Calibration before dB(A)		93.8	93.8							
Calibration after dB(A)		93.9	93.9							
						Position 1 dB(A)		Position 2 dB(A)		
Event No.	Time	Train type	No. carriages	Pass-by time	Direction	SEL	LAmax	SEL	LAmax	Comment
1	10.58	Passenger	8	10.5 seconds	Maidstone	82.7	80.4	81.7	79.2	[illegible]
2	11.18	Passenger	8	8 seconds	Maidstone	85.9	78.9	83.5	77.8	
3	11.22	Passenger	2		Ashford	82.9	81.3	79.6	78.1	
4	11.30	Passenger	2	2 seconds	Maidstone	82.4	79.1	79.3	75.9	[illegible]
5	11.35	Passenger	8	8 seconds	Ashford	88.3	80.8	86.7	78.3	
6	11.44	Passenger	4	3 seconds	Ashford	83.6	77.7	79.6	74.7	
7	11.48	Passenger	8	5 seconds	Maidstone	91.6	85	88.5	81.4	[illegible]
8	11.54									[illegible]
9	12.00	Passenger	8	5 seconds	Maidstone	89.6	83.3	87.3	80.4	
10	12.05	Passenger	8	5 seconds	Ashford	90.1	85.7	87.4	81.1	
11	12.17	Passenger	4	3 seconds	Ashford	81.7	78.4	78.3	73.9	
12	12.31	Passenger	8	4.5 seconds	Maidstone	91.6	86.6	87.6	82.2	
13	12.35	Passenger	8	5.5 seconds	Ashford	88.7	81	84.1	77	

4. SUMMARY OF RESULTS

Although a total of 65 observations were made, a number of these had to be discarded owing to the complicating influence of unrelated background noise. Thus only 43 measurements were deemed acceptable for this study. The difference in the mean SEL and L_{Amax} values between the facade and the free field measurements together with the corresponding standard deviation values obtained at five sites are given in Table 2.

Table 2: Difference between facade and free field levels

Site no.	No. of events	Dist from track metres	Mean SEL dB(A)	Std. Dev	Mean Lmax dB(A)	Std. Dev
1	6	24	4.23	0.52	4.38	0.68
2	6	42	2.83	0.35	2.85	0.69
3	9	70	4.48	0.44	4.52	0.64
4	8	80	3.55	0.58	3.53	0.51
5a	9	124	2.97	0.68	3.43	1.07
5b	5	126	2.82	0.82	2.68	1.14
Total	43		3.54	0.88	3.64	1.05

The mean values of SEL and L_{Amax} are also presented in Figure 1

5.DISCUSSION

The results indicate that the average values attributable to façade reflection effects are around +3.5dB(A) for both SEL and L_{Amax} measurements. The results also show that there is a considerable range in the level differences for both SEL and LAmax values. An examination of the results does not appear to reveal any obvious reason for this variation. For example there appears to be no correlation between the values and distance from the track, number of carriages or train speed. If more train pass-by events had been monitored at each site then a pattern may have become apparent with possible rogue figures having less of an influence.

The reflection effect will depend upon the distance of the microphone to the facade, the reflection coefficient of the facade and the noise spectrum.

FACADE REFLECTION EFFECTS

The draft method states that the facade position shall be one metre outside a qualifying window. It can therefore be assumed that in part the facade will be glass. Four of the sites were brick and glass, while site 3 was predominately brick and it can be seen that the highest mean value was found at this site. The building material of the facade will influence the reflection effect although further research would have to be carried out to determine if this may have a significant effect.

Another possible explanation for the range of the results might be associated with the noise spectrum. If the spectra for the different trains vary considerably then particular frequencies may be absorbed by the facade while others are reflected. This could conceivably account for variations in the facade effect at the same site.

In a similar context, the noise spectrum of high speed trains will be different to trains at low speeds which could also exert an influence on the facade effect.

An additional factor to be considered is the effect of the angle of the facade to the railway line. If the facade of the qualifying window is at right angles to the track then there may be a significant difference in the reflection effect compared to a facade parallel to the track.

Further research is clearly necessary to establish the nature of the relationship between the facade building materials and the spectrum of the noise source. The confidence level of these investigations will be enhanced considerably by including a greater number of measured events for each site.

6. CONCLUSION

The conclusions of this study are as follows:

1) The results of this study indicate that the averaging values attributable to facade reflection effects are around +3.5dB(A) for both SEL and L_{Amax} measurements.

2) It would appear that the facade correction factor of 1.5dB(A) given in the CRN document is likely to be an underestimate.

3) It might be appropriate to specify a value of 2.5 dB(A). This will have the advantage of bringing it in line with other similar compliance requirements such as those stipulated in CRTN and PPG24.

7. REFERENCES

1. 'Noise Insulation Regulations for New Railways and Other Guided Systems' - Department of Transport, 1993.

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5. M.E.Delaney, D.G.Harland, R.A.Hood and W.E.Scholes, 'The Prediction of Noise Levels L_{10} due to Road Traffic' - J.Sound and Vibration, Vol 48, Part 3, 305 - 325, 1976.

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8. 'Train Noise Model, Information Leaflet', Ashdown Environmental Ltd, Apr. 1992.

9. 'Planning Policy Guidance: PPG 24', Department of Environment, Welsh Office, HMSO, 1994.

Figure 1: Mean values of SEL and L_{Amax} at the five sites